ANNEXURE-II

Discipline - wise ARS/NET Syllabus

01. 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 hormones. Functional molecules, antioxidants, nutrient precursor, HSPs, anti-viral compounds.

Unit 3: Enzymology
Enzymes, structure conformation, classification, assay, isolation, purification andcharacterization, catalytic specificity, mechanism of action, active site, regulation of enzyme activity.

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 pseudogenes, 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 transcriptionin 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, northernand 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 reaction, RT-PCR, QRT-PCR spectroscopy, 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, 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-transcriptionalmodifications. Bioprospecting, biofortification, gene pryrimiding and gene fusion, ribozyme technology.

Unit 9 : Plant Molecular Biology
Photoregulation and phytochrome regulation of nuclear and chloroplastic gene expression. photosynthesis, C3& C4 cycle and photorespiration; 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. Clonal propagation, Concept of cellular totipotency. Another culture, somaclonal and gametoclonal variations. Hybrid embryoculture 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, bio-safety norms and controlled field trials and releaseof 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, transcriptomics, ionomics, metabolomics and proteomics, comparative genomics and application of genomics.

02 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, Dip lopoda and Hexapoda. Classification of insects up to order level, habits, habitats and distinguishing features of different Order and important Families. DNA barcoding, Phylogenetic analysis.

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 outbreaks.

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, hyper parasitism, super parasitism 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.

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 LD50, LT50, RL50 etc, Pesticide management Bill, 2020. Pesticides residues in the environment and their dynamics of movements, methods of residue. Codex, FSSAI, HACCP, 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; molecular approaches for developing insect pest management strategies (RNAi, CRISPR).

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 ofarthropod pests of cereals, Oilseed, pulses and fibre crops, sugarcane and tobacco. Polyphagous pests: locusts, termites, hairy caterpillars, 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 ofarthropod 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: Arthropod 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 inducing 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 randomized block design, Latin square design, Split-plot designs. Probit analysis.

03. AGRICULTURAL MICROBIOLOGY

Unit 1: History of Microbial World

History, development and scope of microbiology, evolution of microbial life. Theory of spontaneous generation. Prokaryotes, archaebacteria and eukaryotes. Techniques used in identification and classification of bacteria. Important groups of prokaryotes; photosynthetic bacteria; chemoautotrophic bacteria, spore forming bacteria, actinomycetes, heterotrophic bacteria, nitrobacteria, nitrogen-fixing bacteria, cyanobacteria, lactic acid bacteria, halophiles,thermophiles, acidophiles and methanogens. Structure and classification of viruses, bacteriophages/cyanophages/mycophages; growth of viruses, lytic and lysogenic cycles; plant viruses, viroids, prions and mycoplasma.

Unit 2: Microbial Ecology and Physiology

Principles of microbial ecology, Microbiology of ecosystems -soil, rhizosphere, rhizoplane, endorhizoaphere, phyllosphere, water: fresh and marine, and air. Microbial interactions - symbiosis, synergism, commensalism, parasitism, amensalism, antagonism and predation, adaptation 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, metabolic pathways, microbial photosynthesis, oxidative and substrate level photo-phosphorylation, metabolism of xenobiotics, metabolism of C1 compounds. Biosynthesis of cell wall, protein, macromolecules (DNA/RNA), etc. by microbes. Molecular microbial ecology: numerical and molecular taxonomy and identification.

Unit 3: Soil Microbiology

Soil microorganisms: major groups, decomposition of organic matter, soil health. Root exudates (rhizodeposition) and rhizosphere effects. Exploration of rhizosphere microflora for plant productivity. Microbial biomass. Nitrogen cycle: ammonification, nitrification and denitrification. Biological nitrogen fixation-symbiotic, associative and a symbiotic. Biochemistry and genetics of nitrogen fixation. Microbial transformations of phosphorus, potassium, Sulphur and other minor nutrients. Role of biofertilizers in agriculture and forestry. Bioremediation of problematic soils, plant growth promoting rhizobacteria and their mode of action; Mycorrhiza and their associations. Formation and composition of soil organic matter: ferulic acid, 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, bright field, 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 remediation/amelioration; 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. Fermenter 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, sauerkraut, 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.

Unit 6: Microbial Genetics, Genomics and GMOs

Genetic mechanisms in microorganisms, including bacteria, archaea, and viruses; principlesof genetic variation, gene expression, and genetic engineering techniques used in microbiology; Basic concepts of genetics: DNA, RNA, and proteins; Types of genetic mutations Mechanisms of genetic variation Methods of detecting and analyzing mutations; Transcription and translation in prokaryotes; Regulation of gene expression; Operon model and other regulatory mechanisms; Horizontal Gene Transfer; Bacteriophages and Genetic Exchange; Plasmids and Mobile Genetic Elements; Genomic Analysis and Bioinformatics; DNA extraction and purification; Polymerase chain reaction (PCR); Gel electrophoresis and DNA sequencing; Transformation and cloning experiments; CRISPR, Gene/Genome editing; Genetically modified microorganisms.

04. ECONOMIC BOTANY & PLANT GENETIC RESOURCES

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; Biosystematics and taxonomic tools; Origin, evolution and biosystematics of selected crops (rice, wheat, rape seed & mustard, cotton). Molecular systematics, Global taxonomic initiatives, Barcoding, databases.

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. Structure, development and chemical constituents of plant parts, revival of under- utilized crops and its economic benefits

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, sun hemp, 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-forestry importance: multipurpose trees/shrubs, subabool, *Acacia niiotica,* 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. Agrobiodiversity, habitat fragmentation, ecology concepts, legal issues related to endangered species and protection, conservation genetics, reproductive fitness, Global plan of action, NBA, FAO, Agreement on Agriculture, Delhi declaration, UPOV and PPV&FRA, SPSAgreement.

Unit 6: Germplasm Augmentation

History and importance of germplasm collection, eco-geographical distribution of diversity, logistics of exploration and collection, use of flora and herbaria, random and selective sampling, gene pool sampling in self- and cross-pollinated species; Concept, importance and eco-geographical considerations of introduction and exchange of plant germplasm; prerequisites conventions and achievements of PGR exchange. Multilateral agreements, MTAs, National and international legislations, Geo spatial analysis, Remote sensing, FAO code of conduct, Taxonomic database, and documentation systems,

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 behavior (orthodox, recalcitrant), field gene banks, clonal repositories. Gene bank management, gene bank standard for various crops, ISTA, AOSA, IPGRI guidelines, documentation of information in gene bank.
Cryo conservation strategies, monitoring genetic stability, Global and national gene bank status, strategies to revival and rescue rare genetic material, National action plan for agrobiodiversity, formal and informal seed systems, On-farm conservation

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. DNA fingerprinting, NGS tools, GWAS, bio-informatic tools to analyze molecular data.

Unit 9: Plant Quarantine Principles, objectives and relevance of plant quarantine; Regulations and plant quarantine set up in India; 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. Statistical designs and analysis, evaluation for specific traits like biotic and abiotic stress tolerance, nutritional traits, high throughput phenotyping, reference collection, genetic enhancement.

05. Genetics & Plant Breeding

Unit 1: General Genetics and Plant Breeding

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. Replication, Transcription and Translation. Gene regulation in prokaryotes and eukaryotes. Nuclear and cytoplasmic genome organization. Spontaneous and induced mutations and their molecular mechanisms. Crop domestication, evolution of crops and centres of diversity. Emergence of scientific plant breeding. Objectives and accomplishments in plant breeding and the role of National and International institutes. Gametogenesis and fertilization. Modes of sexual and asexual reproduction and its relationto plant breeding methodology. Apomixes, incompatibility and male sterility systems and their use in plant breeding.

Unit 2: Economic Botany and Plant Breeding Methods

Origin, distribution, classification, description and botany of cereals (wheat, rice, maize, sorghum, pearl millet, minor millets); pulses (pigeon-pea, chickpea, black gram, green gram, cowpea, soyabean, pea, lentil, horse gram, lab-lab, rice bean, winged bean, lathyrus,Lima bean; oilseeds (groundnut, sesamum, castor, rapeseed mustard, sunflower, Niger, linseed); fibers and sugar crops, fodder and green manures; Breeding methods for self- pollinated, cross-pollinated and clonally propagated crops. Component, recombinational and transgressive breeding. Single seed descent. Populations, their improvement methods and maintenance, Hybrid breeding and genetic basis of heterosis. Ideotype breeding.Mutation breeding.

Unit 3: 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. Wide hybridization and chromosomal manipulations for alien gene transfer. Pre-and post-fertilization barriers in wide hybridization. Genome organization and cytogenetics of important crop species- wheat, maize, rice, Brassica, cotton, Vigna, potato and sugarcane. Principles and procedures of genome analysis. Cytogenetic techniques for gene location and gene transfer, Constructionand use of molecular marker-based chromosome maps. Comparative mapping and genomeanalysis.

Unit 4: Quantitative and Biometrical Genetics

Quantitative characters. Multiple factor inheritance. Genetic control of polygenic characters. Genetic advance and types of selection and correlated response. Hardy Weinberg law. Linkage disequilibrium. Genetic load. Polymorphism. 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. Effects of linkage and epistasis on estimation of genetic parameters. Maternal effects. Genotype-environment interactions and stability of performance. Heterosis and its basis. 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.

Unit 5: Genetic Engineering and Biotechnological Tools in Plant Breeding

Somatic hybridization, micro propagation, soma clonal variation, in vitro mutagenesis.Artificial synthesis of gene. Genetic and molecular markers, generations of molecular markers and their application in genetic analyses and breeding. Molecular markers ingenetic diversity analysis and breeding for complex characters. Gene tagging, QTL mapping and marker aided selection. Genome projects and utilization of sequence formation. Vectors, DNA libraries, DNA fingerprinting, DNA sequencing. Nuclei acid hybridization and immunochemical detection. Chromosome walking, Recombinant DNA technology, Gene cloning strategies. Genetic transformation and transgenics. Antisense RNA, RNAi and micro-RNA techniques in crop improvement.

Unit 6: 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. Role of molecular markers in stress resistance breeding: MAS, MARS and MABB.

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, un-replicated evaluation. Data collection and interpretation.

06. 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 parasiticnematodes 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 andsystematics. Molecular taxonomy. 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 techniques for nematode diagnosis. 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 ofnematode 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 dueto infection including formation of feeding cells such as syncytia and giant cells.

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, nematode genomics and transcriptomics 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, mycorrhizae 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 tests. Experimental designs - randomized block, Latin square and split plot designs, their analysis and interpretation.

07. PLANT BIOCHEMISTRY

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 functions of carbohydrates, proteins, lipidsand nucleic acids. Biochemistry and significance of secondary metabolites. Components of immune system, Prostaglandins.

Unit 2: Intermediary Metabolism

Anabolism, catabolism and their regulation. Metabolic flux, Metabolism of carbohydrates - glycolytic 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 triglycerides, sterols and phospholipids. Amino acid metabolism- catabolism of amino acids, transamination and deamination, urea cycle, biosynthesis of amino acids. Conversion ofamino 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, aminoacid metabolism. Inborn errors of metabolism.

Unit 3: Enzymes, Vitamins and Hormones

Classification 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. lsoenzymes and immobilized enzymes, Biosensors, Pseudoenzymes, Enzyme Promiscuity, Abzymes. 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 engineering. Role of enzymes in agriculture, industry, and medicine. Structure, modeof action and metabolic functions of vita mins. Deficiency diseases associated with vitamins. General description of natural 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 Salicylic acid, Brassinosteroids and Strigolactones.

Unit 4: Molecular Biology

Structure of DNA and RNA, Replication, transcription and translation. Posttranscriptional 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 eukaryotes. Chloroplast and Mitochondrial genomes. Replication of viruses. Mutagens, oncogenes and carcinogenesis. General principles of recombinant DNA technology, restriction enzymes., DNA and protein sequence analysis, oligonucleotide synthesis, genomic and cDNA library construction, transposon tagging, chromosome walking. Basics of genome organization and mapping, functional genomics. 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, Spectroscopic techniques- X-ray, UV, Visible, NIR, IR, Raman. Fluorimetry, turbidometry and atomic absorption spectrophotometry, ICP (AES, OES, MS). MALDI-TOF, NMR. Radioisotopic techniques- scintillation' counters and autoradiography and their application in biological sciences Electrophoresis -general principles and applications, gel electrophoresis, isoelectric focusing, pulsed field gel electrophoresis, immune-electrophoresis. Chromatographic techniques -paper, thin layer, column chromatography, GC and HPLC. Centrifugation - principles of sedimentation, 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. DNA and Protein Microarray. Preliminary methodsof 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. Recommended dietary allowances. Physicochemical, functional and nutritional characteristics of carbohydrates, proteins and fats. Nutritional quality of proteins and its evaluation. Dietary fibers. Minerals-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. Polyphenolics, Antioxidants, nutraceuticals, Anti-nutritional factors. Food toxins and anti-metabolites, Food sensitivity, food additives. Seed storage proteins in cereal grains and legumes. Prebiotics and probiotics. Factors affecting bioavailability of nutrients. Food Sensitivity, Nutraceuticals, Glycemic index, Functional foods

Unit 7: Photosynthesis

Photosynthesis, photosynthetic pigments, light reactions, photosystems. Photophosphorylation, dark reactions: C3, C4 and CAM pathways. Regulation of Rubisco. Chemiosmotic coupling. Carbon cycle and its regulation, Ion fluxes and conformational changes during photosynthesis. Photorespiration. Relationship between photosynthesis, photorespiration and crop productivity. Chloroplast 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. Chemoautotrophy in rhizobia and nitrifying bacteria. Cell cycle. Growth regulation in plants. Signal transduction and phytohormones. Biochemical mechanisms of plant growth, hormone action, biotic and abioticstresses. Role of oligosaccharides and polysaccharides in cellular metabolism. Metabolism of cyanogenic glycosides and glucosinolates. Biochemistry of seed germination.

Unit 9: Plant Molecular Biology

General organization of nuclear, mitochondrial and chloroplast genomes. Genomics andfunctional genomics, Epigenetics and Epigenomics. 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. High-Throughput Sequencing (HTS) techniques, Small RNAs, RNA interference, Molecularmarkers 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 vector mediated. Gene silencing. Site directed mutagenesis, Gene editing. 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, nutritional quality improvement, increasing shelf-life, oil quality. Biosafety andIPR issues.

08. 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 chromosomalelements: plasmid borne genes and their expression: *aur, her, uie* and *pat* genes. Bacteriophages: lytic and lysogenic cycles. Prokaryotic inhibitors and their mode of action. Economic uses of prokaryotes. Morphology, biochemical characteristics, reproduction andlife 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. Behavior 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 hypothesis; 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 bioassay 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.

09. 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: Properties and function of water in cell; Soil and plant water relation: Concept of water potential, Plant and soil water potential and their components, SPAC, method to determine soil and plant water status; Mechanism of water uptake by roots, transport in roots and other tissues; Transpiration: Stomatal and non-stomatal water loss from plants, evaporation and transpiration, energy balance, plant and environmental factors affecting transpiration; Stomata: structure and function, Mechanism of stomatal movement, regulation of stomatal opening and closing by endogenous and environmental cues, antitranspirants. Water use efficiency (WUE): physiological basis, methods of measurement, improvement in WUE. 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: Chloroplast- Structure and function; light reaction-cyclic, non-cyclic, psuedocyclic: Rubisco structure and regulations CO_2 diffusion mechanism; Photochemical processes- C_3, C_4 and CAM photosynthesis, Regulation of photosynthetic enzymes, Ecological aspects of C_4 and CAM; Photorespiration- significance and approaches to minimize it in C_3 plants; Sucrose, starch and polysaccharide metabolism; Phloem loading and transport of sugars; Source-sink relationship; Carbon isotope discrimination; Respiration: Mitochondria structure and function; Electron transport and ATP synthesis; Glycolysis, Krebs cycle, anaerobic respiration; Growth Respiration, Maintenance respiration, Apparent Respiration, Cyanide resistant respiration and its significance; Lipid metabolism: storage, structural and protective lipids; Secondary metabolites and their significance in the plant.

Unit 3: Crop Productivity and Modelling

Physiology of major cereals, pulses and oilseed crops. Role of crop physiology in agriculture;Growth models describing yield (Duncan/Passioura); Crop growth Analysis: LAI, NAR,CGR, LAD, RGR, SLA, SPW, HI; Canopy photosynthesis - leaf area and net assimilation rates as determining factors; Light interception, light extinction coefficient and canopy architecture; Light interception as a major function of leaf area-index; Biomass and yield relations; Assimilate partitioning; yield and yield structure analysis; Concept of source and sink; factors influencing source and sink size and productivity; Concept of optimum LAI. Environmental factors determining crop growth: Light, temperature and VPD, effect of photoperiod and thermos-period on duration of growth stages; Ideotype concept: selection- indices for improving crop productivity; Concept of Thermal time, heat unit, GDD in growth and development of crops; Analytical techniques and instrumentation in plant physiology.

Unit 4: Abiotic Stress Responses in Plants

Abiotic stresses affecting plant productivity: Drought, water logging, extreme temperature, salinity, high and low light; Drought: Drought characteristic features, Development of water deficits, energy balance concept, transpiration and it's regulation -stomatal functions/ reponses to VPD. Physiological processes affected by drought; Drought resistancemechanisms: Escape, Dehydration avoidance, Dehydration tolerance; osmotic adjustments and Osmo protectants; Stress proteins-LEA, Dehydrins, etc; stomatal regulation for minimizing water loss; Water use efficiency and Passioura's model; Physiological and molecular mechanism to improve WUE; high and low temperature: physiological effect on plant, role of lipid membrane in tolerance of extreme temperature, HSPs and their function: high and low light stress: photo oxidation, photo inhibition, mechanism of tolerance, shade avoidance response; Salinity: effect on cellular and whole plant level, tolerance mechanism, SOS pathway; Heavy metal stress: Aluminum and Cadmium toxicity effect on plant and their tolerance mechanism, phytochelatins; Stress and hormones: ABA as signaling molecule, cytokinin as negative signal; Oxidative stress: ROS role and tolerance mechanism.

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; Classification, site of synthesis, biosynthetic pathways and metabolism and influence on plant growth and development by auxins, gibberellins, cytokinins, abscisic acid and ethylene; Hormone signal perception, transduction-

Receptor components, signal transduction and mechanism of action of Auxin, Gibberellins, Cytokinin, ABS and ethylene: Action of hormones on cellular functions: Auxins-cell elongation, retardation of abscission of plant parts; gibberellins-stem elongation, germination of dormant seeds; cytokinin- cell division, retardation of senescence; Abscisic acid-stomatal closure and induction of drought resistance: ethylene-fruit ripening, acceleration of senescence of leaves; Hormone mutants; Interaction of hormones in theregulation of plant growth and development processes; Physiological and molecular aspects of regulation of growth and differentiation, rooting of cutting, Apical dominance, Flowering; role of hormone in fruit growth and development, Senescence, Abscission, induction and breaking of seed and bud dormancy; improving post-harvest life of fruits Synthetic growth regulators; Practical utility in agriculture and horticulture.

Unit 6: Mineral Nutrition

Importance of mineral nutrition in plant growth; Classification and essentiality criteria; Beneficial elements; factors affecting the nutrient availability; critical nutrient concentration; Mineral nutrient: function, deficiency symptoms/ disorders, toxicity and remedies; General mechanisms: concept of apparent free space and Donnan free space ; Mineral nutrient uptake and transport: membrane transport proteins - active transport, Primary and secondary transport- carriers and pumps; LATs and HATs; Short distance transport-pathway fromexternal 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; Foliar nutrition: Uptake and release of mineral nutrients by foliage; Rhizosphere and root biology in relation to nutrient acquisition, influence of micro-organisms in nutrient acquisition, release and uptake by plant roots; Yield and mineral nutrition concept of nutrient use efficiency; Heavy metal toxicity and concept of phytoremediation; Physiological and molecular mechanism of nutrient use efficiency; Nitrogen metabolism; Inorganic nitrogen species (N2, N03, NH3) and their reduction, protein synthesis;. Sulphate uptake and reduction.

Unit 7: Climate and Climate Change

Climate change: definition, history and evidences: analytical methods to determine long term changes in environment-Tree ring, cellulose, stable carbon isotope discrimination, for hydrological changes; Climate change projections and its impact on crop and ecosystem; The greenhouse gases and global warning; CO2 as an important green-houses gas; Effect of elevated CO_2 on plant growth and development; Methane as a greenhouse gas. Prediction on global warming; Effect of high temperature on plant growth and development; High temperature and CO_2 interaction on plant growth and productivity; chlorofluorocarbon (CFC)-their impact on ozone layer: ozone hole and alteration in UV-B radiation; Technologies for climate change studies (FACE, TGT, OTC etc.) Approaches to improve adaptation to changing environment. 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, peroxyacetyl nitrate and their effect on the 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; Seed germination: 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; Controlprocesses in mobilization of stored reserves- Role of embryonic axes; Gibberellin and α- amylase and other hydrolytic activity; Seed maturation phase and desiccation damage- role ofLEA proteins; Seed viability; Seed dormancy; Means to overcome seed dormancy; Interaction of Gibberellin and ABA in regulation of seed germination and dormancy

Unit 9: Physiology of Flowering and Reproduction

Evolutionary history of flowering plants (angiosperms); Semelparous and iteroparous reproduction; monocarpic and perennial life; Flowering phenomenon; juvenility to flowering transition; Photoperiodic responses and the mechanisms in short and long day plants; Photoperiodism and its importance; Theories related to flowering; Gene expression and control of flowering; Thermoperiodism and its importance; Mechanism of vernalization; Photomorphogenesis, photoreceptors: phytochrome, cryptochrome, phototropins; Circadian rhythms: features and mechanism; 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 oftree species. Water uptake and transport; Sexual and asexual propagation; Rootstock andscion interactions; Physiology of flowering in perennial species, photoperiodism and thermoperiodism; Physiological aspects of fruit crops: mango, banana, grapes, citrus, papaya and pineapple; Physiological aspects of plantation crops: tea, coffee, cardamom, coconut, andblack pepper.

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 and harvestable maturity; 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; The molecular approach in the regulation of fruit ripening; Transgenic technology for improvement of shelf-life; Edible vaccine; Programmed cell death (PCD).

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, phytochromes, different forms, physiological effects and gene regulation; cellular totipotency; physiologyand biochemistry of differentiation, in organ cell, tissue and cultures; micropropagationstrategies; 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 Genetic engineering and genome editing for trait improvement: Introductionto GMOs and its application in crop improvement, Agrobacterium and other methods of plant transformation; Genome editing techniques: CRISPR/Cas9, Zinc finger nucleases, TALENs, etc.

Unit 13: Phenome-Genome relationships

Next generation Phenotyping: Genome-phenome relationship, definition of phenotyping, GxE interaction on phenome; Phenotyping bottleneck in establishing Phenotype-genotype relationships; The concepts of "phene and trait. Concepts of Plants to sensors and sensors to plants.

10. SEED SCIENCE & 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 development and maturation - synthesis and deposition of storage reserves- longevity in orthodox and recalcitrant seed. Chemical composition of seed. Seed dormancy - types, causes, mechanismsand means of induction and release factors affecting dormancy. 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. Geneticpurity 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 small millets, maize; pulses viz. chickpea, pigeon pea, green gram, black gram, soybean and cowpea; oil seeds 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 andpepper. 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; seed production and clonal propagation of annual and perennial flowers like rose, gladiolus, chrysanthemum, marigold, dahlia, phlox and petunia. Clonal standards and degenerations. Seed production practices and seed quality maintenance in forest and tree seeds, and in medicinal plants. Micro propagation and seed productionunder protected cultivation.

Unit 3: Seed Processing

Principles of seed processing. Seed drying principles and methods. Types of seed driers. 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, spiral separator, needle separator and magnetic separator, seed treater, weighing and bagging machines, their operation and maintenance. Seed quality maintenance during processing. Latest Developments in Seed Industry in Seed 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 (lSTA), its role in development of seedtesting procedures, rules and seed quality assurance for international seed trade. OECD - EXIM policy. Latest Developments in Seed Industry in Seed quality control

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. Modified atmospheric storage. Germplasm storage. Cryo-preservation. Design features of short, medium and long-term seed storage buildings. Operation and management of seed stores. Latest Developments in Seed Industry in Seed Storage Technology.

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, fiber 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. Various Seed health diagnostic kits and their development.

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. Best practices in Seed Industry in seed trade and marketing. Importance of branding, trademarks, agreements, trade secrecy, MoUs, Patents and IPRs in seed industry. Responsibilities of seed companies and dealers in Seed Act. Seed import and export. OECD and other international platforms enabling global seed trade. Principles and practices ofpublic private partnership in R&D and in business– Best global practices. Licensing and commercialization of varieties, Technologies and mechanisms for public- private partnershipsin R&D, seed trade and business - in ICAR and National Agricultural Research System in Agricultural universities.

Unit 8: Protection of Plant Varieties and Biodiversity Conservation

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 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. Plant variety protection systems in various countries.

Harmonization of global PVP laws vis-s-vis Indian PVP law and possible mechanisms to realize the same. Biodiversity Act of India and its provisions and its impact on biodiversityconservation, R&D, germplasm exchange, patenting, licensing in relation to Indian and Multinational companies.

11. FLORICULTURE & LANDSCAPING

UNIT 1: Systematics of Ornamental Plants

Nomenclature: History, origin, plant diversity hotspots, plant classification and nomenclature systems, phylocode, International systems: International Code, Treaties, International and National Organizations, Biodiversity Act, Plant identification features, keys and methods; plant descriptors. Red Data Book, Registration authorties (NBPGR, PPVFRA, NBA) Families: Description of families, *viz.*, Rosaceae, Asteraceae, Caryophyllaceae, Orchidaceae, Aracaceae, Liliacae, Acanthaceae, Palmaceae, Asparagaceae, Malvaceae, Musaceae, Oleaceae, Iridaceae and important genera. Cryopreservation, Role of Molecular Techniques in Modern plant Systematics.

UNIT 2. Breeding of Ornamental Crops

Principles of plant breeding, Evolution, origin, distribution and conservation of ornamental genetic resources, Genetic divergence and varietal wealth, Patents, Intellectual Property Rights (IPR) and Plant Breeders Rights (PBR): Introduction and initiatives in IPR and PBR of ornamental crops and Plant Variety Protection in India. Genetic mechanism and inheritance of flower colour, doubleness, flower size, fragrance, plant architecture, post- harvest life; abiotic and biotic stress tolerance/ resistance. Breeding methods suitable for sexually and asexually propagated, self and cross-pollinated flower crops and ornamental plants-Introduction, selection, domestication, hybridization, pedigree selection, backcross method, clonal selection, heterosis &F1 hybrids, polyploidy and mutation breeding for varietal development. Role of biotechnology in improvement of flower crops including transgenics, somaclonal variation, *in-vitro* mutagenesis, *in-vitro* selection, genetic engineering, molecular markers, *etc.* Role of heterosis, production of hybrids, reproductive barriers-Male sterility, Incompatibility, Breeding objectives, constraints and achievements made in commercial flower crops - rose, jasmine, chrysanthemum, marigold, gaillardia, tuberose, crossandra, carnation, dahlia, gerbera, gladiolus, orchids, anthurium, aster, liliumhibiscus, bougainvillea, nerium, flowering annuals (petunia, zinnia, dianthus, snapdragon, pansy, stock, calendula, balsam, annual dahlia)

UNIT 3. Commercial Production of Cut Flowers

National and International Scenario of cut flower production, Scope and importance of cut flower trade, Cut flower production problems in India (constraints); patent rights, Nursery management-media for nursery raising, special nursery practices; Growing environment- open field and protected cultivation, Soil analysis, soil health card, soil/media requirements, land preparation, planting methods, influence of environmental parameters (light, temperature, moisture, humidity and CO2), microclimate management for growth and flowering; Commercial cut flower production - Commercial varieties, water integrated nutrient management (INM), fertigation, weed management, crop specific practices - ratooning, training and pruning, pinching, deshooting, bending, desuckering disbudding, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes; Flower Regulation-Flower forcing and year round/ off-season flowering through physiological, chemical interventions, and environmental manipulation; Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, methods of delaying flower opening, pre-cooling, pulsing, packing, storage & transportation, marketing, export potential of cut flower crops, institutional support, Agri Export Zones; 100% Export Oriented units in India, Crop Insurance, flower auction centre. Flower crops: Rose, chrysanthemum, carnation, gerbera, gladiolus, tuberose, orchids, anthurium, chinaaster, lilium, bird of paradise, heliconia, alstroemeria, dahlia, gypsophilla, solidago, limonium, stock, cut green foliages and fillers.

UNIT 4. Commercial Production of Loose Flowers

Scope, scenario and importance of loose flower crops, constraints and opportunities in loose flower production. Growing Environment-nursery management, pro-tray nursery under shadenets, Soil and climate requirements, field preparation, systems of planting, precision farming techniques; Soil analysis, soil health card, Water management, weed management, special horticultural practices such as ratooning, training and pruning, pinching and disbudding, etcrole of growth regulators in growth and flowering, physiological disorders and remedies, INM, IPM and IDM. Crop regulation-Flower forcing and year round/ off-season flowering, production for special occasions, through physiological interventions, chemical regulation; Post harvest management-Harvest indices, harvesting techniques, post-harvest handling and grading, packing and storage, transportation and marketing including important Indian flower markets, export potential, HPMC, APMC and online flower trading, institutional support, Crop Insurance. Flower crops -Jasmine, rose, chrysanthemum, marigold, aster, gaillardia, tuberose, crossandra, Nerium, hibiscus, barleria, celosia, gomphrena, non-traditional flowers- Nyctanthes(Har singar), Tabernaemontana, ixora, lotus, water lily, tecoma, michelia (champaka), spider lily, water lily, gardenia, and balsam.

UNIT 5. Ornamental Gardening and Landscaping

Gardens and components: Historical background of gardening, Importance and scope of ornamental gardening, Styles and types of ornamental gardens, formal, informal and free style gardens, types of gardens-English, Mughal, Japanese, Persian, Spanish, Italian. French, Hindu, Buddhist garden. Garden components:living components), arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, trees, shrubs, cacti and succulents, herbs, annuals/seasonals, ornamental grasses, flower borders and beds, ground covers, carpet beds, bamboo groves, bonsai, etc.Production technology for selected ornamental plants; Non-living components-Path, garden gate, fencing, paving and garden features like fountains, garden seating, swings, lanterns, basins, bird baths, sculptures, waterfalls, bridge, steps, ramps, lawn. Specialized gardens: vertical garden, roof garden, terrace garden, water garden, shade garden, , bog garden, sunken garden, rock garden, clock garden, color wheels, temple garden, sacred gardens (emphasis on native plants), Zen garden ; Landscape Planning-Principles and elements of landscaping: Basic drawing skills, use of drawing instruments, garden symbols, steps in preparation of garden design, programmes phase, design phase, *etc.* . Organization of spaces, visual aspects of plan arrangement- view, vista and axis. Principles of circulation, site analysis and landscape, Water requirement, use of recycled water in landscaping. Landscape for different situations: Urban landscaping, landscaping of institutions, industries, residential areas, hospitals, roadsides, traffic islands, dam sites, IT/ SEZ parks, corporates, farm houses, children parks, public parks airports, railway station and tracks, and river banks.Bio-aesthetic planning, eco-tourism, theme parks, therapeutic gardening, xeriscaping, waterscaping

UNIT 6. Protected Cultivation of Flower Crops

Prospects of protected floriculture in India; Types of protected structures –Greenhouses/ polyhouses, shade houses, mist chambers, lath houses, orchidarium, fernery, rain shelters *etc.*, Principles of designing and erection of protected structures. Low cost/medium cost/high cost structures; Location specific designs; Structural components; Suitable flower crops and foliage plants for protected cultivation; Environment control - Microclimate management and manipulation of temperature, light, humidity, air and CO_2; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation; water harvesting, Intercultural Operations and Crop Regulation: Containers and substrates, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, lPM and IDM; Crop regulation by chemical methods, special horticultural practices (pinching, disbudding, deshooting, deblossoming, *etc.* staking and netting, Photoperiod regulation; Automation and standards: Automation in greenhouses, sensors, solar greenhouses and retractable greenhouses, GAP/ Flower labels, Export standards, EXIM policy, APEDA regulations for export, non-tariff barriers. Flower crops: Rose, Chrysanthemum, Carnation, Gerbera, Orchids, Anthuriums, Lilium, Limonium, Lisianthus, Heliconia, Cala lily, Alstromeria, *etc.*

UNIT 7. Value Addition in Floriculture

National and global scenario, scope and prospects of value addition, production and exports, Types of value-added products, techniques of value addition including tinting, pulsing., Value addition in loose flowers and product development such as *gulkand*, floral tea, rose oil, rose water, *Pankhuri*, floral dyes, rose sherbet, floral ice creams, sweets, garlands, veni, floats, floral decorations, etc., value addition in cut flowers such as fresh floral arrangement: Selection of containers and accessories, Flower arrangement styles, Ikebana schools (Ikenobo, Ohara, Sogetsu, etc.), Moribana, Nagiere, contemporary style /free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, etc.; Selection of containers and accessories for floral products and decorations; Dry flowers- identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; tips for collecting dry flower making, selection of stages for picking of flowers for drying, Techniques in dry f1ower making -Drying, glycerising, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement -dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; petal embedded handmade papers, Packing and storage; Post drying management including moisture, pests and moulds in value-added dried products. Concrete and essential oils- Selection of species and varieties (including non-conventional species), extraction methods, packing and storage. Aromatherapy. Types of pigments-carotenoids, anthocyanin, chlorophyll, betalains; Significance of natural pigments as nutraceuticals and pharmaceuticals; Extraction methods; Applications in food, cosmetics, pharmaceutical and poultry industries. Dying: Synthetic and Natural dyes, dying techniques, color retention.

Unit 8. Turf grass Management

History, present status and prospects of turf industry; site selection, basic requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment; criteria for evaluation of turf quality. Turf grasses -Types, species, varieties, hybrids; identification of turf grasses, selection of turf grasses for different locations; Grouping according to climatic requirement, adaptation, ; Turfing for roof gardens; Preparatory operations; Growing media used for turf grasses, turf establishment methods- seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding, instant turfing (portable), astro-turfing, synthetic turfing; Turf management -Irrigation, drainage, nutrition, special practices such as aerating, rolling, coreaerification, dethatching, verticutting, soil top dressing, etc. Use of turf growth regulators (TGRs) and micronutrients. Turf mowing -mowing equipment, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs; standards for turf, use of recycled water for turf establishment and maintenance. Selection and maintenance of turf grasses for playgrounds, residential and public parks, turfing of Govt. and Corporate office gardens, event specific preparation, turf colourants.

UNIT 9: Indoor Plants and Interiorscaping

Importance and scope: Importance and scope of indoor plants and interiorscaping, Indoor plants and indoor air quality. Factors affecting growth, development and flowering of indoor plants. Classification and principles: Classification of indoor plants based on light, temperature, humidity and pollution tolerance. Description and cultivation of various indoor plants. Principles of interior-scaping, Role in pollution mitigation. Cultural operations: Containers and substrates, preparation of growing media, propagation, training, grooming, nutrition, management of disease, pests and weeds. Maintenance of plants including repotting, foliar nutrition, light exposure and plant rotation. Media standards, Nursery and Export standards for potted plants. Special gardens including miniature gardens and plant stand. Presentations like dish garden, terrarium, bottle gardens, hanging baskets, window boxes and bonsai. Vertical gardens- history, planting material, structures, containers, substrate, water and nutrient management, supplemental lighting. Marketing channels, Business models including plant rentals.

UNIT 10: Seed Production in Flower Crops

International and national scenario of flower seed production, scope, and importance of seed production in flower crops. Constraints in flower seed production. Methods of seed production, agro-techniques for production of nucleus, breeder and certified seeds. Harvesting, seed processing, seed priming, seed chain, packaging and storage; Mass selection, progeny selection, use of incompatibility and male sterility, maintenance of variety and seed production in flower crops; F1 hybrid seed production advantages, steps involved in hybrid seed production, pollination behaviour and isolation, pollination management methods in production of F1/ hybrids in different flower crops; Seed certification, Seed standards, seed act, plant breeders rights and farmers' rights, Bio safety, handling of transgenic seed crops, importing of seeds and OGL, trade barriers in seed business, sanitary and phytosanitary issues, custom clearance and quarantine. Marketing and economics of flower seeds; Flower crops: Marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum, poppy, corn flower, rice flower, aster, annual dahlia, crossandra and gaillardia.

Unit 11. Computer Aided Design (CAD) for Landscaping

Principles of integrating the architecture and landscaping, Exposure to CAD (Computer Aided Design) -Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHlCAD, 3D drawing by 3D MAX software. Creating legends for plant and non-plant components. Basics of Photoshop software in garden designing; 2D drawing methods AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects; Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking Script making, Using productivity tools, e- transmit file, Making layout; 3D drawing methods, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHlCAD; ARCHICAD organization tools, Dimensioning and detailing of designs, Landscape designing softwares and CD ROM for ornamental plant material (TRES, HIMFLORA, CAPSSA, *etc),* Attribute settings of components, Visualization tools for landscape preview, Inserting picture using Photoshop.

12. FRUIT SCIENCE

Unit 1. Tropical Fruit Production

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, rootstocks, stionic influence, planting systems, cropping systems, root zone and canopy management, nutrient and water management, fertigation, role of bioregulators, abiotic factors limiting fruit production, physiology of flowering, pollination, fruit set and development, honeybees/pollinators in cross pollination, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques, processing and value addition, industrial and export potential, Agri Export Zones (AEZ) and industrial supports, Canopy management through plant growth inhibitors, training and pruning and management practices in relation to growth, flowering, fruiting and fruit quality, insect and disease management, Integrated Nutrient Management (INM), bio- fertilizers and fertigation in tropical fruit crops, organic fruit production, pre-harvest and post-harvest factors affecting shelf-life of fruits. Crops: mango, banana, citrus, papaya, guava, sapota, jackfruit, pineapple, *Annona*, avocado, *aonla,* pomegranate and *ber*.

Unit 2. Subtropical and Temperate Fruit Production

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, rootstocks, stionic influences, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, bioregulation, abiotic factors limiting fruit production, physiology of flowering, pollinizers, pollinators, fruit set and development, abiotic factors limiting production, physiological disorders- causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, precooling, storage, transportation and ripening techniques; processing and value addition, industrial and export potential, Agri Export Zones (AEZs) and industrial support, Canopy management through plant growth inhibitors, training and pruning and management practices in relation to growth, flowering, fruiting and fruit quality, insect and disease management, pre harvest and post-harvest factors affecting shelf life. Crops: apple, pear, quince, grapes, plums, peach, apricot, cherries, litchi, loquat, persimmon, kiwifruit. strawberry, nuts (walnut, almond, pecan).

Unit 3. Breeding of Fruit Crops

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems – spontaneous mutations, polyploidy, incompatibility, sterility, parthenocarpy, apomixis, breeding objectives, ideotypes, approaches for crop improvement — introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, breeding for biotic and abiotic stresses, biotechnological interventionsand achievements. Intellectual Property Rights (IPR) and Plant Breeders Rights (PBR): Introduction and initiatives in fruit crops.

Crops: mango, banana, pineapple, citrus, grapes, guava, sapota, jackfruit, papaya, custard apple, *aonla*, avocado, *ber*, mangosteen, litchi, jamun, phalsa, mulberry, raspberry, *kokam,* apple, pear, plums, peach, apricot, cherries, strawberry and nuts, pomegranate and kiwi fruit.

Unit 4. Growth and Development of Fruit Crops

Growth and development- definition, parameters of growth and development, growth dynamics, morphogenesis; annual, semi-perennial and perennial horticultural crops, environmental impact on growth and development, effect of light, photosynthesis and photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism; Assimilate partitioning during growth and development, influence of water and mineral nutrition during growth and development, biosynthesis of auxins, gibberellins, cytokinins, abscisic acid, ethylene, brasssinosteroids, morphactins, role of plant growth promoters and inhibitors; Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization, fruit set, fruit drop, fruit growth, ripening and seed development; Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth development, global warming, effect of climate change on spatio-temporal patterns of temperature and rainfall, concentrations of greenhouse gasses in atmosphere. Climate mitigation measures through crop management- use of tolerant rootstocks and varieties, mulching, use of plastic, windbreak, spectral changes, protection from frost and heat waves. Climate management in greenhouse: heating vents, CO_2 injection, screens and artificial light. Impact of climate changes on invasive insects, diseases, weeds, fruit yield, quality and sustainability.

Unit 5. Biotechnology of Fruit Crops

Harnessing biotechnology in horticultural crops; introduction and significance, history and basic principles, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture; callus culture - types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis; use of bioreactors and *in-vitro* methods - for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues, acclimatization of tissue culture plants; Physiology of hardening - hardening and field transfer, organ culture - meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture and fusion; Somatic cell hybridization- construction and identification of somatic hybrids and cybrids, wide hybridization, *invitro* pollination and fertilization, haploids, *in- vitro* mutation, artificial seeds, cryopreservation, rapid clonal propagation, genetic engineering- principles and methods, and transformation in horticulture crops, use of molecular markers and genomics. Gene silencing, gene tagging, gene editing in fruit crops. *In-vitro* selection for biotic and abiotic stress, achievements of biotechnology in horticultural crops.

Unit 6. Propagation and Nursery Management in Fruit Crops

General concepts and phenomena: Introduction, understanding cellular basis for propagation, sexual and asexual propagation, apomixis, polyembryony, chimeras. Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seed germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing. Conventional asexual propagation: Cutting– methods, rooting of soft, semi-hard and hardwood cuttings under mist and hotbeds. Use of PGR in propagation, physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods. Budding and grafting – principles and methods, graft union formation, establishment and management of scion/bud wood bank. Stock, scion and inter stock relationship– graft incompatibility, physiology of rootstock and top working. Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques – *in-vitro* clonal propagation, direct organogenesis, embryogenesis, micro-grafting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules. Management Practices and Regulation, Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, nursery accreditation, import and export of seeds and planting material, quarantine, role of Post-Entry Quarantine (PEQ), and Clean Plant Programme (CPP).

Unit 7. Systematics of Fruit Crops

Nomenclature and classification: Biosystematics – introduction and significance; history of nomenclature of cultivated plants, classification and nomenclature systems; International code of nomenclature for cultivated plants. Identification and description: methods of identification and description of cultivated fruit and nut species and their wild relative; development of plant keys for systematic identification and classification. Development of fruit crop descriptors- based upon Biodiversity International Descriptors and UPOV/ DUS test guidelines, botanical and pomological description of major cultivars and rootstocks of tropical, subtropical and temperate fruits and nut crops. Registration and modern systematics: GI and Farmers variety Registration, Use of chemotaxonomy, biochemical and molecular markers in modern systematics.

Unit 8. Export Oriented Fruit Production

Statistics and World Trade: National and international fruit export and import scenario and trends; statistics and India's position and potentiality in world trade; export promotion zones in India. Government policies, norms and standards: Scope, produce specifications, quality and safety standards for export of fruits, *viz.*, mango, banana, grape, litchi, pomegranate, walnut, apple and other important fruits. Processed and value-added products, post-harvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; FPO license, role of APEDA, FSSAI, BIS, WTO and its implications, sanitary and phyto-sanitary measures, MRLs. Infrastructure and plant material; quality fruit production under protected environment; different types of structures – automated greenhouses, glasshouse, shade net, poly tunnels – design and development of low-cost greenhouse structures. Seed and planting material; meeting export standards, implications of plant variety protection – patent regimes.

Unit 9. Minor Fruit Production

Occurrence, Adoption and General Account: Importance – occurrence and distribution, climate adaptation in fragile ecosystem and wastelands. Propagation and cultural practices: traditional cultural practices and recent development in agro-techniques; propagation, botany-floral biology, growth patterns, mode of pollination, fruit set, ripening, fruit quality. Post-harvest management, marketing; minor fruit crops in terms of nutritional and pharmaceutical values; their uses for edible purpose and in processing industry

Crops: *Bael*, *chironji*, fig, passion fruit, *jamun*, *phalsa*, *karonda*, wood apple, cactus pear, *khejri, kair, pilu, lasoda*, loquat, tamarind, dragon fruit, monkey jack, *mahua, khirni*, *amra*, *kokum*, cape gooseberry, *kaphal*, persimmon, pistachio, sea buckthorn, hazel nut and other minor fruits of regional importance.

Unit 10. Post-Harvest Management of Fruit Crops

Post-harvest management scenario of India and world, fruit maturity indices, harvesting practices in tropical, sub-tropical and temperate fruits, influence of pre-harvest practices, Climacteric and non-climacteric fruits, enzymatic and textural changes, respiration, transpiration during fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest losses, pre-cooling; Treatments prior to shipment, viz., pre-cooling, chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage-ventilated, refrigerated, MAS, CA storage, physical injuries and post-harvest and storage disorders; fruit ripening chambers, Packing methods and transport, principles and methods of preservation, Principles of food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies; Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology of value-added products, processing waste management, food safety standards.

13. SPICES, PLANTATION & MEDICINAL & AROMATIC PLANTS

Unit 1. Production of Plantation Crops

Role of plantation crops in national economy, export potential, role of commodity boards and developmental activities, IPR issues, clean development mechanism, classification, wild species, varietal wealth, DUS and molecular characterization, conservation of biodiversity. Plant multiplication including *in vitro* multiplication, systems of cultivation, multitier cropping, cropping systems, photosynthetic efficiencies of crops at different tiers, rainfall, humidity, temperature, light and soil pH on crop growth and productivity, high density planting, nutritional requirements, physiological disorders, role of growth regulators and macro and micro nutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management, organic production methods, training and pruning, crop regulation, growth and development, developmental physiology, plant protection, maturity indices, harvesting, mechanized harvesting, post-harvest handling, primary processing, processing and value addition. Cost benefit analysis, organic farming, management of drought and precision farming. Crops: Coffee, tea, cashew, cocoa, rubber, palmyrah, oil palm, coconut, areca nut and betel vine.

Unit 2. Production Technology of Spice Crops

Introduction, importance of spice crops-historical accent, present status - national and international, future prospects, role of spices board and other development agencies, IPR issues, classification of spices – major minor, tree, seed, herbal spices, botany and taxonomy, wild species, DUS and molecular characterization, conservation of biodiversity, climatic and soil requirements, commercial varieties/hybrids, site selection, layout, propagation and nursery management, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, organic production methods, mulching, growth and development, developmental physiology, physiological disorders, maturity indices, harvesting, mechanized harvesting, post-harvest management, primary processing, processing and value addition, different kinds of packing material, containers, equipment, labeling, packing and storage of the processed produce, plant protection measures and seed planting material and micro propagation, precision farming, organic resource management, organic certification, quality control, pharmaceutical significance and protected cultivation of: Black pepper, small and large cardamom, clove, cinnamon, nutmeg, allspice, turmeric, ginger, garlic, coriander, fenugreek, cumin, fennel, ajwain, tamarind, garcinia and vanilla.

Unit 3. Production of Medicinal and Aromatic Crops

Importance of medicinal and aromatic plants in human health, area, production, national economy and related industries, problems, prospects and challenges, role of medicinal plants board and NGOs in R&D, IPR issues, Indian system of medicine, medicinal industries, sources of medicinal plants, export and import, taxonomy, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge. Indian perfumery industry, important constituents of medicinal and aromatic crops, physical and chemical properties of aromatic crops. Climate and soil requirements, wild species varietal wealth, DUS and molecular characterization, conservation of biodiversity, propagation through seed, vegetative and micropropagation, nursery techniques and management, site selection, layout, sowing/planting, nutrition and irrigation management, intercropping, mixed cropping, mulching, organic production methods, growth and development, developmental physiology, plant protection, yield, harvest indices, harvesting methods, post harvest handling, primary processing, processing, study of aroma compounds, extraction, grading, packing, storage, value addition and quality standards in herbal products, GAP, GMP certification, Extraction and analysis of active principles using TLC/HPLC/GC of medicinal plants (Senna, periwinkle, medicinal coleus, ashwagandha, glory lilly, Dioscorea sp. Digitalis, medicinal Solanum, Mucuna pruriens, Plumbago zeylanicum, Piper longum, Isabgol, Rauwolfia, Poppy, Aloe vera, Stevia, Safed Musli, Kalmegh,); and aromatic plants (Citronella, Palmarosa, Mentha, Lemongrass, Patchouli, Geranium, vetiver, sweet flag, jasmine, lavender, Artemisia, Ocimum *sp.*, Eucalyptus, sandal wood).

Underexploited crops: *Flacourtia montana, Plectranthus aromaticus, Adhatoda sp, Hemidesmus indicus,Tinospora cordifolia, Gymnema sylvestra,Morinda citrifolia, Bursera sp, Commiphora wightii, Ocimum kilimandjaricum*

Unit 4. Breeding of Plantation Crops and Spices
Species and cultivar diversity, floral and reproductive biology, cytogenetics, male sterility, incompatibility, varieties, survey, collection, conservation and evaluation of germplasm, breeding objectives on the basis of yield, quality, stress tolerance, adaptation, approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploid breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, molecular aided breeding and biotechnological approaches, marker-assisted selection, bio- informatics, breeding for climate resilience, IPR issues, achievements and future thrusts.
Crops: Coffee, tea, cashew, cocoa, rubber, palmyrah palm, oil palm, betel vine, coconut, arecanut, black pepper, cardamom, ginger, turmeric, fenugreek, coriander, fennel, cumin, celery, ajwain, garlic, nutmeg, cinnamon, clove, garcinia, tamarind and allspice.

Unit 5. Breeding of Medicinal and Aromatic Crops
Plant bio-diversity, survey, collection, conservation and evaluation of germplasm, IPR issues, floral and reproductive biology, cytogenetics, male sterility, incompatibility, Breeding problems, genetics of active principles. Major objectives of breeding of Medicinal and Aromatic Crops for yield, quality, stress tolerance, adaptation, herbage yield, essential oils, secondary metabolites, Scope for introduction, cytogenetic background of important Medicinal and Aromatic Crops, Scope for improvement of Medicinal and Aromatic Crops through selection, intra and interspecific hybridization, induced autotetraploidy, mutation breeding and biotechnological approaches; Assay techniques useful in evaluation of breeder's material. Breeding problems in seed and vegetatively propagated medicinal and aromatic crops: Achievements in terms of varieties, parentage, salient features, molecular breeding, biotechnological approaches, marker assisted selection, bioinformatics and prospects in breeding of medicinal crops, *viz. Cassia angustifolia*, *Catharanthus roseus, Gloriosa superba*, *Coleus forskohlii*, *Stevia rebaudiana*, *Withania somnifera*, *Papaver somniferum*, *Plantago ovata,* , *Piper longum, Plumbago zeylanica, Aloe vera, Rauvolia serpentina, Chlorophytum sps.* Geranium, Vettiver, Lemon grass, Palmarosa, Citronella, *Kaempferia galanga*, Patchouli, Lavender, Ocimum *sp.*, Eucalyptus, Artemisia and Mint.

Unit 6. Systematics of Plantation, Spice, Medicinal and Aromatic Crops
Centre of origin, distribution, taxonomical status, phylogeny; botany, cytology, ploidy status, sex forms, flowering and pollination biology and cytogenetics; wild and related species, cultivars, indigenous and exotic germplasm; descriptors, DUS guidelines, molecular aspects of systematics of:
Plantation crops: Coconut, oil palm, cocoa, arecanut, tea, coffee, betel vine, cashew, rubber Spice crops: Black pepper, cardamom, ginger, turmeric, clove cinnamon, nutmeg, vanilla, garlic, coriander, fennel, fenugreek, cumin
Medicinal crops: Opium poppy, isabgol, ashwagandha, senna, medicinal coleus, glory lilly, periwinkle, sarpagandha, long pepper, Stevia, safed musli, *Plumbago zeylanica*
Aromatic crops: Lemon grass, citronella, palmarosa, vetiver, Geranium, patchouli, mint, Ocimum, lavender, rosemary eucalyptus, *Kaempferia galanga.*

Unit 7. Growth and Development of Plantation, Spice, Medicinal and Aromatic Crops Growth, development, assimilate partitioning and plant bio regulators; Growth and development, definitions, components, photosynthetic productivity, different stages of growth, growth curves, growth analysis, morphogenesis; Growth pattern in annual, semi- perennial and perennial crops, growth dimorphism, environmental impact on growth and development: effect of light, temperature, photoperiod; Assimilate partitioning: Assimilate partitioning during growth and development, influence of water and mineral nutrition. Canopy management for conventional and high density planting pruning, training, chemicals, crop regulation for year-round and off-season production; Plant bio regulators: plant bio regulators- auxins, gibberellins, cytokinins, ethylene, inhibitors and retardants, basic functions, biosynthesis and role in crop growth and development; Developmental physiology and biochemistry during dormancy, bud break, juvenility; Physiology of flowering, photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism, pollination, fertilisation, fruit set, fruit drop, fruit growth, ripening, seed development; Growth and development process during stress, production of secondary metabolites, molecular and genetic approaches in growth and development.

Unit 8. Biochemistry of Plantation, Spice, Medicinal and Aromatic Crops

Maturity indices, changes during ripening, processing, factors affecting quality. Secondary metabolites and their biosynthetic pathways, factors affecting production of secondary metabolites; Contaminants: Adulterants, and substitutes, sources of contamination microbial, heavy metal, pesticide residues; Value added products: Fixed oils, essential oils, dyes, oleoresins, aroma chemicals and other value added products, their content, storage, medicinal and pharmacological properties, use in the food, flavour perfumery and pharmaceutical industries; Quality standards of raw materials and finished products; Basic and advanced extraction techniques - Soxhlet, SCFE, Membrane extraction. Chemical characterization- HPTLC, GCMS, LCMS, NMR; Plant tissue cultures in the industrial production of bioactive plant metabolites. Cell suspension culture systems for large scale culturing of plant cells and production of secondary metabolites. Advantages of cell culture over conventional extraction techniques.

14. VEGETABLE SCIENCE

Unit 1. Production of Cool Season Vegetable Crops

Introduction, botany and taxonomy, classification of cool season vegetable crops, scope , importance and problems of cool season vegetable crop production, nutritional composition, cropping systems, precision farming in cool season vegetable crops, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate ,and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, plant protection measures, harvesting, post-harvest management and economics of production of potato; cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts, winter squash (zucchini), carrot, radish, turnip, beetroot, onion, garlic, peas, French bean, broad bean and green leafy vegetables (spinach, palak, fenugreek and coriander).

Unit 2. Production of Warm Season Vegetable Crops

Introduction, scope, importance and problems of warm season vegetable crop production, Classification of warm season vegetable crops, nutritional composition, cropping systems, precision farming in warm season vegetable crops, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and economics of production of tomato, eggplant, hot and sweet peppers, okra, lab beans, cowpea, cluster bean,cucumber, bitter gourd, bottle gourd, ridge gourd, snake gourd, sponge gourd, water melon, musk melon, pumpkin, squashes, tapioca, sweet potato, green leafy vegetables (amaranthus, sorrel, rosella and portulaca) and moringa.

Unit 3. Breeding of Vegetable Crops

History and evolutionary aspects of vegetable breeding, origin, botany, taxonomy, genetic resources, wild relatives, cytogenetics, genetics, breeding objectives, pollination and fertilization mechanisms, techniques of selfing and crossing; Breeding systems; breeding methods for self and cross pollinated vegetables (introduction, selection, pedigree, hybridization, mutation and polyploidy breeding), heterosis breeding- types, mechanisms and basis of heterosis, inbreeding depression, facilitating mechanisms like male sterility, self-incompatibility and sex forms; varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, synthetic breeding, Speed breeding, rootstock breeding, biofortification, parthenocarpy, improvement of asexually propagated vegetable crops,breeding for protected environment; ideotype breeding; doubled haploid technique, gene pyramiding, pre-breeding, molecular marker, genomics, genome editing, marker assisted breeding and QTLs, biotechnology, and their use in breeding, Issue of patenting, PPV& FR Act, varietal release procedure; DUS testing in vegetable crops; potato, tomato, eggplant, hot pepper, sweet pepper, okra, peas and beans, amaranth, chenopods and lettuce, fenugreek, coriander, gourds, melons, pumpkins and squashes, cabbage, cauliflower, brussels sprout, broccoli, carrot, beetroot, radish, onion, sweet potato, taro, yam and tapioca.

Unit 4. Growth and Development of Vegetable Crops

Cellular structures and their functions; definition of growth and development, phases of growth, growth analysis and its importance in vegetable production; Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; role of auxins, gibberellins, cytokinins ethylene, abscisic acid and bassinosteroids; application of synthetic hormones, plant growth retardants and inhibitors for various purposes in vegetable crop, role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production; Role of light, temperature and photoperiod on growth, development of underground parts, flowering and sex expression in vegetable crops including cucurbits; apical dominance; physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; vernalisation, photoperiodism, phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening; plant growth regulators in relation to vegetable production; morphogenesis and tissue culture techniques in vegetable crops. Checking flower and fruit drops and improving fruit set in Solanaceous vegetables.

Unit 5: Seed Production of Vegetable Crops

Introduction; Seed history of vegetable seed production, definition of seed and its quality, modes of propagation in vegetables; Seed morphology, development and maturation in vegetable seeds; Apomixis and fertilization; Modes of propagation and reproductive behavior; Pollination mechanisms and sex forms in vegetables; Deterioration of crop varieties, genetical and agronomic principles of vegetable seed production; Seed village concept. Floral biology; classification of vegetable crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production; Classification based on growth cycle and pollination behavior; methods of seed production, TPS (true potato seed) , comparison between different seed production methods; seed multiplication ratios and replacement rate in vegetables; pollination mechanisms; sex types, ratios and expression and modification of sex and flowering pattern in cucurbits; nursery raising and transplanting stage; Seed production technology of vegetables *viz.,* solanaceous, cucurbitaceous, leguminous, malvaceous, Cole crops, leafy vegetables, root, tuber and bulb crops and seed spices; harvesting/picking stage and seed extraction in fruit vegetables; clonal propagation and multiplication in tuber crops e.g. Potato, sweet potato, Colocasia, tapioca; seed-plot technique in potato tuber seed production; hybrid seed production technology of vegetable crops, and its production technique; hybrids in vegetables; maintenance of parental lines; use of male sterility and self-incompatibility in hybrid seed production, environmental factors related to flowering/bolting in vegetable crops; generation system of seed multiplication; maintenance and production of nucleus, breeder, foundation, certified/ truthful label seeds; seed quality and mechanisms of genetic purity testing. maturity standards; seed harvesting, curing and extraction; seed processing, *viz.,* cleaning, drying and treatment of seeds, seed health and quality enhancement, packaging and marketing; principles of seed storage; orthodox and recalcitrant seeds; field and seed standards, importance and present status of vegetable seed industry and share of vegetable seeds in seed industry; intellectual property rights and its implications, impact of PVP on growth of seed industry.

Unit 6: Systematics of Vegetable Crops

Principles of classification; different methods of classification; salient features of international code of nomenclature of vegetable crops; origin, history, evolution and distribution of vegetable crops, botanical description of families, genera and species covering various vegetables; morphological keys to identify important families, floral biology, floral formula and diagram; morphological description of all parts of vegetables; cytological level of various vegetable crops; descriptive keys for important vegetables; importance of molecular markers in evolution of vegetable crops; molecular markers as an aid in characterization and taxonomy of vegetable crops.

Unit 7: Production of Underutilized Vegetable Crops

Introduction, importance and scope of underutilized vegetable crops, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, nursery techniques *viz.* (sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching), physiological disorders, harvesting, post-harvest management, plant protection measures: Asparagus, artichoke and leek, Chinese cabbage, kale and artichoke, celery, parsley, parsnip, lettuce, rhubarb, bathu/chenopods, chekurmanis, elephant foot yam, lima bean, winged bean, vegetable pigeon pea, jack bean and scarlet runner bean, sword bean, sweet gourd(*Kakrol*), spine gourd (Kartoli), pointed gourd, Oriental pickling melon, little gourd (kundru), Taro, Tannia, and Chinese potato.

Unit 8: Post Harvest Management of Vegetable Crops

Importance and scope of post-harvest management of vegetables; maturity indices and standards for different vegetables; methods of maturity determinations; biochemistry of maturity and ripening, enzymatic and textural changes, ethylene evolution and ethylene management, respiration, transpiration, Harvesting tools, harvesting practices for specific market requirements; post-harvest physiological and biochemical changes, storage disorders - chilling and freezing injury in vegetables, influence of pre- harvest practices and other factors affecting post-harvest losses, packaging house operations, pre-cooling- methods of precooling commodity pretreatments-chemicals, wax coating, prepackaging and irradiation; packaging of vegetables, post-harvest diseases and prevention from infestation, principles of transport; Methods and practices of storage-ventilated, refrigerated, MA & CA storage, hypobaric storage and cold storage, zero energy cool chamber; storage disorders.

Unit 9: Organic Vegetable Production

Importance, principles, perspective, concepts and components of organic farming in vegetable crops. Organic production of vegetable crops *viz.*, Solanaceous, Cucurbitaceous, Cole, root and tuber crops. Managing soil fertility, mulching, raising green manure crops, weed management; crop rotation and crop diversification in organic production; quality control of organic vegetable produce. Indigenous methods of composting, Bioformulations, Panchyagavvya, Biodynamics preparations and their application; ITKs in organic vegetable farming; concentrated organic manures, crop residues, agro industrial wastes; Role of botanicals and bio-control agents in the management of pests and diseases in vegetable crops. Techniques of natural vegetable farming, GAP and GMP-certification of organic products; organic vegetable seed production; processing, export opportunity and challenges in organic vegetable production.

Unit 10: Protected Cultivation of Vegetable Crops

Concept, scope and importance of protected cultivation of vegetable crops; Principles, design, orientation of structure, low and high-cost polyhouses/greenhouse structures. Classification and types of protected structures: greenhouse/polyhouses, plastic-non plastic low tunnels, plastic walk-in tunnels, high roof tunnels with ventilation, insect proof net houses, shade net houses, rain shelters, naturally ventillated polyhouse, climate control greenhouses, vertical farming, hydroponics and aeroponics; soil and soilless media for bed preparation; design and installation of drip irrigation and fertigation system, use of IoT and digital technologies, Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity on growth and yield of different vegetables under protected cultivation. Climate control and automation. High tech vegetable nursery raising; Nursery problems and their management. Regulation of flowering and fruiting in vegetable crops; Technology for raising tomato, sweet pepper, cucumber, cabbage, cauliflower, broccoli and off-season leafy vegetables in protected structures, including varieties and hybrids, training, pruning and staking in growing vegetables under protected structures. Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for seed production; Economics of greenhouse crop production.

Unit 11: Processing of Vegetable Crops

Present status and prospects of vegetable preservation industry in India. Spoilage of fresh and processed vegetable produce; biochemical changes and enzymes associated with spoilage of vegetable produce; Principal spoilage organisms, food poisoning and their control measures; Role of microorganisms in food preservation. Raw material for processing; Primary and minimal processing; processing equipment; Layout and establishment of processing industry; FPO license; Importance of hygiene; Plant sanitation. Quality assurance and quality control, Food standards-FPO, PFA, *etc.*; Food laws and regulations; Food safety- Hazard analysis and critical control points (HACCP), Labeling and labeling act and nutrition labeling. Major value added vegetable products; Dehydration- methods, canning, pickling- spoilage of pickles; Utilization of byproducts of vegetable processing industry; Management of processing industry waste; Investment analysis; Principles and methods of sensory evaluation of fresh and processed vegetables.

15. ANIMAL BIOCHEMISTRY

Unit 1: Scope of Biochemistry in animal sciences

Physical properties of water-the medium of life, Acids and bases, ionic strength and activity, Henderson-Hasselbach equation, pH, indicators and buffers, Colloids and their properties, Structure and functions of bio- membranes with special reference to active transport of ions and metabolites. Mechanism of osmosis, osmotic pressure, Donnan membrane equilibrium, Viscosity, surface tension, surface forces, Adsorption and light scattering, Membrane filtration, dialysis, diffusion coefficient and partial specific volume. Structural and functional organization of prokaryotic and eukaryotic cells. Compartmentalization of metabolic processes within the cell and fractionation of subcellular components.

Unit 2: Carbohydrates

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 principle s of isolation, estimation and analysis of carbohydrates and lipids.

Unit 3: Amino Acids

Amino acids, 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 behavior, hyperchromic effect, base sequencing and restriction analysis of DNA.

Unit 4: Enzymes

Major classes of enzymes, general properties, 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

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, transamination and deamination, urea cycle. integration 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:Transcription and traslation

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: Vitamins

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, *nutraceuticals* & 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, parathyroid, adrenal, pancreas, pineal and gonads.

Unit 8: Biochemistry of blood

Blood composition and biochemical constituents of erythrocytes, leucocytes and platelets. Important plasma proteins and their functions. Hemoglobin 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 t ests for hepatic and renal functions. Urine composition and analysis.
Biochemistry of Wild Animals - Blood biochemistry and blood typing of wild animals - Fluid balance and electrolyte maintenance in wild animals - Biomarkers for assessment of diseases in wild animals - Diabetes mellitus in primates - Neurological diseases in cheetah. Metabolism of xenobiotics and role of liver and kidneys in detoxification of xenobiotics

Unit 9: Determination of biochemical constituents

Basic principles and use of latest photometric, chromatographic. electrophoretic and radioisotopic methods of biochemical analysis. Methods 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, hormone, vitamins and other biochemical constituents with special reference to disease diagnosis in domestic animals.

Unit 10: Bioinformatics

Introduction to bioinformatics, scope and applications of bioinformatics; biological databases: primary, secondary and structural; basic concept of Protein and Gene Information Resources-PIR, SWISS-PROT, PDB, GenBank, DDBJ; Basic concept of computational biology, applications in different subfield of biology, software tools.
Basic concept of sequence search algorithm and alignment tools: BLAST and FASTA; DNA and protein sequence analysis, local and global alignment; Algorithms: Dot Matrix method, dynamic programming methods; Pairwise and multiple sequence alignment and its application; Tools of Multiple sequence alignment: ClustalW. Basic concept of Phylogeny study; cDNA libraries and EST, EST analysis; database search engines: introduction and application; Commercial databases and software packages, GPL software for Bioinformatics.Computer aided drug design: basic principles, docking; QSAR, 2DQSAR, 3DQSAR, their basic concept and applications, machine learning tools for QSAR.

16. ANIMAL BIOTECHNOLOGY

Unit 1: Cell Biology

Origin and evolution of cells, Prokaryotic and eukaryotic cell architecture, Structure of cell, Molecular organization and functions of cell membrane, organization and functions of the cytoplasm, cell organelles, endoplasmic reticulum, ribosomes, Golgi complex, mitochondria, lysosomes, nucleus, nucleolus and sub-nuclear structures, Protein secretion and targeting. Cell division, cell cycle, Cell growth and differentiation. Apoptosis and molecular pathways, different techniques used to study cells. Cell Membrane transport, transport of small molecules, macromolecules and particles, exocytosis and endocytosis, nuclear transport, protein synthesis and sorting, Cell signaling and Signal Transduction, steroid receptor super family – Neurotransmitters, peptide hormones and regulation of cellular functions.

Unit 2: Molecular Biology

History and scope of molecular biology – Discovery of DNA and evidence for DNA as the genetic material - structure of DNA, RNA and proteins – Organization of prokaryotic and eukaryotic genome, DNA replication - genetic code - transcription, RNA processing and alternative splicing – Translation in prokaryotes and eukaryotes - Regulation of gene expression. 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 microsatellites. Molecular mechanism of spontaneous and induced mutations. Recombination in bacteria, viruses and fungi. Molecular mechanism of genetic recombination, transduction, transformation and conjugation.

Unit 3: Gene Structure and Regulation of Gene Expression

Repeated and non-repeated DNA sequences. Structure and function of gene. Expression of genetic information, transcription - mechanism of transcription in prokaryotes and eukaryotes, transcription unit, regulatory sequences and enhancers, transcription factors, post- transcriptional modifications, DNA-protein and protein-protein interactions. Genetic code, Overlapping genes, Mechanism of translation and its control, post-translational modifications, Control of gene expression in prokaryotes and eukaryotes, Gene mining.

Unit 4: Genetic Engineering and Recombinant DNA Technology

Enzymes used in molecular biology and recombinant DNA research, Isolation and purification of DNA and RNA from prokaryotes and eukaryotes. Reverse transcription and cDNA synthesis, Restriction endonucleases, Generation of DNA fragments, Cloning and expression vectors-plasmids, cosmids, phages, phagemid, shuttle vectors, BAC, YAC, MAC. Eukaryotic vectors-viral vectors (vaccinia, retro, adeno, baculo) and yeast expression system, Cloning and expression in prokaryotic and eukaryotic hosts. DNA libraries (genomic and cDNA), Screening and characterization of DNA clones. Transformation of bacterial cells, Transfection in animal cells, *In situ* mutagenesis. Site directed mutagenesis, Antibody engineering, Production of diagnostics, therapeutics and vaccines using r-DNA technology, Nano-delivery system, Genetically modified organisms, Genetic manipulation of microbes, single cell protein, Reverse genetics, RNA interference (RNAi, siRNA, peptide nucleic acid), Gene silencing, Biosafety and biosecurity aspects and regulations associated with recombinant DNA technology research, Ethical issues related to use of biotechnology products, Patenting and Intellectual Property Rights.

Unit 5: Cell culture and Hybridoma Technology

History of cell culture development, Methods of sterilization, Different tissue culture techniques including primary culture, Continuous cell lines- anchorage dependent and independent cell lines, Organ culture, Cell bank. Factors that affecting the growth of cells. Development and applications of cell and organ culture techniques. Nutrient requirements for cells of animal and fish origin. Media for culturing cells, Growth supplements. Stationary, roller and suspension culture techniques. Large-scale production of cells using bioreactors, micro-carriers and perfusion techniques. Characterization and maintenance of cells/cell lines, karyotyping, cryopreservation and revival. Detection of contaminants in cell cultures. Cell viability and cytotoxicity assays. Isolation and culture of lymphocytes. Micro-manipulation of cells, Cell fusion, somatic cell hybrids, sub-cloning of cells. Principles and methods of hybridoma technology, Production and characterization of monoclonal antibodies, epitope mapping of antibodies, application of monoclonal antibodies in diagnostic, cancer research and therapeutics, Antibody engineering: designer antibodies, Chimeric and humanized monoclonal antibodies, Recombinant antibodies.

Unit 6: Reproductive Biotechnology and Related Techniques

Assisted Reproductive Technology, Multiple Ovulation Embryo Transfer (MOET), *in-vitro* fertilization, Micro assisted fertilization, Embryo culture, Micromanipulation of gametes and embryos, preservation of embryos and oocytes, Embryo splitting, sexing, transfer and their applications, Superovulation, Semen sexing technology. Cryopreservation of gamete and embryos. *In vitro* fertilization, Embryo cloning, nuclear transplantation, Transgenic technology, Production of transgenic animals and gene pharming, Gene knockout techniques. Identification and transfer of genes influencing production and disease resistance. Stem cells and applications in animal health and production. Somatic cell nuclear transfer and application. Isolation and characterization of embryonic stem cells. Different applications of embryonic stem cells.

Unit 7: Molecular Biology Techniques & Molecular Diagnostics

Quantitation of protein and nucleic acids. Gel electrophoretic techniques. Isolation of plasmids. Molecular cloning, Nucleic acid probes, GFP from jelly fish and its applications. Nucleic acid hybridization including in *situ* hybridization and FISH techniques. Autoradiography. Blotting techniques. Nucleic acid sequencing methods including next generation sequencing (NGS), Protein purification methods. RFLP, RAPD and AFLP. DNA fingerprinting. Single Nucleotide Polymorphism (SNP). Polymerase Chain Reaction (PCR) and its variants, Real-time PCR, molecular beacons. DNA/Protein Microarray techniques, Biosensors, Nano diagnostics, Mass spectrometry, Bead based assays and lateral-flow technology. Solid phase peptide synthesis and applications of synthetic peptides.

Unit 8: Bioinformatics in biotechnology

Introduction, Database searching - Biological Data Acquisition, Retrieval methods for DNA sequence, protein sequence and protein structure information, General Introduction of Biological Database, Protein and nucleic acid data banks, sequence alignment, sequence editing, phylogenetic tree, Genome analysis using *in silico* tools, Introduction to concept chemo informatics computer aided drug Design–basic principles, Docking, QSAR, Immuno-informatic, Artificial intelligence and applications in drug designing, animal health and production, Genome databases.

Unit 9: Animal Genomics and Genome Editing Technology

Genome organization in eukaryotes-Chromosome numbers in farm animals, Importance of repetitive DNA, Minisatellite and microsatellite based fingerprinting techniques. Metagenomics, RNASeq analysis, Gene mapping in livestock, DNA markers, Role of MHC in disease resistance, Genes influencing production traits, Mitochondrial DNA of farm animals, Genome editing techniques–Zinc fingers, TALENS, Mega nucleases and CRISPR – Cas and importance in livestock improvement.

Unit 10: Vaccine Technology

Current trends in vaccine development against animal pathogens (virus, bacteria, parasites); Molecular approaches for vaccine development including: recombinant vaccines, vectored vaccines, Marker vaccines, DNA vaccines, genetically manipulated live vaccines etc.; Plant expression system-based vaccines, idiotype and synthetic peptide-based vaccines. Vaccinomics, Adversomics, Systems Vaccinology, reverse vaccinology, Structural Vaccinology, DIVA Vaccines for animal disease, Novel immunomodulators and vaccine delivery systems: Immunomodulators including cytokines and new adjuvants; delivery of immunogens through liposomes, microspheres, ISCOMS, nanotechnology based vaccine delivery, Clinical trials of vaccine and its regulation, Vaccine formulation: pharmacopeia requirements; Vaccine qualities and its control; Large scale vaccine production technology, Use of modern adjuvants in vaccines.

17. ANIMAL GENETICS & BREEDING

Unit 1: Overview of Genetics

Mendelism 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 and Genetic disorders. Cytogenetics & Immunogenetics of farm animals. Immune response. Antigen-antibody response. MHC, BoLA, BuLA. Toll like receptors, Interleukins. Hybridoma and its significance.

Unit 2: Advanced Genetics

Fine structure of chromosomes and chromosomal banding. Gene and mechanism of gene action. DNA replication. Genetic code. Recombinant DNA technology. Development of clones in relation to animal productivity and maintaining biodiversity. Production of transgenic animals. Gene mixing for useful functions. Gene expression and its control. Concept of genomics and proteomics. DNA sequencing, Genome Sequencing. Next generation sequencing, GWAS. Epigenetic control. Genomic selection.

Unit 3: Overview of Breeding

Brief history of domestication of livestock. Important breeds of livestock and 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. 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. Biodiversity. Genetic diversity assessment. Population structure. Genetic Admixture. Breed signature.

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 correlated response. Theoretical basis of change of population mean and variance on inbreeding and cross breeding. Genotype-environment interaction. Metric characters under natural selection. Quantitative trait loci and their applications. Marker-assisted selection. Candidate gene approach.

Unit 6: Genetic Strategies

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 / MOE technology in animal breeding. Formulation 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 recommendations of breeding programmes of cattle, buffalo, sheep, goat, swine, camel and equine 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. Realized 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

Gene sequencing. Karyotyping and chromosomal mapping. Concept of recombinant DNA techniques cloning and gene mapping. Nucleic acid hybridization. Development of breed descriptors at molecular level for different livestock and poultry breeds. 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. Cloning. Cryogenic preservation of animal germplasm. ELISA. FISH chromosome painting and PRINS; SCH and RH panel mapping.

Unit 9: Research Techniques for Quantitative Animal Genetics

Estimation of variances and covariances. ANOVA. Maximum likelihood. REML. MINQUE. Bayesian approach. Development of statistical models for analyses of breed data and to quantify environmental variance. BLUP animal model, sire model and repeatability model. Estimation of inbreeding and relationship. Estimation of inbreeding rate in a closed herd / flock. Estimation and interpretation of genetic and phenotypic parameters. Estimation of genetic gains. Designing field-based progeny testing programmes. Development of efficient methods and traits for genetic evaluation of males under indigenous conditions. Data bank concept. Genetic distance and phylogeny analysis. Whole genome analysis. Bioinformatics tools for sequence analysis. Concept and application of Multiple linear regression, Discriminant function, Cluster analysis, Least squares analysis, Principal component analysis, Multiple dimension scaling and Random regression models.

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

18. ANIMAL NUTRITION

Unit 1: Energy and Protein

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 methods in non-ruminant and ruminants. Metabolizable protein concept. Protein energy inter-relationship. Energetics 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 of minerals in different categories of livestock. Different sources and comparative bio-availability among inorganic, organic, hydroxy and nano –minerals. Role of chelated minerals. Probable trace minerals. Toxic minerals. Vitamins: Physiological functions and co-enzyme role, Deficiency symptoms, hyper-vitaminosis. Requirements, Sources and vitamin analogues- Anti-vitamins. Feed Additives: Nutritional role. Prebiotics, Probiotics, phytochemicals and metabolic modifiers. Role of phyto-chemicals as growth promoters. Feed enzymes.

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. Methanogensis, methane estimation using different in vitro and in vivo techniques 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 monogastrics. Inter relationship in nutrient sparing activity. Nutrient requirements and feeding systems of swine and poultry. Role of feed additives - Factors affecting nutritional quality and performance. Special nutritional needs of rabbits, horses and companion animals.

Unit 5: Nutrient Requirements

Energy and 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. Feeding and Nutrient requirements of zoo and wild animals.

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 hay making. Quality criteria and grading of silage and hay. Artificial drying of forages. Factors affecting quality of conserved forages.

Unit 7: Feed Processing and Technology

Significance and 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), Codex Alimentarius and HACCP in quality control. Feed mill, its layout and operations. Handling and storage of raw and finished feeds. Methods to improve shelf life of fat rich feeds, Utilization of by-products of newly introduced commercial crops including residues of genetically modified feeds. Alternative feed resources for ruminants and non-ruminants. 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 animal 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, etc.) and metabolic profile tests. Role of nutrition in immunity, nutrition and reproduction, nutrients as antioxidants. Role of nutrition in management of GI parasites.

19. ANIMAL PHYSIOLOGY

Unit 1: Blood and Circulation

Composition of blood, structure & functioning of its constitutes. Blood coagulation and anti-coagulants. Hemoglobin and its polymorphism. Anaemia, Reticulo-endothelial System. Body defense mechanism and immunogenesis. Hematopoietic stem cells, Fate of erythrocytes. Porphyrias, Resistance of the body to infection, Leukocytes, tissue macrophage system and inflammatory response. Iron binding proteins in blood, Haemoglobin disorders. Hemophilias. Functional anatomy of heart and properties of cardiac muscle, Origin and propagation of cardiac impulses. Rhythmic excitation of heart. Electrophysiology of heart. Electro-cardiography - Principles and interpretation. Hemodynamics and concerned biophysical principles. 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. Circulatory shock and hypertension and cardiac failure. Cardiac murmurs and cardiac arrhythmias. Echocardiography. Pathophysiology of circulation.

Unit 2: Respiration

Mechanics of respiration. Neural and chemical control of respiration. Gaseous transport and exchange. Respiratory adjustments at high altitude, Stress and exercise. Pulmonary volumes and capacities. Respiration in birds.

Unit 3: Excretion

Modern concepts of urine formation. 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. Endocrine control of renal function, Renin angiotensin aldosterone system. Non-excretory functions of kidney. Renal functions in birds. Body fluids – various body fluid compartments, Different types of body fluids and their functions, and their regulation.

Unit 4: Digestion

Basic characteristics and comparative physiology of digestive system of monogastric and polygastric animals. Appetite and control of feed intake. 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. Fate of rumen fermentation products. Avian digestion (different features).

Unit 5: 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. Length and tension relationship, Force and velocity relationship. Skeletal muscle energetics, Metabolism and lactate shuttle. Exercise, adaptation to training and performance.

Unit 6: Nervous System

General organization of nervous system. Neuron structure and function. Excitability and transmission of impulse in neuron and muscle. Junctional transmission. Neuro- transmitters. Reflex action. Functions of spinal cord, brain stem and cerebellum, Limbic system and cerebral cortex. Cerebral cortex, its role in motor and sensory functions. Physiology of learning and memory. Special senses (hearing, vision, taste, smell etc.).

Unit 7: Endocrinology

Methods of study of bioregulation including methods of endocrine analysis. Manipulation and disruption of biorhythms in homeostatic and natural ecosystem. Hormones, Hormone receptors, Mechanism of hormone action at cellular and sub-cellular levels. Feedback control of hormone secretion. Hypothalamic-hypophyseal axis and its hormones.

Pineal gland and its hormones. Hormones of hypophysis and all other endocrine glands. Mechanisms of different hormone actions. Endocrine disorders. Hormonal relationship in animal production. Concepts in hormone function, classification and methods of study, Hormonal assay. Endocrine control of carbohydrate and calcium homeostasis. Hormonal regulation of gastro-intestinal activity. Prostaglandins. Hormones in fertility regulation and production augmentation. Avian endocrinology.

Unit 8: Reproduction

Gonadal hormones and their functions in male and female. Male spermatogenesis. Accessory sex glands. Sexual behavior, 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, Oestrous synchronization, Sperm super-ovulation, capacitation and acrosomal reaction. Sperm and ovum transport in female genital tract. Fertilization, Implantation, Maternal recognition of pregnancy, Maintenance of pregnancy, Physiology of placenta, Physiology of parturition, In vitro fertilization and Embryo transfer technology, Avian reproduction. Mammary gland structure, growth and development. Lactation- Hormonal control of lactation and milk let-down. Mammary gland involution. Milk precursors and synthesis. Methods of studying mammary uptake of nutrients, Milk composition in different animals.

Unit 9: Physiology of Growth

Concept and definition, Growth regulation and factors affecting prenatal and post-natal growth. Role of growth in production. Growth curve and Minerals-Classification-functions and disorders. Vitamins - Classification-functions and disorders. Synthetic vitamins.

Unit 10: Climate Physiology

Physiology of climate stress. Effects of stress on production and reproduction. Neural and hormonal regulation of body temperature in homeotherms. Mechanism of adaptation. Photoperiodicity and biological rhythms. Environment - Introduction and concepts. Weather and climate. Homeothermy, Poikilothermy. Hibernation and estivation. Thermoregulation, thermal stress. Effect of environment on production and reproduction.

Unit 11: Physiology of Wild Life

Overview of Indian forests, Identification of sex in wild animals and birds, Blood collection methods in wild animals, Hematology and Biochemistry, Body temperature measurement techniques, Measurement of stress, Measuring senescence. Reproduction management in wild animals, Understanding sound mechanics and communication methods.

Unit 12: Clinical Physiology

Relationship of cardiovascular, renal, respiratory systems and liver in healthy domestic animals and compensatory mechanisms during failure/disorder of one or other systems. Clinical Hematology and enzymology. Metabolism of carbohydrate, protein, lipid, vitamin and minerals in health and disease of various species of domestic animals and poultry. Clinical evaluation of Gastrointestinal tract; Clinical evaluation of Special Senses; Neuromuscular disorders and clinical correlation; Assessment of acid base and electrolyte balance.

20. ANIMAL REPRODUCTION & GYNAECOLOGY

Unit 1: Veterinary Gynaecology

Biology of sex determination and sex differentiation. 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. Corpus luteum development and regression. Transport and survival of gametes, fertilization, cleavage, implantation and maternal recognition of pregnancy. Development of foetus and foetal membranes. Placenta- classification and functions. Physiology of 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

Abnormalities of fertilization and fetal development, Embryo mortality, Pseudocyesis, ectopic pregnancy, Superfecundation and superfetation. Abortion - bacterial, viral, mycotic, protozoal, physical, toxic and miscellaneous causes, diagnosis and prevention, dropsy of fetal membrane and fetus, 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 p eriod. Presentation, position and posture. Causes and forms of dystocia and its treatment. Epidural anesthesia. Obstetrical maneuvers including fetotomy and Caesarean section. Uterine involution, Postpartum complications in domestic animals, retention of fetal membranes, uterine prolapse, endometritis, metritis, septic metritis. Transition cow management. Peri and 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 seminiferous 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 behavior. Semen and its composition, biochemistry of semen and sperm metabolism, sperm sperm abnormalities and its classification, sperm separation and sperm selection methods.

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. Diseases transmitted through semen.

Unit 7 : Frozen Semen Technology and Artificial Insemination

History and development of artificial insemination. Advantages and disadvantages of Al and frozen semen, selection of bulls for Al purpose. Management of breeding bulls, methods of semen collection in different domestic animals, routine semen evaluation and factors affecting semen quality. 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 f reezing . Cold shock and ultra- low temperature shock. Cryodamage to sperm and cryocapacitation, Cryoprotectants. Semen additives. Evaluation of frozen semen - advanced high throughput semen evaluation methods including computer assisted semen analysis and flow cytometry-based methods, specific fluorochromes for sperm quality/function assessment and principle of the assays. Transport and storage semen. Handling of frozen semen, Liquid nitrogen and its containers. Insemination techniques. Planning and organization of semen bank. Factors affecting success of artificial insemination. Minimum standards and biosafety/biosecurity guidelines for semen stations.

Unit 8: Reproductive Technology

Synchronization of oestrous cycle in domestic animals, control of ovulation. Methods for semen sexing and offspring sex preselection, Embryo transfer technology - History, advantages and disadvantages, superovulation, collection, evaluation, preservation and transfer of oocytes / embryos. Recovery of oocytes *in vitro* and *in vivo,* maturation, fertilization, culture, evaluation, preservation and transfer of embryos. Micromanipulation of embryos. Embryo splitting and cloning. Stem cells and production of transgenic animals. . Embryo sex determination. Establishment of laboratory for ETT, IVM, IVF and IVC. Principles and use of ultrasonography, laparoscopy and ovum-pick technology in farm animals.

Unit 9: Infertility in Cows and Buffaloes

Fertility, subfertility, 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 and their therapeutic and preventive management. Sexualhealth control and reproductive health programmes. Breeding soundness examination of cows and buffaloes. Methods for detection of subclinical/clinical uterine infection, and conventional and alternate therapy.

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. Semen collection, preservation and artificial insemination in sheep and goats. Synchronization of estrous cycle. Embryo transfer. Causes of infertility and their management.

Unit 11: Reproduction and Infertility in Swine

Estrous cycle, synchronization of oestrous cycle, Hormonal control of reproduction. Semen collection, preservation and artificial insemination in swine. Various forms of infertility in swine and their management. Various obstetrical problems and their management. Metritis -mastitis-agalactia syndrome.

Unit 12 : Equine Reproduction

Functional anatomy and physiology of mare and stallion reproduction. Manipulation of estrous cycle and brood mare management. Reproductive behavior and management of stallion. Semen collection, examination and artificial insemination. Pregnant mare behavior. 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, pseudopregnancy, pyometra, cystic endometrial hyperplasia, tumors of reproductive t ract. Difficult whelping - types and methods of handling dystocia. Caesarean section. Ovario-hysterectomy. Peri-parturient complications. Semen collection, evaluation, techniques of artificial insemination, infertility in male including testicular tumors - cryptorchid, affections of prostate.

21. DAIRY CHEMISTRY

Unit1: Physico - Chemical Aspects of Milk Constituents

Specific compositional differences among milk from various species; Variation in milk composition due to breed, feed, season, stage of lactation and mastitis; acid-base equilibria, oxidation- reduction potential, density, viscosity, interfacial tension, freezing point, electrical conductivity, thermal conductivity, refractive index; buffer capacity and buffer index. Electrolytic dissociation: activity, ionic strength and dissociation constants of acids and bases; effect of ionic strength on dissociation constants. Colloidal and surface phenomena in milk; adsorption at solid-liquid and liquid-liquid interphases; Gibb's equations; interfacial tension, surface tension, surface active agents, general aspects of foaming, churning and whipping of cream; emulsion and emulsion stability; coalescence and dispersion. Nano emulsions and Nano micelles: Definition, critical micelle concentration, formation and stability; colloidal stability of casein micelles in milk, zeta potential, size distribution of casein micelles and fat globules; gels and their formation, structure and stability; acid and rennet gels; chemical reaction kinetics, order and molecularity of a reaction, kinetics of denaturation of whey proteins, maillard browning and enzymatic reactions. Role of enzymes as biological catalyst; factors affecting the rate of enzyme reaction and inhibition. Concept of activation energy.

Unit2: Milk Carbohydrates, Minerals and Vitamins

Lactose: Occurrence, isomers, molecular structure; Physical and chemical properties of lactose: crystalline habits, lactose glass, glass transition temperature, specific rotation, equilibrium, solubility, density, sweetness and hydrolysis, pyrolysis; oxidation, reduction, degradation with strong bases, derivatives dehydration and fragmentation, browning reaction; Lactose intolerance; Oligosaccharides in milk: health significance. Major and minor minerals; Factors affecting variation in salt composition of milk; Distribution and importance of trace elements in milk; Physical equilibrium amongst milk salts; Effect of various treatments on salt equilibrium; Partitioning of salts and factors affecting them; Salt balance and its importance in the processing of milk; Protein-mineral interactions; Water soluble vitamins: Molecular structure, levels in milk and milk products; Factors affecting their levels; Biological significance; Relationship of ascorbic acid with redox potential (Eh) of milk and milk products.

Unit 3: Chemistry of Milk Lipids

Classification of milk lipids; Gross composition of milk lipids from different species; physico-chemical properties of milk lipids, role and significance. Composition of milk fat globule membrane. Fatty acid profile of milk lipids; factors affecting the profile of fatty acids. Unsaponifiable matter: Composition, chemistry, levels and physiological functions of sterols; Fat-soluble vitamins and carotenoids in milk; Chemical properties of milk lipids: hydrolysis by alkali, water and enzymes; Hydrogenation, halogenation, transesterification, inter - esterification and fractionation; Oxidation of milk fat; Autoxidation: Definition, theories, induction period, secondary products, factors affecting autoxidation, prevention and measurement. Thermal oxidation of fats; Antioxidants: Definition, types, reaction mechanism and estimation. Dietary and biological significance of milk lipids.

Unit 4: Chemistry of Milk Proteins

Milk proteins of different species and their variability; Distribution and fractionation of different nitrogen fractions of milk proteins; Nomenclature of milk proteins; Genetic polymorphism and biological significance. Major milk proteins: caseins, methods of isolation, fractionation of casein and heterogeneity, physico-chemical properties; amino acid composition, Casein micelle models; Modification of casein: Physical, chemical (glycosylation, phosphorylation) and enzymatic. Whey proteins: Classes, distribution, methods of isolation and their physico-chemical properties; Minor milk proteins: Proteose- peptone, immunoglobulins, lactoferrin, and milk fat globule membrane (MFGM) proteins; Denaturation of milk proteins, various factors affecting denaturation; Casein-whey protein interactions. Milk enzymes: lipases, proteases, phosphatases, catalase, peroxidase, xanthine oxidase, lysozyme, lactoperoxidase and galactosyl transferase, properties and significance.

Unit 5: Chemistry of Dairy Processing

Heat induced changes in milk leading to coagulation. Heat stability of concentrated milk as affected by different process variables, milk constituents and additives. Process-induced changes in milk constituents during preparation and storage of concentrated and dried milks; Age gelation: mechanism and control; Role of biologically active components in human milk; Standards, composition and properties of infant milk and infant food formulations. Biochemical changes during ripening of different varieties of cheese; lactic acid fermentation in cheese and other fermented dairy products; chemical defects in cheese; Storage stability of cream, butter and ghee; physico-chemical properties of ghee; ghee flavour, texture (grains) and colour in ghee. Role of different ingredients during processing and storage of ice cream/ frozen desserts; Concept of antifreeze protein/ice structuring protein in ice cream.

Unit 6: Chemical Quality Assurance and Management Tools

Concept of quality assurance and quality control in relation to dairy industry; Quality management systems – good manufacturing practices (GMP); HACCP certification; ISO9001, ISO 22000, FSSC, Total quality management (TQM); Lean and Six sigma, Five-S, Kaizen, Kanban and other quality tools; Good laboratory practices (GLP); Laboratory accreditation; Role of international organizations: ISO, IDF, CAC, AOAC, WTO; Role of national organizations: BIS, FSSAI, Agmark, QCI, EIC, APEDA in dairy industry. Guidelines for setting up quality control laboratory and chemical safety aspects; sampling of milk and milk product; food labelling guidelines. Detergents, sanitizers and disinfectants; Calibration of milk testing glassware; Preparation of standard reagents; Detection of adulterants in milk and milk products; Instrumentation in analysis of milk and milk products. Quality of packaging material for dairy products. Occurrence of veterinary drug residues, pesticide residues, antibiotic residues, heavy metals etc. in dairy products and their testing methods; Laboratory auditing; Food traceability systems; Food recall and withdrawal.

Unit 7: Analytical Techniques in Dairy Chemistry

Chromatographic techniques: Principles and types (Paper and Column Chromatography, TLC, GLC, HPLC, gel-permeation, ion-exchange, affinity). Electrophoresis: principles and types, Isoelectric focusing. Enzyme linked immune-sorbent assay and lateral flow assay; Separation of bio-molecules using membranes; Centrifugation: principle, types and applications. Spectrophotometry: UV, visible, IR, fluorescence, flame photometry and Atomic spectroscopy: AAS (Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy); Potentiometry: principles, ion-selective electrodes; buffers, Dynamic light scattering/ particle size analyzer: Principles and applications.

22. DAIRY MICROBIOLOGY

Unit 1: Microflora in Dairy and Public Health

Milk and milk product microflora, characteristics, and classification (modern approaches); Somatic cell counts and mastitis significance in dairy industry; Foodborne illness (i.e. poisoning, infection, intoxication, toxi-coinfection) and emerging pathogens; Public health significance of Zoonotic and antimicrobial resistance pathogens in milk; Microbial contamination sources and control during production; Microbial and chemical changes during chilling and refrigeration; Epidemiological studies using PCR and other DNA fingerprinting techniques like PFGE, RAPD, RFLP, DGGE, TGGE, MLST, Rep-PCR, etc.

Unit 2: Milk Processing and Spoilage

Bacteriological aspects of processing (i.e. Pasteurization, Sterilization, UHT, filtration, thermization, etc.); Thermal death parameters of bacteria (i.e. D, F and Z values); Spoilage in heat-treated milks; Heat resistance, spore germination, and post-processing contamination; Bacteriological grading and spoilage in raw and thermally processed milk; Psychrotrophic, thermoduric, Thermophilic bacteria and their metabolites; Biofilms formation and control; Role of resuscitation in recovery of heat injured microbial cells.

Unit 3: Milk Preservation and Safety

Natural antimicrobial systems in milk (i.e. LP system, Immunoglobulin's, Lysozyme, Lactoferrin, etc.); Physical and chemical preservation methods; Food-grade bio-preservatives (GRAS); Bacteriocins (Nisin and other metabolites of lactic acid bacteria); Genetic engineering of lactic acid bacteria; Residues (i.e. antibiotics, pesticides, detergents, sanitizers, aflatoxins, etc.) and their detection methods (i.e. Charm test, ROSA, HPLC, ELISA, biosensor based techniques etc.).

Unit 4: Microbiological Quality of Dairy Products

Fat-rich products (i.e. cream, butter); Frozen products (ice-cream); Concentrated products (i.e. evaporated, sweetened condensed milk etc.); Traditional Indian Dairy Products (i.e. *Khoa*, *Channa*, and *Chakka* based products etc.); Dried products (i.e. roller/spray dried milk and infant formula); Factors influencing microbiological quality, defects, safety, and standards (i.e. BIS, FSSAI, ICMR, Codex etc.)

Unit 5: Lactic Acid Bacteria and Starters

Lactic acid bacteria as starters, types, classification, and identification tools (i.e. 16S rRNA sequencing. Ribotyping, PCR and DNA fingerprinting etc.); Recent/ revised nomenclature of lactic acid bacteria; Starter culture microbiology, growth, metabolism (lactose & citrate), and flavor/aroma production in fermented milks and milk products; Propagation, production, preservation, and quality assessment of starter cultures; Direct vat inoculation and starter concentrates; Starter defects, failures, and bacteriophage impact; Lactic acid bacterial genetics, molecular biology, and genetic manipulation; Lactic acid bacteria as hosts for heterologous protein expression and vaccine development; Lactic acid bacteria genome projects.

Unit 6: Functional Dairy Products and Probiotics

Probiotics regulation, selection criteria, colonization, mechanisms and functional properties; Antibacterial and therapeutic properties; Survival, stability, Safety, and tracking; Methods/ Techniques of preserving the viability of probiotic bacteria; Probiotics, prebiotics, postbiotics, synbiotics; Genetic markers of probiotics and their function and application for mass screening; Genomics of probiotic Lactobacilli and Bifidobacteria; Lactic acid bacteria as nutraceutical ingredients in dairy foods (i.e. vitamins, exopolysaccharides, bioactive peptides etc.); Bioinformatics Tools for comparative genomic analysis (i.e. Blast, Clostal W,Clustal X, Pair-wise/ multiple alignment/ Homology and Phylogenetic tree / dendrograms etc.). Bioremediation of environmental contaminants using lactic acid bacteria.

Unit 7: Fermented Dairy Products and Cheese

Starters in fermented products (yogurt, kefir, cultured butter milk, whey based beverages etc.); Therapeutic properties and defects in fermented dairy foods, safety and their prevention and control; Cheese microbiology (i.e. hard, semi-hard and soft varieties of cheese), starter cultures, and ripening; non-starter lactic acid bacteria during cheese preparation and ripening; Production, use and application of microbial rennet substitutes and recombinant chymosin; Cheese defects, microbiological safety and control.

Unit 8: Indigenous Dairy Products
Microbiological quality of indigenous dairy products (khoa, paneer, chhana based sweets i.e. *Burfi, peda, rasogulla, gulabjamen, kheer, kulfi, shrikhand, paneer, dahi, lassi, ghee*, etc.); Contamination sources, spoilage, and safety; Prevention and control through hygiene practices; Microbiological standards and quality assurance (QMS, TQM, FSMS, HACCP, ISO 17025, ISO 19011, ISO 9000); Packaging for extended shelf life (antimicrobial, CAP/MAP); Modern processing technique (i.e. ohmic heating, cold plasma, HPP, infra-red heating, pulse electric field, ultra sound, etc.). Shelf life enhancement of milk and fermented milk products.

Unit 9: Dairy Waste and Hygiene
By-products preparation from dairy effluents by microbial fermentations; Cleaning and sanitation of dairy equipment and surfaces; Detergents, sanitizers, their mechanisms of soil removal from the surfaces; and evaluation of efficacy; Built detergents, commercial; detergents and combined detergent-sanitizers Dairy effluent disposal and environmental impact (BOD, COD etc.); Microbiological quality of air, equipment, and water in dairy plants.

Unit 10: Quality Control and Assurance
Microbiological aspects of quality control and assurance; Management system standards and food safety techniques: GMP, SSOP, ISO 9001 (QMS), TQM,ISO 22000 (Food Safety Management system), ISO 17025, (Laboratory management system) 14001 (environmental management system), ISO 19011 (Audit management system), EMS, and HACCP implementation; Biofilm formation and control on equipment surfaces; Microbiological Risk assessment and predictive microbiology in dairy foods; Biosafety concepts and principle; Modern detection methods for food pathogens (i.e. impedance, ATP luminescence, Immunological, PCR, DNA probes, microarrays, biosensors, etc.; Biosafety of Genetically Modified Organisms {GMOs)/ foods.

23. DAIRY TECHNOLOGY

Unit 1: Market Milk, Unit operations in Milk & Dairy Products Processing and Dairy Beverages
Status of dairy industry in India. Recent policies related to dairy sector (National and International). NPDD and DIDF and other schemes for dairy development. Principles and practices for production of high quality milk (Clean milk production). Methods of milk procurement, payment, quality assessment, detection of adulterants, contaminants and microbial safety aspects of liquid milk, handling and transportation of milk. Methods of raw milk preservation. physical properties, chemical composition and legal standards of milk of cow, buffalo and other species of milch animals. Centrifugal separation, clarification, bactofugation and bactocatch processes and factors affecting their efficiency. Homogenization process and its implications in dairy processing; theories and efficiency of homogenization and factors affecting the process. Thermal processing of milk. Principles and methods of pasteurization and sterilization. UHT processing and aseptic packaging. Special milks including emerging classes of dairy beverages.

Unit 2: Indigenous Milk Products and Technological Advances in Traditional Dairy Products
Status and role of traditional dairy products in Indian dairy industry and economy. Classification, characteristics, composition, legal standards, yield of various traditional products. Methods of production – conventional, improved and industrial processes; physico-chemical changes during manufacture; quality attributes, factor affecting shelf-life, common defects during storage. Packaging systems of indigenous milk products. Convenience traditional Indian Milk products – production process, packaging and shelf life. Long-life TDPS, application of emerging technologies for quality improvement of TDPs including hurdle technology, membrane processing and newer additive, Innovations in formulations and processing of TDPs (Low calorie, Low fat products), equipment for the commercial production of TDPs.

Unit 3: Technological Aspects of Processed Dairy Products
Fat-rich dairy products: Chemistry of milk fat; 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. Mechanization of manufacturing fat rich dairy products. Role of milk fat in human nutrition. Different fat replacers and their mechanism. Rheological properties of fat rich products.
Frozen Milk Products: Trends in the frozen milk products industry in India. National and Global scenario of frozen milk products trade. 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 dietetic ice creams and novelties. Indigenous frozen desserts, kulfi, malai-ka-baraf etc.; their production techniques and quality. Storage and distribution of ice cream/frozen desserts. Newer ingredients for use in the ice cream industry. Recent advances in freezing of ice cream/frozen desserts. Different types of freezing techniques and their effect on quality attributes of frozen dairy products.

Concentrated and Dried Milk Products: Milk in relation to processing and manufacture of concentrated and dried milk. Different methods used for milk concentration. Principles and methods of manufacture, storage and defects in sweetened condensed milk. Heat stability of milk. Evaporated milk. UHT sterilized concentrated milk. Manufacturing process and quality aspects of Whole milk powder, Skimmed milk powder, high-fat powders, ice-cream powder and dairy whitener. Instantization of milk powder. Newer technologies and formulations for infant foods and weaning foods, malted milk and malted milk foods.

Unit 4: Advanced Dairy Processing
UHT processed milk products: properties and prospects, equipment, heat stability and deposit formation, effect on milk quality; Principles and equipment for bactofugation and bacto- therm processes; Partial/High Pressure Homogenization and its application in dairy industry; Microfluidization of milk; Concentration processes and their impact on quality of finished products; Advances in drying of milk and milk products; Freeze drying: physico-chemical changes and industrial developments; Hurdle technology and its application in development of shelf-stable products; Use of carbonation in extending the shelf life of dairy products; Advances in bakery processing: Application of dairy ingredients in bakery and confectionary products; Technological aspects and issues in fermented foods and beverages; Extrusion processing of food and dairy products; Advances in cleaning and sanitization of dairy equipment: Bio-films; Bio-detergents; Innovations in sanitizers: chemical, biological, radiation; Assessing the effectiveness of cleaning and sanitization of dairy equipment.

Unit 5: Emerging Technologies for Milk and Milk Products Processing

Non-thermal & Thermal processing technologies for food: Irradiation, High frequency heating, Infra-red (IR) heating, Ohmic heating, Ultrasonic treatment, High hydrostatic pressure processing, Pulsed electric field processing; cold plasma; super critical fluid extraction. Their principles, effect on food constituents and salient applications in food sector/industry; Enzymes in dairy and food processing; Newer concepts in food processing including organic foods; Processing of organic raw material; Genetically modified foods; Space foods; Nutrigenomic, metabolomics and other Omic concepts in dairy and food processing.

Unit 6: Rheology of Dairy Products

Rheological classification and characterization of dairy foods: Shear-rate and time dependence of the flow-curve; Factors affecting flow behaviour; Viscosity of food dispersions: dilute and semi-dilute systems, concentration effects; Dynamic measurement of viscoelasticity; Instrumental measurements: Empirical and fundamental methods; Viscometers: Types and working; Rheometer: principles and operational features; Large Deformations and failure in foods: Texture Profile Analysis; Microstructure of dairy products; Tribology and its applications. Food emulsions; Emulsifiers and their functions in foods; Dairy based foams and their applications, Structure of dairy based emulsions, foams and gels; Blends of stabilizers and emulsifiers.

Unit 7: Cheese and Fermented Milk Products & Biotechnological Application in Dairy Processing

Status and scope of cheese industry. Fermented milk products – their nutritional and therapeutic value. Definition and classification of cheese and fermented milks. Quality of Milk in relation to cheese making. Pre-treatments of milk for cheese making. Cheese Additives. 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. Acid coagulated cheeses and whey cheeses. Mechanization of cheese-making process. Modern concepts in accelerated cheese ripening. Storage and defects.

Development and impact of biotechnology on dairy and food industry; Principles of recombinant DNA technique; Production and storage of *dahi,* yoghurt, *shrikhand, lassi* and *misti dohi*. Probiotic dairy products. Preparation and applications of microbial rennet, recombinant chymosin; Exogenous free and microencapsulated enzymes, immobilized enzymes; Production, bio-functional properties and applications of protein hydrolysates; Enzymatic hydrolysis of lactose for preparation of whey and UF-permeate beverages; Bio- preservatives: characteristics and their applications in dairy and food industry.

Unit 8: Membrane Processing for Dairy Applications

Membrane techniques; Classification and characteristics of filtration processes; Types of commercially available membranes; Membrane hardware, design of membrane plants, modeling of ultrafiltration (UF) processes; Membrane fouling-problems and mitigation strategies; Cleaning and sanitization of different types of membranes; Applications of ultrafiltration (UF), reverse osmosis, nano-filtration and microfiltration in the dairy industry; Application of membrane processing techniques for the manufacture of lactose, low lactose milk powder, dairy whiteners, WPC, WPI, MPC, MPI, native micellar casein powder, etc.; Properties and utilization of WPC, WPI, Milk Protein Concentrate (MPC) and Milk Protein Isolate (MPI); Application of membrane processing on quality of traditional dairy products, fermented milks and cheese.

Unit 9: Dairy and Food Packaging

Trends in packaging industry; Testing of packaging materials; Adhesives; Graphics; Coding (Barcode and Quick Response code) and labeling used in food packaging; Protective packaging of foods; Effect of light, oxygen and moisture on packaged food; Packaging of dairy and food products; Modified atmosphere packaging; Shrink and stretch packaging; Self-heating and self-cooling cans; Retort pouch technology; Microwavable, biodegradable, and edible packages; Principles and applications of Active, Smart, Intelligent and Antimicrobial packaging; Industrial packaging: unitizing, palletizing, containerizing, distribution systems for packaged foods; Safety aspects of packaging materials; Sources of toxic materials and migration of toxins into food materials; Interaction of food flavours with packaging.

Unit 10: Functional Foods, Nutraceuticals, Novel Dairy Ingredients
Milk nutraceuticals and functional foods: Trends, market, classes, mechanisms of action and applications; Milk fortification; Developments in Infant formula and complementary foods; Geriatric Foods, Sports foods; Dairy foods for metabolic disorders; Reduced calorie foods, Low sodium and low lactose foods: Herbs and phytochemicals for fusion health foods; Bioactive ingredients from milk; Probiotic, prebiotic and synbiotic foods. Demineralization of milk and whey. Processing, preservation and value addition of buttermilk and ghee residue. Development / formulation of new products based on dairy byproducts.

Unit 11. Sensory Evaluation of Milk and Milk Products
Introduction, definition, importance and requirements of sensory evaluation. Design of sensory evaluation lab. Physiology of sensory organs and sensory perception. Basic tastes. Various types of sensory receptors, stimulus, and corresponding sensory responses. Definition of terminologies related to sensory evaluation - Thresholds, Mouthfeel, Texture etc. General rules of sensory evaluation. Sensory test methods - Difference, Rating, Sensitivity, and Descriptive tests - procedure, requirements and applications. Advances in sensory techniques- Temporal, Spectral analysis etc., Psychophysical theories. Sensory evaluation of Indigenous and Western dairy products – methods score card, desirable sensory attributes and sensory defects - their causes and prevention.

Unit 12: Management & Food Safety aspects with reference to dairy plant operations Cleaning & Sanitization of dairy plant: 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 equipment. Automation in cleaning and sanitization processes including CIP. Quality of water in detergency. Advances in cleaning and sanitation viz. biodetergents, etc. Waste Management of dairy plant, Plant operational efficiency including energy, water and waste minimization & auditing, zero waste disposal concepts, Personnel management, Maintenance of dairy processing equipments.

Unit 13: Legal and Quality Management System for Milk and Milk Products
Safety aspects of milk with reference to mycotoxins, antibiotics, pesticides, weedicides and heavy metals. FSSAI, BIS and AGMARK standards for milk and milk products. Quality systems such as HACCP, ISO certification, six sigma, GMP, etc. Other advanced quality management systems applied in dairy and food industry.

24. LIVESTOCK PRODUCT 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. Market milk production-reception of milk, platform tests, filtration and clarification, chilling, separation, standardization, pasteurization and homogenization. Cleaning and sanitation of dairy equipment. 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. Postmortem aspects of muscle as meat. Ageing of meat and chemical changes. Meat in human health. Factors affecting quality of meat. Bacteria, yeasts, molds, parasites important in food microbiology. General principles of spoilage. Intrinsic and extrinsic factors affecting growth of microorganisms in food. Chemical and deteriorative changes caused by micro-organisms. Contamination and spoilage of milk, meat, fish, poultry and eggs. Food poisoning and food-borne infections. Assessment of microbial condition and wholesomeness of different livestock products. National and International microbial standards. Sensory evaluation and organoleptic properties of livestock products. Sensory evaluation tests. Layout and designing of sensory evaluation laboratory.

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 transportation of food animals. Different slaughtering techniques and dressing of 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 and design of effluent treatment plant. Sanitation, plant operation and maintenance. Sanitary standards for meat packing plants. Fabrication of dressed carcasses and preparation of different cut up parts, dressing percentage and meat: bone ratio. 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 for industrial purposes. Preparation of pet food. Application of computer science in abattoir operations. Robot technology and its application in meat and poultry industry.

Unit 3: Processing and preservation

Principles of processing of dairy products and their defects. Special milk: sterilized milk, flavoured milk, homogenized milk, soft curd milk, Vitaminized/irradiated milk, fermented milk, standardized milk, reconstituted/rehydrated milk, recombined milk, toned milk, double toned milk, skimmed milk, humanized milk. Processing of dairy products: - butter, butter oil, ice-cream, cheese, cream, condensed milk, dried milk, dried milk products etc. Indigenous dairy products: *ghee, khoa, dahi, makkhan, chhana, paneer, khurchan, Lassi*, Organic milk. Genetically modified milk and milk products. Efficient utilization of dairy by products. 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, bio preservation, use of chemical additives and antibiotics. Different cooking methods including micro-wave cooking. Tenderization and use of enzymes for processed foods. Production of value-added products, process methods, process optimization and quality control. Development and preservation of shelf stable (earned and dehydrated) intermediate moisture, textured, cured, fermented, enrobed, restricted, emulsion based, 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 compounds 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). Quality evaluation of wool fibers. Differentiation between wool and synthetic fibers, specialty wool fibers.

Unit 5: Packaging

Principles of packaging. Types of packaging materials. Characterization, methods and systems of packaging. Gas packaging, Vacuum packaging, modified atmosphere packaging, controlled atmospheric packaging, active packaging, intelligent packaging, biodegradable/edible packaging, shrink and stretch packaging, industrial packaging. Aseptic and retort pouches. Standardization and quality control of packaging material. Product attributes, packaging and labeling requirements for different livestock products. Nanotechnology for food packaging, recycling of packaging materials. Latest trends in packaging of milk, meat, poultry, eggs, wool and fish products.

Unit 6: Quality Control

Grades and grading of livestock products. Stress factors effecting meat quality - PSE, DFD, PSS, Hot boning, Cold shortening, thaw rigor, freezer burn 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. FSSAI standards related of different livestock 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 of livestock products

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.

25. LIVESTOCK PRODUCTION MANAGEMENT

Unit 1: General

Present status and future prospects of livestock development in India. Animal production systems in different agro-climatic zones of the country. Effect of industrialization and mechanization of agriculture on livestock sector. Breeds of cattle, buffalo, sheep, goat, pigs, equine, camels, and various important lab animals. Various livestock development programmes operative in the country. Animal behaviour vis-a-vis adaptation and production. Principles of domestication and behavioural factors favouring domestication. Mating behaviour in various species of livestock. Agnostic behaviour - causes and control. Social order in farm animals. Adaptation of livestock in tropics, deserts cold and high altitudes. Mixed farming, integrated and specialized farming systems. Vices – causes and prevention, Livestock transportation. Approaching, handling and restraining of livestock species.

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. Importance of maintaining records and their scientific interpretation.

Unit 3: Feeding Management

Nutrients and their functions. Nutritional requirements and feeding managements of different categories of livestock. Feed additives including antibiotic, pre and probiotic feeding in farm animals. Feed conversion efficiency of various categories of livestock. Processing and storage of conventional and non-conventional feed ingredients.

Unit 4: Reproduction Management

Climate and nutrition affecting reproductive performance in farm animals. Importance of early pregnancy diagnosis. Methods of heat detection. Artificial insemination and timed A.I. Oestrous synchronization. Causes of disturbed fertility and its prevention in farm animals. Management factors affecting reproductive efficiency. Summer and winter management problems (stresses) and their solutions.

Unit 5: Shelter Management

Housing systems, Selection of site and lay out of animal. Space requirement for various livestock species, Housing designs in different agro-climatic regions. Macro and micro- climatic factors affecting designs of animal and poultry houses. BIS (standards) for livestock housing. Construction of cheap animal houses 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 spreading of diseases among the herd mates through isolation, quarantine, disinfection etc. Hygiene and sanitation on animal farm. Symptoms of ill health, important infectious diseases of livestock and their control. Vaccination schedules in animals, Internal and external parasites and their control through spraying, footbath, dusting, dipping, deworming etc. Accidental health disorders and their control. Common disinfectants used on animal farms. Concept of first aid at farms. 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, dry and lactating animals. Management strategies for reducing mortality in calves, age at first calving, and calving intervals. Management strategies to improve production, reproduction and growth efficiencies in cattle and buffalo. Water requirement of dairy animals. Herd registration. Daily routine operations at dairy farms. Clean milk production. Selection and judging of dairy type animals. Preparation of animals for show purposes.

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. Harness for various types of draft animals. Training of work animals. Management of camel with special reference to rearing, feeding and watering. Behavioural studies of various draft animals.

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: Poultry housing systems - cage vs floor system, litter management and lighting for Poultry. Management of chicks, growing, laying, broiler and breeding flocks. Selection and culling of laying flocks. Biosecurity and environmental considerations. Light management. Hatchery management. Management of birds during stress. Chick sexing. Maintenance of farm records. Health and sanitation problems. Prevention and disease control. Handling care of table eggs. Management of birds during disease outbreaks.
Equine: Care and management of horses including feeding, breeding, and 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 and other stages of sows and unweaned piglets. Common problems in pigs and their preventive 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 grazing management. Enrichment of poor-quality roughages.

Unit 11: Economics and Marketing of Livestock 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.

26. 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 methods of mating-pen mating, flock mating, stud mating, shift mating, artificial 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, layers and rural poultry strains. Breeding and management of other species of poultry. 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 integrating 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. Calorie protein ratio. Essential fatty acids. Essential vitamins and minerals and their functions. Nutrients deficiency, toxicity, synergism and antagonism. Nutrient requirements for various species of poultry. Factors influencing the nutrient requirements. Naturally occurring toxicants, 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. Quality 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, flavoring agents, coloring agents and other non-nutrient feed additives. Organic, functional, designer and SPF feed production. Regulations for import and export of feed and feed supplements.

Unit 3: Poultry Physiology

Homeostasis and its regulation. Characteristic features of endocrine glands. Regulation of feed and water 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. Photo period and its role in optimization of reproductive functions; physiology of poultry testes, spermatogenesis, semen ejaculation and its characteristics. Fate of sperm in oviduct and fertilization. Respiratory system- mechanisms of gaseous exchange. Thermo-regulatory 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 and chicken meat. Various measures 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. Quality control of poultry meat. Further processing and fast food preparation. Physical, chemical, microbial and organoleptic evaluation of meat quality. Processing 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. Layout of a modern hatchery. Equipment 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 Japanese quails, ducklings, guinea fowl and turkey poults. Management during growing period. Overcrowding, culling. Management of replacement pullets for egg production and breeding stocks. Management of layers and breeders,Light management, and Debeaking, dubbing and other farm routines. Litter management. Broodiness and forced molting in layers. Management of turkey, ducks, Japanese quails and guinea fowl. Concept and definition of organic poultry. Status, certification and guidelines for organic poultry production. Government policies on organic poultry farming. 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, drinkers, laying nests, cages etc. Automation in poultry production.

Unit 6: Poultry 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-security measures in poultry farm.

27. VETERINARY MEDICINE

Unit 1: General Medicine

Epidemiology and Its Components: Definitions of various disease types such as Infectious, Contagious, Sporadic, Epizootic, Enzootic, Panzootic, Exotic, Zoonotic, etc. Explanation of Segregation, Isolation, Quarantine, etc., and its significance. Role of Occurrence, Prevalence, Incidence, Morbidity Rate, Mortality Rate, Case Fatality Rate, Mode of Transmission, Vectors, Spread, and Economic Factors in Epidemiology of Diseases. Overview of General Systemic States such as Bacteremia, Septicemia, Pyemia, Toxemia, Hyperthermia, Hypoglycemia, Allergy, Anaphylaxis, Shock, Dehydration, Stress, Sudden Death, Anasarca, Anemia, Pica, etc.

Unit 2: Diagnosis of Animal Diseases

History taking. General clinical examination. Special clinical examinations - electrocardiography, paracentesis, rumen fluid examination, hematology, blood biochemistry, urinalysis, ophthalmoscopy, otoscopy, endoscopy, ultrasonography, biopsies, etc.

Unit 3: Gastroenterology

Specific conditions of the organs of the gastrointestinal system with special emphasis on simple/acid/alkaline indigestion, GI ulcers, choke, tympany, colic, impaction, traumatic reticulitis/peritonitis, abomasal displacement, ascites, jaundice, hepatitis, enteritis, acute gastritis, chronic gastritis, gastric dilatation, volvulus, tumors of the stomach, intussusception, inflammatory bowel disease, colitis, gastric and intestinal foreign bodies, peritonitis, diseases of the gall bladder, cholangitis, acute pancreatitis, and exocrine pancreatic insufficiency.

Unit 4: Diseases of Cardiovascular and Pulmonary System

Examination of the cardiac system and special examination of the heart (including ECG, echocardiography, and markers for diagnosing cardiac disorders), principal manifestations of cardiovascular diseases, acute heart failure, congestive heart failure, peripheral circulatory failure, myocardial and valvular diseases, congenital cardiac diseases, myocarditis, dilated cardiomyopathy, cardiac arrhythmias, pericardial disorders, phlebitis, thrombosis, anemia, lymphangitis, lymphadenopathies, and thrombocytopenia; principles of circulatory failure, epistaxis, pulmonary congestion, and edema, emphysema, pneumonia, pleurisy, upper respiratory tract infections, aspiration pneumonia, guttural pouch diseases, tracheal collapse, adult pneumonia, foal pneumonia, recurrent airway obstruction, inflammatory airway disease, pleuropneumonia, pulmonary congestion, and edema, diseases of the nasal cavity, tracheobronchitis, chronic bronchitis, pulmonary congestion, and edema, feline asthma, pleural effusions, and neoplasms of the respiratory tract.

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

Nephrosis, Nephritis, Pyelonephritis, Cystitis, Urolithiasis, Uremia, Urinary incontinence, Hematuria, Cerebral anoxia, Encephalitis, Encephalomalacia, Meningitis, Encephalomyelitis, Paralysis, Seizures, Coma, Diseases of the spinal cord and peripheral nervous system, Vestibular diseases and toxins affecting the nervous system, Myositis, Myopathies, Foot lameness, Arthritis, Osteodystrophies, Degenerative joint disease, and nutritional deficiency diseases affecting the musculoskeletal system, Conjunctivitis, Keratitis, Uveitis, Horner syndrome, Keratoconjunctivitis, Corneal ulcers, Neoplasms of the eye, Otitis media, Otitis externa, Urticaria, Pruritus, Dermatitis, Photosensitization, Seborrhea, Eczema, Impetigo, Alopecia, Skin neoplasms, Common pyodermas, Atopy, Dermatophytosis, Dermatomycosis, Demodicosis, Scabies, Myiasis, Nutritional disorders related to the skin and its therapeutic management, Flea allergy and its treatment and control measures, Cutaneous manifestations of hormonal imbalances and systemic disorders, Autoimmune diseases of the skin.

Unit 6: Production, Metabolic and Deficiency Diseases

Metabolic profile test, parturient paresis, Downer cow syndrome, Acute hypokalemia in cattle, Transit recumbency, Lactation tetany of mares, Hypomagnesemia, Tetany of calves, Ketosis, subclinical ketosis, Pregnancy toxaemia, Fatty liver syndrome, Equine hyperlipidemia, Steatitis, Neonatal hypoglycemia, low milk fat syndrome, Postparturient hemoglobinuria, and Eclampsia in bitches. Azoturia, rickets, osteomalacia, Osteodystrophia fibrosa. Primary and secondary hyperparathyroidism, Diabetes mellitus, Diabetes insipidus, Hypothyroidism, Obesity, Hypo- and hyperadrenocorticism, Deficiency of energy and protein, Deficiency of fat and water-soluble vitamins, and deficiency of macro- and microminerals.

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 Bites, 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 animals: Mastitis, Strangles, Caseous lymphadenitis in sheep and goats, Clostridial diseases, Ulcerative lymphangitis in horses and cattle, Listeriosis, Leptospirosis, Erysipelas, Colibacillosis, Salmonellosis, Pasteurellosis, Brucellosis, Tuberculosis, Johne's Disease (JD), Actinomycosis, Actinobacillosis, Glanders, Kennel cough, and Mycoplasmal diseases.

Unit 9: Infectious Diseases (Viral, Chlamydial, Rickettsial, Haemo-parasitic, and Fungal)

Etiology, epidemiology, pathogenesis, clinical manifestations, postmortem findings, diagnosis, treatment, and control of the following diseases of animals: Hog cholera, African swine fever, Leukosis, Foot-and-mouth disease (FMD), Rift Valley fever (RVF), Peste des Petits Ruminants (PPR), *Bovine malignant* catarrhal fever (BMCF), Bovine Spongiform Encephalopathy (BSE), Bovine Viral Diarrhea, Mucosal Diseases, Bluetongue, Influenza, Maedi, Pulmonary adenomatosis, Rabies, Encephalomyelitis, Pseudorabies, Louping ill, Caprine arthritis-encephalitis, Scrapie, Visna, Contagious ecthyma, Pox, Papillomatosis, Canine Distemper, Infectious Canine Hepatitis, Parvovirus enteritis, Feline Panleukopenia, Anaplasmosis, Heartwater disease, Lymphangitis, Babesiosis, Theileriosis, Coccidiosis, Trypanosomosis, Ehrlichiosis, Hepatozoonosis, Toxoplasmosis, Aspergillosis, and Dermatophytosis.

Unit 10: Parasitic Diseases

Etiology, epidemiology, pathogenesis, clinical manifestations, postmortem findings, diagnosis, treatment, and control of the following diseases of animals: Major conditions produced by nematode, cestode, and trematode infestations; major conditions produced by arthropod parasites; Ancylostomiasis, Dirofilariasis, Giardiasis, Coccidiosis/Isosporosis, Neosporosis.

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, leukosis, Marek's disease, mycotoxicosis, avian encephalomyelitis, hydropericardium syndrome, avian influenza, psittacosis-ornithosis, avian tuberculosis, histomoniasis, spirochaetosis, trichomonosis, etc., parasitic diseases of poultry.

Unit 12: Veterinary Jurisprudence and Ethics

Judicial procedure. Duties of a veterinarian, particularly as an expert witness. Vetero-legal aspects of wounds. Vetero-legal aspects of death, including those resulting from diseases, drowning, near-drowning, electrocution, lightning, etc. Post-mortem examination in Vetero- legal cases. Collection and dispatch of materials for forensic science examination. Common offenses 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 veterinarians. Laws: Role of the veterinarian. Legal enactments in the Indian Penal Code related to animals and veterinarians. Prevention of Cruelty to Animals Act, Indian Veterinary Council Act. Wildlife (Protection) Act. Glanders and Farcy Act, Livestock Importation Act. Dangerous Drugs Act and Poisoning Act. Legal provisions related to animals, animal diseases, and drugs.

Unit 13: Special Therapeutic Approaches

Veterinary fluid therapy with fluids, electrolytes, plasma expanders, packed cell transfusions, etc. Clinical assessment of their requirements and doses. Blood transfusion with blood groups in animals - their therapeutic significance. Blood matching methods. Oxygen therapy. Natural remedies and products for use in therapy for animal ailments. Acupuncture, physiotherapy, laser therapy, nutraceuticals, and dietary supplements.

Unit 14: Prevention and Control of Diseases

General principles of disease control, including the role of the OIE (World Organisation for Animal Health) in disease control. Internationally recognized methods for controlling specified diseases. Prevention and control methods for national, regional, and herd-based disease control programs, such as tuberculosis (TB), Johne's disease (JD), rabies, brucellosis, hemorrhagic septicemia (HS), anthrax, bovine tuberculosis (BQ), mastitis, foot-and-mouth disease (FMD), bluetongue, etc. Investigation and diagnosis of diseased animals, both live and deceased, as well as poultry. Point-source and propagating epidemics. Collection, preservation, and transportation of materials during disease outbreaks, and processing of materials in laboratories for diagnosis. Recording and analysis of epidemiological data. Establishing working hypotheses and formulating, advising on, and/or implementing treatment, control, and prevention measures. Definition of biosecurity, related concepts, principles, and basic components. Physical and operational elements of biosecurity. Routes of pathogen entry and transmission dynamics. Pathogen shedding patterns by infected animals and their survival in the environment. Protection of susceptible animals, interruption of transmission pathways, and the role of disinfection in breaking the cycle of infection. Sterilization, fumigation, and disinfection methods. Classification of disinfectants and microbial resistance to them. Risk assessment and management. Principles of biosecurity in laboratory animal facilities. Biosecurity measures for collecting specimens from wild animals. Biosecurity in research laboratories. Success stories of disease eradication through vaccination.

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

Clinical signs, diagnosis, and treatment of diseases in wildlife and zoo animals include shock, stress, cardiovascular diseases, capture myopathy, metabolic and nutritional disorders, toxicosis caused by chemicals and plants, tuberculosis, paratuberculosis, pasteurellosis, anthrax, rabies, foot-and-mouth disease (FMD), rat-bite fever (RP), Kyasanur forest disease (KFD), Surra, and helminthiasis. Clinical symptoms, diagnosis, and treatment cover Tyzzer's disease, salmonellosis, pasteurellosis, streptococcosis, staphylococcosis, pseudomoniasis, corynebacteriosis, mycoplasmosis (MRM), herpesvirus infection, pox diseases, coccidiosis, toxoplasmosis, giardiasis, helminthic infections, dermatophytosis, scabies, dermatitis, and metabolic and nutritional deficiencies of laboratory animals. Management-related diseases of mice, rats, guinea pigs, hamsters, and rabbits are addressed.

28. VETERINARY MICROBIOLOGY

Unit 1: General Bacteriology

Milestones in the development of microbiology, classification and nomenclature of bacteria. Structure, function and chemistry of bacterial nuclear apparatus. Cytoplasm, Intracellular granules, Cell wall, Cytoplasmic membrane, Mesosomes, Capsule, Flagella, Fimbriae, Endospore, Protoplasts, Spheroplasts, L-forms, Involution forms. Bacterial stains, staining and microscopy. Growth and nutritional requirements of bacteria. Bacterial metabolism, Bacterial growth and Reproduction. Bacterial genetics, Bacterial variation, Horizontal genetic transfer mechanisms (transformation, transduction and conjugation), Plasmids, Transposons and drug resistance. Bacteriophages: temperate and virulent phages; lysogeny and lysogenic conversion. Determinants of pathogenicity and its molecular basis, Markers and PAMPs, Bacterial 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. Antimicrobial agents and disinfectants: Mechanism of action, Resistance and susceptibility testing.

Unit 2: Systematic Bacteriology

Systematic study of bacteria belonging to genera *Borrelia, Leptospira, Brachyspira, Campylobacter, Pseudomonas, Burkholderia, Brucella, Bordetella, Escherichia, Citrobacter, Salmonella, Shigella, Klebsiella, Enterobacter, Proteus, Vibrio, Pasteurella, Mannheimia, Haemophilus, Staphylococcus, Streptococcus, Bacillus, Clostridium, Dichelobacter* and *Fusobacterium, Listeria, Erysipelothrix, Rickettsia, Chlamydia, Coxiella, Mycoplasma, Acholeplasma, Actinomyces, Corynebacterium* and *Trueperella, Mycobacterium, Actinomycetes: Nocardia* and *Rhodococcus, Dermatophilus*. Emerging and transboundary bacterial pathogens.

Unit 3: General Virology

Historical development of virology. Evolution, classification and nomenclature of viruses. Morphological structure and chemical composition 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.

Genetic and non-genetic interactions between viruses. Virus-cell interactions, viral pathogenesis, viral persistence, oncogenic, oncolytic viruses and epidemiology of viral infections. Latent, persistent and chronic viral infections. General principles of laboratory diagnosis of viral diseases. Epidemiology and pathology of viral infections. Immune mechanism in viral diseases. Interference and interferon.

Viral vaccines, Antiviral drugs: Scope, Use and limitations, Existing antiviral drugs and their mechanism of action, Latest trends in antiviral drug development.

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 virus families: *Orthomyxoviridae, Paramyxoviridae, Rhabdoviridae, Arenaviridae, Bunyaviridae, Filoviridae, Bornaviridae, Reoviridae* and *Birnaviridae, Picornaviridae, Caliciviridae, Togaviridae, Flaviviridae, Coronaviridae, Arteriviridae, Astroviridae* and *Retroviridae*. DNA virus families: *Poxviridae, Asfarviridae, Iridoviridae, Herpesviridae, Adenoviridae. Hepadnaviridae. Circoviridae, Parvoviridae*. Slow viral infection and Prions, Emerging, re-emerging, and transboundary viral pathogens.

Unit 5: Mycology

History of mycology, Glossary of mycological terms; Morphology of fungi: structure and ultra-structure, differentiation, nutrition, physiology, reproduction, spores, cultural characters and classification of fungi of veterinary importance, Antifungal agents and important techniques in diagnosis of fungal infections.

Systematic study of animal mycoses: Aspergillosis, Candidiasis, Cryptococcosis, Epizootic lymphangitis, Rhinosporodiosis, Zygomycosis, Blastomycosis, Sporotrichosis, Histoplasmosis, Coccidioidomycosis, Paracoccidioidomycosis, Mycetomas, Dermatophytoses, Dermatomycosis, Mycotoxicosis, Malassezia infections, Mycotic abortion, Mycotic mastitis, and Emerging mycoses.

Unit 6: Immunology

Historical Perspectives. Host-parasite relationships. Antigens. T y p e s of antigens. Properties and specificity of antigens. Factors determining antigenicity. Haptens and carriers. Heterophile antigens. Antigenic determinant/epitope and cross reactivity. B- cell epitope and T cell epitope.

Lymphoid organs: primary, secondary and circulation of lymphocytes, cel1s involved in the immune response B-lymphocytes, T-lymphocytes, subsets and nature of receptors. Macrophages, Dendritic reticular cells, Langerhans cells. Cellular interactions, Cell- mediated immune responses.

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.

Major Histocompatibility Complex, General feature, structure, function, gene organization, MHC and immune response. Immune-response development: Phases of humoral and cell mediated immune response. Immunoregulation with B and T-cells: Antigen recognition, antigen presentation and processing, antigen recognition by TCR, MHC restriction, Cytokines and chemokines. Cell mediated immune response: General properties of effector T-cells, cytotoxic T-cells, NK-cells and ADCC. Role of integrin and selectin. Complement System Basic concept of complement, mechanism of complement activation, complement pathways and Complement deficiencies. Autoimmunity and autoimmune diseases, immunological tolerance and hypersensitivity: classification, mechanism of induction with examples. Immunodeficiency: Types with examples. Immune response in fetus and new born.

Immunomodulators: Types of Immunomodulators and their mechanism of action. Adjuvants: classification, Mode of action, Adjuvants combination and safety. Cytokine as adjuvant, PLG and microparticle as adjuvant, TLR agonist as adjuvant. Antigen delivery system and mode of action. Immunostimulants: Bacterial product and synthetic Compound, Complex carbohydrates, Immune enhancing drugs, Vitamins and cytokines. Mechanism of interaction of antigen and antibody. The complement system. Classical and alternate pathways. Serological reactions: agglutination, precipitation, neutralization, CFT, FAT, ELISA, DIE, RIA, western blotting techniques etc.

Unit 7: Techniques in Microbiology & Vaccinology

Principle and application of molecular techniques like PCR, real-time PCR, Isothermal amplification methods, RNA electropherotyping, Nucleic acid hybridization methods for animal disease diagnosis.Types of vaccines -Conventional and new generation vaccine, Subunit vaccine, recombinant vaccines, Vectored vaccines and DNA vaccine, Edible vaccine, DIVA strategy and reverse vaccinology, Vaccine delivery system, Bioinformatic tools in microbial research.

29. VETERINARY PARASITOLOGY

Unit 1: Veterinary Helminthology
Introduction to veterinary helminthology, classification, economic importance, morphology, life-cycle patterns, epizootiology, pathogenesis, symptoms, diagnosis, treatment and control of helminths of veterinary importance belonging to various families.

Unit 2: Veterinary Entomology:
Introduction to veterinary entomology, classification, economic importance, distribution, morphology, life-cycle, seasonal patterns, vector potential, pathogenesis, and control of insects and acarines of veterinary importance belonging to various families. Chemical, biological, immunological and managemental control measures and integrated pest management. Mechanisms and mitigation of acaricide resistance in ticks.

Unit 3: Veterinary Protozoology:
Introduction to veterinary protozoology, classification, economic importance, morphology, life-cycle, pathogenesis, clinical symptoms, diagnosis, treatment and control of protozoans of veterinary importance belonging to the various families.

Unit 4: Clinical Parasitology:
Clinical signs of parasitic infections in domestic animals. Parasitic diseases of skin, eyes, alimentary, respiratory, urinary, genital, nervous, cardio-vascular and haematopoietic systems. Identification of eggs/ova/cysts, nematode larvae, gravid proglottids, protozoans and arthropods of veterinary importance.

Unit 5: Parasitic Zoonoses
Introduction and importance of parasitic zoonoses, classification of parasitic zoonoses, host-parasite relationships, modes of infections and factors influencing prevalence of zoonoses. Transmission, epidemiology, clinical features, pathology, diagnosis and control of common helminths, arthropods and protozoa of zoonotic importance. Morphology, geographical distribution, epidemiology, diagnosis and management of helminth, arthropods and protozoan parasites of zoo and wild animals.

Unit 6: Management of livestock parasitism
Conventional and novel methods for control of parasitic infections in livestock – Chemotherapy: anthelmintics, antiprotozoal and insecticides/ acaricides, their mode of action, delivery devices, Ethno veterinary practices. Integrated control methods including immunological, biological and genetic control. Snail and other intermediate host/vector control. In vivo and in-vitro detection of efficacy of control agents and resistance to anthelmintics, anticoccidials, insecticides and acaricides.

Unit 7: Immunoparasitology
General principles of parasitic immunity and immune responses to helminths, protozoa and arthropods of veterinary importance. Types of immunity in parasitic infections, invasive and evasive mechanisms, immunomodulators and their uses. Types of parasite-specific antigens and their characterization. Immunological control against parasitic diseases.

Unit 8: Diagnostic Parasitology
Laboratory diagnostic procedures for isolation, identification and preservation for parasites of veterinary importance and their vectors. Conventional, immunological and molecular assays for detection of various stages of parasites in host/vector. Culturing of parasites, Laboratory maintenance of fly and tick colonies. Remote Sensing (RS) and Geographic Information System (GIS) for mapping parasitic diseases.

30. 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 response 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 – antibody and cells, immune-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, 78mmune-deficiency diseases, defective immuno- competence, autoimmune diseases.

Unit 5: Genetically Determined Diseases

Genetic abnormalities, aberrations of chromosomes, mosaicism, 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. Neoplasm: Etiology, carcinogens and oncogenesis, nomenclature and classification, characteristics of benign and malignant tumours, molecular mechanisms, pathways of spread of tumors and tumor immunology. Effects of tumour, grading, staging and laboratory diagnosis of tumours pathological features of various neoplasms.

Unit 7: Postmortem Diagnosis and Histopathological Techniques

Postmortem 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. Regulations dealing with diseases of animals in India regarding epidemiology, quarantine certificate, issue of soundness certificate. 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, processing of tissue for scanning and transmission electron microscopy.

Unit 8: Clinical Pathology

Clinical laboratory examination of various biomaterials from different livestock species, complete blood profile, changes in plasma/serum including biochemical profile for organ function tests, cytological examination and examination of urine, faeces, skin scrapings, cerebrospinal fluid and biopsy specimens and their interpretation.

Unit 9: Systemic Pathology
Advance 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
Etiology, pathology and pathogenesis of bacterial, viral, fungal, parasitic, mycoplasmal, rickettsial, chlamydial, and diseases caused by prions.

Unit 11: Avian Pathology
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, nephrosis / nephritis syndrome, multi-etiology syndromes. Eio-pathology, clinical symptoms, and diagnosis of nutritional deficiencies - vitamin and mineral deficiencies; metabolic diseases- ascites, gout, fatty liver and kidney syndrome, fatty liver haemorrhagic syndrome, cage layer fatigue; miscellaneous conditions of poultry-heat stress, blue comb, breast blister, bumble foot, cannibalism, false layer, internal layer, pendulous crop, round heart disease. Emerging and re-emerging diseases of poultry.

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
Pathology and pathogenesis 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, wild and zoo animals.

31. VETERINARY PHARMACOLOGY

Unit 1: General Pharmacology:

History, Development and Scope, branches of pharmacology, Terminology, Sources and nature of drugs. Pharmacopoeia and drug compendia. Principles of biopharmaceutics and veterinary dosage forms, Drug Schedules, Factor modifying drug activity, Definition of pharmaco-genomics, Single Nucleotide polymorphism (SNPs), Screening and Assaying of drugs, Designing and Development of drugs, Regulations and standards; Gene based therapy and drug delivery system.

Pharmacodynamics: Structure activity relationship, Theories of Drug receptor interaction, Role of secondary messengers, Drug Targets, Pharmacodynamics of signal transduction (G- Protein coupled Receptor, Ion channels, Enzyme linked receptors and Nuclear receptors), Regulation and malfunctioning of diseases. Agonist, antagonists, Partial Agonist, Inverse Agonist, Spare receptors Dose response Curve, Drug-Drug Interactions, Types of Antagonism, Adverse drug reaction.

Pharmacokinetics: Dynamics of ADME, Drug metabolism and biotransformation. Factors modifying drug kinetics. Kinetic constants. Different models, determination of kinetic parameters and application in rational dosage regimen, Genomics of Drug Metabolic enzymes.

Pharmacometrics: Organization and screening programmes and drug development. Multidimensional screening methods, Bioassay, Determination of median doses – Lethal Dose 50 (LD50), Effective Dose (ED50), Therapeutic indices. Dose response relationship.

Unit 2: Drug Acting on Central Nervous System

Anatomical and physiological considerations and neurohumoral transmission in CNS, Historical development, theories, principles and stages of general anaesthesia, Recent advances in pharmacology of general anaesthetics and therapeutic gases, local anaesthetics, sedatives, hypnotics, neuroleptics, antiepileptics. Pharmacology of CNS stimulants, analeptics, opioid agonists and antagonists; non-steroidal anti-inflammatory agents, central muscle relaxants, Pharmacology and regulations of euthanizing agents, Muscle relaxants.

Unit 3: Drugs Acting on Autonomic and Autacoid Nervous Systems

Anatomical and physiological considerations of autonomic and somatic motor nervous system and Neurohumoral transmission, Agents modulating peripheral nervous system, Non- adrenergic-non cholinergic (NANC) transmission, Pharmacology of adrenergic agonists, Antagonists and Adrenergic neuron blockers. Pharmacology of cholinergic agonists, Antagonists and cholinergic neuron blockers. Drugs acting at the Neuromuscular Junction and Autonomic Ganglia. Autacoids: Introduction to immunity and inflammation, Immuno- stimulants, Immuno-suppressants and Tolerogens, Pharmacological aspects of histamine, serotonin, kinins, eicosanoids and platelet activating factor, Angiotensins and other putative autacoids.

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

Cardiac electrophysiology consideration, Pharmacology of antiarrhythmic drugs, Cardiac glycosides, Myocardial stimulants, Antihypertensive, Antihypotensive and Antihyperlipidaemic drugs, Coagulants and anticoagulants, Thrombolytic agents, Plasma expanders, Drugs affecting haemopoietic system and antiplatelet drugs. Physiological considerations of respiratory functions in animals. Pharmacology of drugs acting on respiratory system: Bronchodilators, Antitussives, Mucolytics, Expectorants, Decongestants. Drugs used in treatment of asthma.

Unit 5: Drugs Acting on Digestive System

Pharmacology of drugs acting on gastrointestinal tract. Appetite stimulants, emetics and anti-emetics. Pharmacology of anti-ulcer drugs, modulators of gastric and intestinal motility and secretions. Agents promoting digestive functions; bile acids and pancreatic enzymes, drugs affecting liver; rumen pharmacology, Gastrointestinal protectant and adsorbents, laxatives and cathartics.

Unit 6: Drug action on Urinary System

Pharmacology of drugs affecting renal functions and fluid-electrolyte balance: Diuretics, Antidiuretics, Urinary acidifiers, Urinary alkalizers, Urinary antiseptics and Uricosuric and other anti-gout drugs. Principles of acid-base balance, fluid and electrolyte therapy and blood substitutes.

Unit 7: Endocrine and Reproductive Pharmacology:
Drugs affecting endocrine functions of hypothalamus, pituitary, thyroid, adrenals and pancreas. Drugs affecting calcium and phosphorus homeostasis, Drugs affecting male reproductive organs, spermatogenesis and erectile dysfunctions. Drugs affecting female reproductive organs: ovulation, oestrus, conception, gestation and lactation. Oxytocic and other drugs affecting uterus.

Unit 8: Chemotherapy
Classification of chemotherapeutic agents; Molecular mechanism of Antimicrobial resistance development and Prevention strategies; Antiseptic and disinfectants. Mechanism and therapeutics of sulphonamides (gut active, systemic), trimethoprim and congener. Antibiotics: Penicillin, cephalosporins, aminoglycosides, macrolide, surface active, tetracyclines, polypeptide. Antitubercular drugs, Glycopeptides, and Polypeptide antibiotics, Methenamine, Carbadox, Novobiocin, Virginiamycin, Spectinomycin, Oxazolidinones and newer agents. Antifungal and other emerging antibiotics. Quinolones, nitrofurans, Antitubercular, antiviral and antineoplastic drugs. Anthelmintic: Antinematodal, anticestodal, antitrematodal drugs. Antiprotozoons, 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 9: Toxicology: Terminology. Classification of poisons. Toxicity rating. Principles of selective toxicity. Toxicodynamics. Toxicokinetics. Diagnosis and treatment of poisoning (antidotal and non anti-dotal). Mechanism of detoxification. Poisons causing respiratory insufficiency. Toxicology of common inorganic compounds. Toxicity of metals, non- metals and metalloids, solvents and vapors, common salt, urea. Toxicity of drugs. Poisonous plant- cyanogenic, nitrate and oxalate producers. Mycotoxins: aflatoxin, rubratoxin, ergot, Toxic ferns. Venoms from snakes, scorpions, toads, etc. and treatment. Zootoxins: snake venom, scorpion, spider and insect stings and bufotoxins, Puffer fish and Shell fish toxins. Bacterial toxins (botulinum and tetanus toxins). Genotoxic and other effects of radiations and radioactive chemicals; toxicogenomics and developmental toxicology; forensic and regulatory aspects of toxicology

Unit 10: 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, embryo toxicity for toxicological evaluation.

Unit 11: Miscellaneous Topics: Drugs promoting growth and production. Agents used for doping and restraining of wild animals. Euthanizing agents. Drug control and regulation.

32. VETERINARY PUBLIC HEALTH

Unit 1: Veterinary Public Health

Definitions: Veterinary Public Health, One Health, Eco-Health; concept of Veterinary Public Health and its dimensions; intersectoral/interdisciplinary approach to Human-Animal- Environment Health; historical emergence of One Health approach; objectives and areas of activities under One Health framework; role and participation of veterinarians in community health and One Health; National and International organizations related with Veterinary Public Health, rural and community health and One Health.

Unit 2: Hygiene and Safety of animal foods

Milk hygiene: Definitions; dairy Industry in India and other countries; microbiology of milk and milk products; microbial spoilage of milk and milk products; sources of contamination of milk and its products; public health aspects of residues: agricultural chemicals, antibiotics and drugs, toxic metals, mycotoxins and adulterants; milk borne pathogens; concept of milk hygiene; hygienic aspects of milk production and processing; clean milk production; lactose intolerance; prevention of contamination by sanitary measures at dairy farm, transportation, collection centres, milk processing and manufacturing plants; pasteurization; sterilization; quality control tests for milk and milk products; national standards for safe milk production and marketing.

Meat hygiene: Definitions; meat industry in India and other countries; raising meat food animals and poultry, 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 hygiene and sanitation, microbiology of meat and their products; sources of meat contamination; disposal and reclamation of slaughterhouse wastes and byproducts and associated public health problems; spoilage of meat and meat products; preservation of meat and meat products; 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.

Food microbiology: Food microbiology: concepts and principles; characters of food bacteria, virus, parasite, moulds and yeast; 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; Hurdle technique and its relevance; use of predictive microbiology in food industry; pathogen-associated virulence factors, toxic metabolites and other molecules associated with pathogenic mechanisms; resistance mechanism of microbe survival in environment in and outside the host; traceability system; organic food production; microbiological, serological, biological and nucleotide based diagnostic methods; Issues on bioterrorism.

Guidelines and legislation: Definitions, standards / guidelines of products and product ingredients; Hazards Analysis Critical Control Points (HACCP); Good Manufacturing Practices (GMP): Good Laboratory Practices (GLP): Total Quality Management (QM): Quality Assurance and Food Safety Management Systems, ISO 22000, Bureau of Indian Standards, International Organization for Standards; Food Safety and Standards Authority of India: aims, scopes and role in safeguarding the national food safety; Codex Alimentarius, World Trade Organization, Sanitary and Phyto-sanitary (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 3: 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, ready-to-eat/street foods; epidemiological characteristics of food-borne infections and intoxications, intensive agriculture and animal husbandry practices;, sources of pathogens and factors favouring for bacterial, viral, parasitic, mycotic and chemical food poisoning; epidemiological investigation of food-borne outbreaks; detection of foodborne pathogens and their toxins; prevention and management of food poisoning outbreaks; Antimicrobial resistance (AMR) in food-borne pathogens-definition, current status, factors responsible, mechanism of resistance, mode of transmission and control.

Unit 4: Zoonoses

Definitions; concept and classification of Zoonoses; history, etiology, transmission dynamics, risk factors, signs and symptoms, diagnosis and management of important bacterial, viral, parasitic, rickettsial, prions and fungal zoonoses; farm animals, wild animals and aquatic life-associated zoonoses; Vectors related zoonoses; occupational bio-hazards and zoonoses; occupational health and safety in the care and use of research animals; nosocomial zoonoses; xenozoonoses; nationally and internationally emerging and re-emerging zoonoses (including transboundary zoonoses);epidemiology of bacterial, viral, parasitic, rickettsial, and mycotic Zoonoses; principles and methods of zoonoses management: methods of prevention, control and eradication of zoonoses; farm biosecurity– definition, importance, and principles; farm biosecurity at specialized animal facilities; biomedical hazards and biosafety in the laboratories.

Unit 5: Veterinary Epidemiology

Definitions; historical perspective and scope of veterinary epidemiology; casual association; concept of disease transmission; ecological basis of diseases; sampling methods and strategies; methods of data presentation and epidemiological analysis; measurement of disease occurrence; distribution of diseases in space and time; epidemic curve; concept of herd immunity; epidemiological hypothesis; types of epidemiological studies [observational (cross-sectional, case-control, and cohort studies) and experimental studies (field and clinical trials)]; epidemiological survey, surveillance, and monitoring of diseases; field and experimental epidemiology; participatory epidemiology; epidemiological measurements; predictive epidemiology; epidemiological models; sero-epidemiology; deterministic and stochastic models; disease reporting system and early warning system; concept of risk analysis; characteristics of diagnostic tests, multiple testing and evaluation of tests; use of information technology/artificial intelligence/machine learning in disease monitoring; epidemiological investigation and evaluation of intervention measures; animal disease economics (cost-benefit analysis, internal rate of return, payback period, partial budgeting), decision analysis; uses of multivariate analysis.

Unit 6: Environmental Hygiene

Definitions; water hygiene; pure and wholesome water; microbial contamination and chemical pollution of water; impurities in water; purification and sanitization of water; waterborne diseases; microbiological examination of water; standards for drinking water; impact of noise pollution on health; air pollutants; air-borne pathogens and diseases; ventilation; methods of air purification, agricultural chemicals; industrial wastes; farm effluents polluting environment and associated hazards and preventive measures; health problems due to nuclear energy, microwave, electro-magnetic and other radiation pollution; environmental pollution; agrochemical pollution, pesticides pollution; industrial pollution as well as pollution due to plastic and petrochemical products; antibiotic and pesticide residues and their effect on animal-human-environment health; farm, slaughterhouse and dairy plant waste management; methods of disposal of bio-medical waste and dead animals; rodents and vector control measures; green-house gasses and its effect; effect of climate change on animal-human-environment health; environmental risk assessment and management; national and international regulations on control of environmental pollution; role of veterinarians in disaster management.

33. VETERINARY SURGERY

Unit 1: Principles Of Surgery

Classification of wounds, wound healing, mechanism of wound repair, local and systemic factors affecting wound healing, advances in wound closure, current concepts of inflammation and its management, thermal, electrical and chemical injuries and their management. Principles of Plastic and Reconstructive Surgery. Principles of asepsis, sterilization, disinfection and practice of antimicrobial therapy in surgical patients. Disinfection and sterilization. Physiopathology of burns, trauma, surgical stress and shock. Haemorrhage, haemostatic techniques and haemostatic agents (active, passive, sealents etc). Acid — base and electrolytes imbalance. Rehydration and fluid therapy. Surgical infection, its pathophysiology and management. Sutures and suture materials. General surgical affections viz. abscess, cyst, haematoma, tumour, gangrene, sinus, fistula and hernia. Surgical instrumentations. Skin grafting techniques in animals. Principles, instrumentation and clinical applications of laser surgery, cryosurgery, electrosurgery, and physiotherapy. Minimally invasive surgical procedures which includes laparoscopy and endoscopy. Principles of microscopic surgery, vessel and nerve anastomosis, application of computers in surgery.

Unit 2: Anaesthesia And Analgesia

History and instrumentation. General consideration for anaesthesia in animals, properties of ideal anaesthetic agent, types of anaesthesia, anaesthetic triad, preanaesthetic evaluation of patient and selection of anaesthesia. Preanaesthetic medication (anticholinergics, sedatives, tranquilizers, alpha-2 agonist, narcotics), muscle relaxants and neuromuscular blocking agents with their reversal agents. General anaesthetics and factors affecting their uptake, distribution and metabolism. Inhalant (properties, methods of administration, dosage and usages) and injectable anaesthetic agents (properties, dosage and usage) including dissociative, neurolept and balanced anaesthesia and their administration in small and large animals. Inhalation anaesthesia equipment and breathing circuits, mechanical and artificial ventilation. Monitoring of patient during anaesthesia and recovery. Anaesthetic emergencies and their management. Local anaesthetic agents, their mechanisms. Local and regional anaesthetic procedures, spinal analgesia, intravenous regional anaesthesia, peri-operative and post-operative pain and its management. Techniques for pain management. General consideration in chemical restraint of captive and free ranging wild animals, handling of birds with minimum stress, Methods of administration of anaesthesia in captive, free ranging animals, birds and laboratory animals. Local and general anaesthesia in exotic species, wild animals, birds, zoo animals and laboratory animals.

Unit 3: Diagnostic Imaging Techniques

Regulations regarding establishment and handling of x-ray units. Requirements for establishment of x-ray units, conventional and digital X-ray machine, x-ray films, cassettes, screen, x-ray production, qualities of x-rays, image formation and dark room procedures, Image plate, radiographic quality, contrast, density and details), radiographic accessories, radiographic positioning for different organs/parts in small and large animals. Formulation of technique chart. Radiographic artifacts and their prevention. Plain and contrast radiography techniques of small and large animals. Fluoroscopy/C-arm, principles of radiographic interpretation. Radiation hazards and monitoring of radiographic exposure to personnel and protection. Principles of radiotherapy. Medical radioisotope curves, radiation laws and regulations. Radiography of head and neck region, radiography of thorax, lung patterns, radiography of abdominal and pelvic region. Basic physics of ultrasound waves and image formation, scanning principles of ultrasound, transducers, equipment controls, modes of display, terminology used for echotexture and USG artifacts, application of ultrasound in small and large animals. Doppler techniques, echocardiography and its application, introduction to nuclear imaging techniques, computerized tomography, magnetic resonance imaging, positron emission tomography technique.

Unit 4: Orthopaedic Surgery

Physiological and biochemical considerations of bone. Bone structure and function, growth, response to injury. Fractures and luxations. Classification and healing of fracture, biomechanics of fracture healing. Considerations for selection of fixation techniques. Treatment of fractures of different bones in companion and farm animals. Diseases of bone. Classification, diagnosis and treatment of arthritis. Surgical affection of vertebral column and injury to axial skeleton. Technique, scope and application of arthroscopy. Anatomical confirmational and pathological causes of lameness and allied surgical conditions of fore and hind limbs, rehabilitation of orthopaedic patient. Affections of joints, tendons, ligaments and their management. Conformation of the limbs and hoof. Management of congenital and acquired disorders of joints like traumatic dislocations, luxations

and dysplasia. Etiopathology, diagnosis and management of equine lameness including laminitis, navicular disease, quitter, canker and thrush, sand cracks, ring bone, hygromas, upward fixation of patella, string halt, bursitis, spavins and splint. Soundness and examination of horse for soundness.

Unit 5: Soft Tissue Surgery

Skin, adnexa, integument, appendages, horn, tail, sinus affections of equine and bovine, teat affections. Surgical approaches/affections of oral cavity, larynx and pharynx, salivary glands, oesophagus, abdomen, rumen, reticulum, omasum, abomasum, stomach, intestines, rectum, anus, liver and biliary system, pancreas and porto-systemic shunts. Surgical affections and management of ear and guttural pouch. Abdominal hernia, diaphragmatic hernia, perineal hernia, ventral, femoral, umbilical hernia, ritcher hernia, hiatal hernia, omental hernia, pre- pubic tendon rupture, use of biological and synthetic grafts for hernia repair, laparoscopic repair of hernia. Principles of thoracic surgery, Functional anatomy of respiratory system, diseases of upper and lower respiratory system. Functional anatomy of cardiovascular system and common affections of heart. Principles of neurosurgery and common surgical affections of nervous system and special sense organs. Haemolymphatic system, bone marrow, spleen, tonsils, lymph nodes and lymphatics, thymus. Laryngeal paralysis, tracheal collapse, tracheostomy (temporary/permanent), Pneumo thoracic emergency procedures like chest tube placement, thoracocentesis, pneumectomy (partial/unilateral), trans tracheal intubation, thoracoscopic procedure. Different congenital and acquired surgical affections of thoracic wall and thoracic organs viz. lung, mediastinum, oesophagus, heart and diaphragm in large and small animals. Esophageal affections in small and large animals, dilatation, diverticulum, intussusception, caecal dilatation, short bowel syndrome, colostomy, traumatic reticulitis, abomasal displacement, impaction of omasum, pyloric stenosis, gastric dilatation and torsion, intestinal obstruction. Anal and Perianal affections and management. Colic in horse:- etiology, diagnosis and treatment.

Unit 6: Urogenital Surgery

Surgical anatomy of urinary and reproductive tract in male and female animals, congenital anomalies of organs of male and female urinary and reproductive system. Principles of urinary tract surgery, pathophysiology, diagnosis and surgical management of affections of kidney, ureter, urinary bladder and urethra, medical dissolution and prevention of canine uroliths, feline urologic syndrome, surgical management of urolithiais in ruminants and its prevention, management of uroperitoneum and renal failure. Pathogenesis, clinical symptoms, diagnosis and surgical management of vaginal and uterine prolapse, rectovaginal fistula, pneumovagina, vaginal tumours, vaginal hyperplasia, ovarian remnant syndrome, pyometra, cysts of Gartner's canal and vestibular glands. Surgical conditions of penis, prepuce, prostate and testicles, cryptorchidism, inguinal and scrotal hernia, affections of teat and udder. Indications, techniques and postoperative complications of episiotomy, ovariectomy, ovariohysterectomy and caesarean section, pyometra and its surgical treatment. Castration, vasectomy, cauda epididymectomy and penile deviation.

Unit 7: Dentistry and Oral Surgery

Anatomy, development of teeth (odontogenesis), dentition and aging of different species. Clinical examination of oral cavity, dental anesthesia and pain management, dental radiographic interpretations. Diseases of oral cavity and teeth, congenital and developmental anomalies of oral cavity, abnormal tooth eruption, irregular wear of teeth in companion and farm animals, occlusion and malocclusion, mandibular fracture, malformation of mandible, maxilla (cleft palate). Acquired diseases of teeth (halitosis, dental caries, fracture of teeth, dental materials and dental radiography), oronasal fistula, maxilla and mandibular fractures repair, orthodontics, tumors and other acquired condition of oral cavity. Exodontics, restorative dentistry, periodontal disease, tooth extraction, gum diseases. Endodontics, pulpectomy, root canal therapy, current techniques in dentistry.

Unit 8: Ophthalmology

Anatomy and physiology of eye and its adnexa. Ophthalmic examination and diagnosis, diagnostic instrumentation, anaesthesia and surgery. General consideration for eye surgery in companion and farm animals, therapeutic agents for eye diseases and surgery of eye lids, lacrimal apparatus, naso-lacrimal duct. Diseases of conjunctiva, cornea, sclera, iris, orbit, lens, vitreous and aqueous humor, retina and optic nerve, eye tumours, enucleation, exenteration. Ocular manifestations of systemic diseases. Advances in diagnosis and diseases of the eye and adnexa. Ocular neoplasia. Ocular imaging, advances in ocular anaesthesia and analgesia. Ocular emergencies, Corneal grafting, Cataract and its management.

34. AQUACULTURE

Unit 1. Aquaculture Systems

Present status, prospects and constraints of Aquaculture; Aquaculture practices in different parts of the world; National and global aquaculture production, consumption scenario and emerging trends; Different freshwater, brackishwater and marine Aquaculture systems- extensive, intensive, semi-intensive, flow-through and re-circulatory. Farming systems-ponds, pens, cages, raceway, raft, rope, monoculture, polyculture, mixed culture; Capture and culture-based aquaculture, Integrated multi-trophic Aquaculture (IMTA), Integrated aquaculture (fish-cum-rice, fish-cum-duck, fish-cum-poultry, fish-cum-pig, fish-cum-Makhana/chestnut). Multi-component integrated farming system. Intensive aquaculture (Recirculation Aquaculture Systems (RAS), Aquaponics, Biofloc). Partitioned aquaculture system, Traditional Aquaculture Systems; Peri-urban aquaculture systems; Sewage-fed farming**,** Organic aquaculture, Natural Farming, Culture in seasonal ponds; Seaweed farming (Major seaweed species of commercial importance, Method of culture, emerging trends in farming of seaweeds); molluscan farming/pearl culture. Ornamental fish culture, commercially important exotic and indigenous ornamental species, Ornamental fish seed production and feed development, National and global status of inland saline soils and underground saline water. Inland saline aquaculture systems and its potential for finfish and shellfish farming. Aquaculture and sustainable development goals.

Unit 2. Broodstock Development and Hatchery Technology of Finfish and Shellfish Broodstock management and seed production-Natural seed collection, holding, packaging, transportation, environmental, nutritional and endocrine control of reproduction, Reproductive cycles, factors influencing reproduction, Gametology (evaluation of milt and egg); Overview of current developments in reproductive biology of commercially important finfishes and shellfishes. Broodstock transportation, quality seed production through induced breeding, different types of inducing agents, pituitary gland structure and function, preservation of pituitary gland, Natural and synthetic hormones and its analogues and their application, lay-out and design of hatcheries, tagging, cannulation, hormonal and volitional spawning, incubation of eggs, types of hatchery (Jar hatchery, Chinese eco-hatchery, portable hatcheries their operation and troubleshooting), Hapa breeding, water quality management in hatcheries. Cryopreservation of gametes. Larval rearing and role of live feed (microalgae, rotifers, copepods, artemia hatching and enrichment). Seed production of Carps, Snakeheads, Mahseer, Trout, Pearlspot, Ornamental fish, Cobia, Grouper, Pompano, Tilapia, Seabass, Mullets, Milkfish, Snappers, Breams, Shrimps (*Penaeus monodon*, *P. indicus*, *P. semisulcatus, Litopenaeus vannamei*), sand lobster, spiny lobster, mud crab, blue crab, and giant freshwater prawn. Seed production of molluscs (mussel, edible oyster, pearl oyster). Larval transportation, Specific Pathogen-Free (SPF) broodstock, seed certification. Assessment of seed quality.

Unit 3. Aquaculture Ecosystem Management and Practices

Aquatic microorganisms and their role in carbon, nitrogen, phosphorus and sulphur cycle, Natural productivity of ponds, Primary, secondary and tertiary productivity, Carrying capacity and associated factors, carrying capacity and marketable size-based optimization of stocking size, density and culture duration, Aquaculture practices for freshwater fish- carps (IMC, Exotics, Major & Minor), catfishes, snake heads, feather backs, tilapia, murrels, mahseer, trout, freshwater prawn and brackish water and marine shrimp and fish (seabass, milkfish, mullets, pearl spot, cobia, pompano, grouper, snappers, breams, other perches), lobsters, freshwater and marine ornamentals (Native and exotic species). Nursery rearing,pre-stocking, stocking and post-stocking management, soil and water quality management, liming, manuring and fertilization, bio-fertilization. Polar algal resources and their application; Role of algae in global warming and mitigation (Ocean fertilization, bioprospecting and biopiracy, bioprocessing, bio fouling, bioleaching, biocorrosion, bioremediation, biofilm).Harvest management (staggered harvest, managing differential growth). Live fish marketing. Best Management Practices (BMP) in Aquaculture. Carrying capacity and stocking density of aqua farms. Waste water fed aquaculture, Waste water treatment practices. Exotic fishes and its impact. Environmental Impact Assessment (EIA). Algal bloom control, Eutrophication, Aquatic Weed Management. Microplastics in Aquaculture, Renewable Energy in Aquaculture, Responsible aquaculture, Guidelines for sustainable aquaculture, Waste discharge standards, Sanitary and phyto-sanitary (SPS) agreement, Ecosystem approach to aquaculture, CRZ implications, CAA and its role. Ecolabeling, Organic certification. Weather elements of concern in aquaculture, Greenhouse gases, Global warming and their impact. Carbon sequestration in aquaculture, Climate resilient aquaculture. Carbon sequestration, carbon credit, Life cycle Analysis, Physical and chemical properties of soil and water productivity *vs* nutrient quality, Salinization of soils and water. Bioremediation; role of biotechnology, traceability. FAO Code of Conduct for Responsible Fisheries; Holmenskollen Guidelines for Sustainable Aquaculture, Carbon

foot print and climate resilience of aquaculture. Pollution problem in groundwater resources (Arsenic, fluoride, nitrite, pesticide), sources of contamination and management issues. Ecological sanitation, Constructed wetland, River continuum concept, integrated environmental management, ICZM, principles of ISO 14000 (EMS).

Unit 4. Aquatic Animal Health and Nutrition

Common fin fish and shellfish diseases and their control measures. Environmental and nutritional support methods for disease management. Immune modulation (probiotics and pre biotics), Immunostimulation, Use of vaccines and other preventive methods. Concept of therapeutics in aquaculture, drugs in aquaculture, herbal therapeutics, Issue of misuse of chemicals and drugs in aquaculture. Biosecurity, Sustainable use of Antibiotics, AMR. Legislation and jurisprudence in therapeutics for aquaculture organisms.

Nutritional requirement of commercially important fishes & shellfishes and associated factors, energy partitioning, Protein:Energy ratio, high energy/low pollution diets, Common, alternative and novel feed ingredients in aqua feeds and their quality, feed additives (preservatives, binders, antioxidants, hormones, non-antibiotic growth promoters, probiotics, prebiotics), antinutritional factors, formulation of feeds, feed processing, Natural and formulated feeds, weaning to artificial feeds, feed formulation and manufacturing methods (compression, extrusion), Larval, grow-out and broodstock diets, advanced feeds, supplementary feeds, balanced feeds, feeding strategies, rations and feeding methods, manual and automatic feed dispersers, demand feeders, feed rationing, feeding protocols. Feed formulation and nutritional requirements. Larval diets, advanced feeds, Feed storage and quality deteriorations, dos and don'ts of storage, Feed economics and Feed evaluation criteria (FCR, PER, NPU, BV). Nutritional diseases, Culture of Live food organisms, bio-enrichment, bio-routing, Feed economics and Feed evaluation criteria. Equipments used in feed manufacture.

Unit 5. Farm & Hatchery Design and Construction

Criteria for site selection for various culture practices. Design and construction of aqua-farms (site selection, nutrient and soil quality, water supply and water circulation). Design and construction of carp, freshwater prawn, shrimp and trout hatchery. Design, layout planning and construction of different types of production systems, Earthwork calculations and cost estimation, Surveying and levelling. Types of pumps, types of Aeration system. Design of channels, Aeration and its types, Air blower, Filtration system, Design and types of filter. Types of ponds, shape, size and orientation, design of embankments, construction of poly houses, recirculatory system; construction of pens, cage design and construction, fixed cages, floating cages, semi-submerged and submerged cages, towing cages, flow through systems, race ways, aquaponics, biofloc systems. Water budgeting and renewable energy on aquaculture. Artificial intelligence and machine learning in aquaculture. Precision Aquaculture.

35. FISHERIES RESOURCE MANAGEMENT

Unit 1. Fisheries Resources

Major fisheries resources of the world and India, global trends in production; Commercially exploited fish and shellfish stocks of India - their distribution, potentials, status, means of exploitation and yields; Target and non-target fisheries resources of the Indian subcontinent and the Exclusive Economic Zone (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 and oceanic islands; Resources associated with open sea and sea mount; Straddling/shared stocks and non-conventional resources; Sport fisheries. Biodiversity, Juvenile exploitation, Bycatch and Discards, Destructive fishing gears and methods.

Unit 2. Fish Biology and Physiology

Biosystematics of commercially important fish, shellfish; Classical and Modern tools in ichthyotaxonomy; Fish phylogeny; Speciation; Fish reproductive biology: Gonado Somatic Index; Fecundity; length at first maturity; Male reproductive system of finfish and shellfish; Female reproductive system of finfish and shellfish; Physiological control of reproduction in finfish, crustaceans and molluscs; Feeding, Developmental biology of commercially important finfish and shellfish; Age and growth studies; Mortality and Recruitment; GIS in resource mapping and forecasting; Monitoring Controlling and Surveillance; Application of tagging and marking in fisheries, Fish migration; Structures and design of fish passes. Modern techniques in fisheries biology: DNA isolation, PCR; DNA barcoding, Meta barcoding, Application of mitochondrial and nuclear markers for genetic stock identification.

Unit 3. Fish Stock Assessment

Concept of fish stock; Distribution and type of stock: unit stock, mixed stock, straddling stock; Characterization and delineation of fish stocks (life history traits, truss network, environmental signals, otolith shapes, genetic analyses); Principle and general procedure of fish stock assessment; features of tropical and temperate fish stocks; Sampling and data collection methods; Indicators and reference points; Carrying Capacity; Recruitment, growth and mortality of fish in natural water bodies; Gear selectivity; Fish stock assessment models - holistic models, analytical models, rapid stock assessment, their advantages and disadvantages; Cohort dynamics; Concept of Maximum Sustainable Yield and Maximum Economic Yield; Prey- predatory models, ECOPATH with ECOSIM; Computer softwares in stock assessment.

Unit 4. Fishing Technology

Different types of fishing crafts and gears, operation and their maintenance; Boat building materials, fishing gear materials, advantages and disadvantages; Evolution of mechanization of crafts in India; Safety measures for the fishing boats; Recent advancements in the construction of active fishing gears; Fishing gears and crafts for deep sea and inland fishing; Green fishing practices; By-catch reduction devices, turtle excluder devices, finfish and shrimp excluder devices; Use of modern techniques and electronic equipment for fish finding, aggregating and capturing; Vessel monitoring system. Fishing Harbours – Types and Components.

Unit 5. Sustainable Fisheries Management

Components and indicators of sustainability; Issues in fisheries - overexploitation, overcapacity, ghost fishing, habitat degradation, damming of rivers, interlinking of rivers, climate change; Reduction of bycatch; Rebuilding fishery/stock; Fishing conflicts - exotic species and their impact, accidental introductions, invasive species, transboundary issues, Illegal, Unreported and Unregulated (IUU) fishing; Traceability certification; Technical guidelines of CCRF for responsible fishing; National and international treaties. Concepts and principles of fisheries management (inland, estuarine and marine); Fisheries biosystems; Indicators and reference points of sustainability; Anthropogenic intervention, stock enhancement and sustainable management approaches in riverine, reservoir, lacustrine, floodplain wetlands and marine fisheries; Modes of fisheries management – open access, regulated, advisory, participatory, user rights; Input control measures - access control and limited entry (size, type, number and power of boats, duration of fishing), licensing, capital investment; Output control measures - total allowable catch, catch quotas, minimum legal size; Technical control measures - size limitations, closed areas, closed seasons, eumetric fishing and mesh size regulations; co-management, right-based fishing, Management of conflicts within sub-sectors in fisheries; alternative livelihood options; Ecosystem based fishery management; Fishing down the food web.

Unit 6. Aquatic Ecosystem and Restoration

Aquatic habitats – freshwater, estuaries, and marine – their structure, functions, ecological services, productivity and carrying capacity; Trophodynamics and energy flow in aquatic ecosystems, ecological nice, trophic indices and modeling; Plankton and benthos, their role in productivity; Bioindicators, bioaccumulation, bioconentration and biomagnification; Ecological stability and homeostasis; Aquatic pollution and impacts on aquatic resources; Habitat degradation and its impact on fisheries; Synoptic oceanographic analysis – currents, waves, tides, El Nino-southern oscillation; mudbanks, upwelling, downwelling and circulation patterns ocean circulation and fisheries; Fisheries forecasting using environmental parameters; Application of bioprocesses – bioremediation, biomanipulation, bioaugmentaion, biofouling; Influence of environmental parameters on fish abundance, distribution, fish production and resource resilience; harmful effects of algal blooms on fisheries; Ecosystem valuations, Integrated coastal zone management (ICZM); Vulnerability of fishers to natural disasters and coping mechanisms; Artificial Reefs, Fish Aggregating Devices and their uses.

Unit 7. Aquatic biodiversity and conservation

Biodiversity – species, genetic and ecosystem; Biodiversity assessment and indices; Endemic biodiversity; Biomonitoring, bioprospecting and biopiracy, Influence of environmental parameters on fish abundance, distribution, resource resilience; Species concept for conservation related decisions - unique species, umbrella species, flagship species, keystone species, State Fish concept; Threats to fish diversity; biodiversity conservation methods - *ex situ* and *in situ*; IUCN criteria, IUCN-Red List; Participatory approach; Conservation biology- Concept of hotspots. GIS and Remote Sensing, their applications.

Unit 8. Management of ecologically sensitive areas

Ecologically sensitive areas (mangrove, corals, seagrass beds, mudflats and dunes, turtle nesting grounds, horseshoe crab habitat, protected areas, biosphere reserves, salt marshes; freshwater wetlands), their distribution, ecological role, associated fauna and flora – taxonomy, adaptations and biology; Issues, management, regulations and conservation strategies.

Unit 9. Climate change and fisheries

Climate change, causes and its impacts on sensitive aquatic ecosystems, capture fisheries and fish abundance, distribution and physiology; Carbon footprint in fisheries and its impacts on fisheries (temperature rise, ocean acidification, coral bleaching, Ocean acidification; Global ocean circulation; El Nino and Southern Oscillation, IPCC and its reports, UNFCCC, Kyoto Protocol; Global and regional models on climate change and fisheries; Mitigation and adaptation strategies - resilience, vulnerability and risk assessment, institutional mechanisms.

Unit 10. Fisheries legislations and regulations

Fisheries policies, instruments and mechanisms for fisheries management; Overview of fisheries acts and legislations, revisions and amendments; National policies and regulations – Indian Fisheries Act, The Environmental (Protection) Act; Wildlife protection act, Maritime Zones of India Act, Biodiversity Act, National policy on fisheries, Territorial sea, Contiguous zone, Exclusive Economic and Fishery Zones Act; MFRA, Deep sea fishing policy, Guidelines for deep sea vessels, Coastal Regulation Zone notification, green certification, fish catch certificate, MPEDA Act; International fishery regulations, treaties and instruments – UNCLOS, UNFSA, FAO-CCRF, CITES, CMS, Ramsar Convention, MARPOL, CBD, IWC, IOTC, RFMOs, BOBP, NFDB.

36. FISH PROCESSING TECHNOLOGY

Unit 1. Fish Biochemistry

Major and minor constituents of fish, their distribution and function-– Proteins- classification- Fish muscle proteins- Structure -Myosin –Actin- other structural proteins – classification- functional properties and their applications in product preparation -protein Denaturation- Lipids-types – structure and classification; PUFA and its health benefits ; lipid oxidation- Pro- and anti- oxidants- indices of lipid oxidation-Carbohydrates- classification, structure and properties - Vitamins and minerals- seafood flavors and pigments – Myoglobin– Hemoglobin- Myocyanin - allergens – Antifreeze proteins. NPN compounds- Fresh Fish quality and biochemical indices of quality – Post-mortem changes. Effect of preservation methods on proteins.

Unit 2. Microbiology of Fish and Fishery Products

Microbial activities in different foods in relation to intrinsic and extrinsic parameters. Microbial composition of fresh and preserved fish. Control of microorganisms in foods. Modification of intrinsic and extrinsic parameters for fish preservation -Food-borne pathogens of public health significance infection and intoxication- virulence- incidences – prevention- Sources of contamination and control measures -Isolation and identification of pathogens- Microbial spoilage of fresh, semi-processed and processed fish and fishery products; biogenic amines; Microbial quality standards for export trade. Viruses and parasites in fish. Biofilm formation and its significance in fish processing, Quorum sensing. Antimicrobial resistance. Immunological techniques- Antigen – Antibody reactions- Immunoassays – ELISA, Molecular methods of pathogen detection – PCR, Real Time PCR, microarray. Microorganisms of public health significance.

Unit 3. Low-temperature Preservation of Fish

Chilling of fish: Principles- Types of chilling- Icing -quality of ice- ice making- onboard handling of fish-chilling rate; spoilage of fish during chilled storage- Chilled fish transportation - refrigerated transport systems, storage methods and Heat load calculations - Fish freezing: principles- freezing point depression, eutectic point; Glass transition- freezing rate crystallization and recrystallization- Freezing rate calculation -Types of freezers- Methods of freezing – Quality changes during frozen storage- microbiological, physical and chemical changes- Prevention of quality loss- Cryoprotectants-Glazing -Drip loss. Thawing: Principle -Methods of thawing - Sanitation in freezing plants - HACCP in freezing industry- National and International Quality standards- Requirements for construction of cold storage; Cold chain system.

Unit 4. Fishery Products

Principles of fish preservation and processing. Intrinsic and extrinsic factors-Handling of fresh fish- Hurdle technology in fish preservation. Preservation of fish by curing: salting, sun drying, smoking, marination and pickling; and fermentation -Fish paste products. Fermented fishery products of India and the world. Health benefits of fermented fish; Drying and dehydration- principles - water activity – drying kinetics-hysteresis in fish drying process, Artificial drying- solar dryers- Mechanical dryers - Irradiation preservation.

Unit 5. Thermal Processing of Fish

Classification of foods based on pH -–Principles of thermal processing- mechanism of heat transfer--cold point – sterility- heat resistance of bacteria and spores. Thermobacteriology-*Clostridium botulinum* TDT, D value, Z value and F0 value- 12 D concept -Cook value- Types of packaging materials for canned foods- Types of containers – metal containers (Tin Plate, TFS, Aluminium cans)- Manufacturing of cans -Canning unit operations - HTST and UHT processing – Aseptic canning- Retort pouches-properties, manufacturing, retort pouch processing- over pressure retort- Methods of thermal process calculation- Spoilage of canned foods. Standard specifications for canned fishery products.

Unit 6. Value-added Fishery Products

Concepts of value-addition - types of value-addition - Machineries – Mince-based products - Surimi preparation- Mechanism- -Packaging- Storage- Quality evaluation -Analogue products - Battered and breaded products - Freeze dried products – Ready-to-eat and ready- to-cook products - extruded products- Mechanism of extrusion- Type of extruders – Fortification of foods-Seaweed based products. - Zero waste in fish processing.

Unit 7. Fish by- products and Waste Utilization

Fish meal, FPH, fish silage, fish oils-squalene- shark cartilage- ambergris- extraction of collagen, gelatin, fish leather, and enzymes- carotenoids-chitin-chitosan- glucosamine- pigments. Agar, carrageenan, alginates, bioactive peptides- Industrial waste – liquid and solid waste in fish processing- Anaerobic treatment- Animal feed production- Biodiesel production-biogas production-Industrial application.

Unit 8. Food Additives in Fish Processing

Classification of food additives-preservatives-antioxidants- emulsifiers – Stabilizers – Food colors – Flavors – sequestrants - anticaking agents- humectants – firming and crisping agents-Sweeteners - enzymes – Hydrocolloids – functions and significance as food additives- Cryoprotectants, etc. - Risks and benefits of food additives – Health considerations and safety evaluations – GRAS additives.

Unit 9. Packaging of fish and fishery products

Principles and purposes – Packaging materials- Basic films and laminates - Properties and testing methods of packaging materials - Packaging for live fish transportation – Chilled and frozen fish-Vacuum packaging - Modified atmospheric packages- Package designs - Labeling and printing - Edible packaging- Biodegradable packaging, Active packaging, Intelligent/Smart Packaging and RFID Technology.

Unit 10. Fish quality assurance and management

Factors affecting seafood quality- Quality assessment: Sensory, Instrumental and Biochemical-Hazards: Physical, chemical and biological hazards- Quality Assurance, Quality Management, Total Quality Management – GMP – SSOP- HACCP for seafood industries: Principles and Applications - Risk analysis and assessment-Plant sanitation - Plant layout (canning plant, fish meal plant, surimi plant, freezing plant) - Personnel hygiene – water quality- Pest control – Environment, energy and food safety standards.

Unit 11. Seafood trade regulation and certification

Seafood Trade - World Trade Organization - Sanitary and Phytosanitary (SPS) Agreement - Technical Barriers to Trades (TBT) Agreement- Food laws and standards - Legislation for export - Role of EIA and MPEDA in seafood export- IPQC, Self-Certification, food safety management systems based certification- Processing Plant Registration -Fishing Vessel Registration -Processing Plant Approval -Monitoring Schedule -Health Certificate -Internal Alert- Recall procedures -Catch Certificate- Pre-Harvest Test Certification -Seafoodregulation- EU, USFDA, FSSAI , ISO, Codex Standards - Seafood audit : GFSI, BRC – Ecolabelling-Traceability.

37. FISH NUTRITION

Unit 1. Principles of Fish Nutrition

Nutrients, sources, structure, classification and biosynthesis; metabolism of proteins, lipids, carbohydrates, nucleic acids, vitamins and minerals; essential amino acids,; amino acid analogues; fatty acids; vitamins and minerals and their role in fish nutrition, protein and amino acid requirements, lipids and fatty acid requirements, vitamin and mineral requirements in herbivores, carnivores, major freshwater, marine and brackish water cultured species; energy requirements, sparing action; P:E ratio; assessing nutritional requirements of larvae, fingerlings, juvenile, grow out, broodstock and fattening; basic fish bioenergetics, energy partitioning, and energy budget equations.

Unit 2. Nutritional Physiology

Morphology, anatomy and physiology of the digestive systems of various types of fish and shellfish; nutrient digestion and digestive processes; digestive enzymes in fish; gastric, pancreatic and intestinal secretions; nutrient and neuro-endocrine regulation of digestion; factors affecting feed intake, digestion, absorption and assimilation; microbial digestion; digestibility and factors affecting digestibility; absorption and transport of nutrients in the body, storage, conversion and utilization; role of liver and muscles in fat and glycogen storage and release: significance of reproductive physiology in fish and shrimp.

Unit 3. Feed Formulation, Feed Technology and Feeding Management

Principles of feed formulation; feed ingredients; international coding of feed ingredients; feed quality; evaluation of feed/ingredient; conventional unconventional and novel ingredients; feed additives and feed binders; antinutritional factors and their remedial measures; methods of feed formulation; Design of pelleted and extruded feed mill; methods of feed processing; milling; micronisation; solid state fermentation; feed processing unit; various feed types such as moist, semi-moist, dry, crumble, pellet, sinking, slow sinking, floating, microbound, microencapsulated and micro-coated feeds; feed storage, packaging and prevention of spoilage; high energy and low pollution feeds; system-specific feeds; Feed standards, quality control in feed, traceability of feed ingredients, feed and food safety; climate smart feeds; feed and feeding management; feeding frequency, ration and feeding rates and feeding methods. recent developments in feed processing and feed management.

Unit 4. Nutrition and Fish Health

Nutrients and their effects on fish health; antinutritional factors and their effects on fish health; nutritional disorders: deficiency, imbalances and toxicity; nutraceuticals for fish health; Nutrients as stress busters, prebiotics, probiotics, synbiotics, nutrients and immunity; nutrients and flesh quality; hyper- and hypo vitaminosis; mycotoxins in fish feed,; dietary fatty acids and stress tolerance in fish larvae, biofloc and its significance as feed and functional ingredient for improved health.

Unit 5. Nutrigenomics

Nutritionally important genes; genetic control of metabolic pathways; nutrigenetics; epigenetics; immune genes, growth factors; gene regulation by protein, lipids, carbohydrates, vitamins and minerals; gene and protein expression changes with nutrients and feeds; techniques in transcriptomics; reverse transcription and cDNA synthesis, proteomics and metabolomics; and applications of nutrigenomics in fish nutrition.

Unit 6. Broodstock and Larval Nutrition

Role of nutrition in gonadal development, maturation and reproductive performance; special ingredients and nutrients for broodstock feed; bioenergetics of maturation; energy flow during early ontogenesis; nutritional profile of egg; utilization of egg proteins, amino acids and lipids; abiotic factors influencing yolk absorption; ontogeny of digestive system; formulated feed in larval nutrition, preparation techniques, weaning and significance of live feeds: nutritive value of live food, live food enrichment, weaning and co-feeding strategies; bottlenecks in larval nutrition and nutritional programming.

Unit 7. Physiology of Homeostasis and Nutrient Utilization

Physiology of feed intake; factors affecting feed intake; feeding stimulants and feeding behavior; neuroendocrine regulation of feed intake; circadian rhythms of feeding activity; starvation and feed restriction; neuroendocrine control of metabolism and nutrient utilisation; osmoregulation, ionic balance and regulation strategies; nutrients and osmoregulation; vitellogenesis; mechanism of excretion of nitrogenous waste; stress physiology and dietary mitigation measures, nutrients role in high and low saline environment.

38. FISH HEALTH

Unit 1. Principles of Aquatic Animal Health Management

Definition of health and disease in fish. Predisposing factors, biotic and abiotic factors, Stress and general adaptation syndrome. Role of physical chemical (pH, salinity, toxins, ammonia, nitrogenous waste, endogenous chemical metabolites, free radicals, oxidants), soil and water parameters in fish health. Aquatic animal health safety regulations at national and international levels; Principles of quarantine and biosecurity, Transboundary diseases, disease reporting, live fish transportation, import risk analysis. Health certification: Principle, procedure, the regulatory body for aquaculture health certification. Legislative framework of chemotherapy in aquaculture, drug regulation acts and other legal aspects. Management measures for the environment: bioremediators, biocontrol agents. Management measures for the host: specific pathogen-free (SPF), specific pathogen-resistant (SPR) and specific pathogen-tolerant (SPT). Probiotics, prebiotics and paraprobiotics, immunomodulators and concepts of vaccination, types of vaccines, advances in fish vaccinology, climate-pathogen-host interaction.

Unit 2. Diseases of Finfish & Shellfish

Basic understanding of fish pathogens: Bacterial morphology, classification, metabolism, bacterial toxins and virulence factors. Major bacterial, Classification of viruses, virus-host relationship, replication of virus**,** virulence factors. Pathogenesis, molecular biology, epidemiology and major viral pathogens of finfish and shellfish (both OIE-listed and non-OIE listed). Major fungal diseases of finfish and shellfish. Zoonotic pathogens and public health, emerging and re-emerging diseases, disease problems in smart aquaculture. mycotoxicosis, Clinical signs, etiology, pathology, epidemiology, host-parasite relationship, diagnosis, treatments and control of the diseases caused by protozoan and metazoan parasites of fish and shellfish. Environmental and non-infectious diseases of fish: Mycotoxicosis- important mycotoxins; chemical toxins, and other toxicants and their effects on fish health; Various diseases due to nutritional imbalance, vitamin deficiencies and mineral deficiencies and their toxicity.

Unit 3. Fish Pathology

General pathology- degeneration, necrosis and different morphological patterns, autophagy apoptosis, pyroptosis, necroptosis, inflammation, types of inflammation, mediators and their function. Causes and cellular responses to inflammation. Abnormalities in cell growth aplasia, hypoplasia, atrophy, metaplasia, dysplasia. Tumours and neoplasm growth. Clinical and systemic pathology caused by fish pathogens. Reversible cellular changes and accumulations: fatty changes and pigments; tissue repair. Clinical pathology: Normal constituents of blood, alterations in the haematological parameters and enzymes with reference to different pathological conditions in finfish, haematology of shrimp and molluscans, clotting mechanisms. Systemic pathology of finfish: integumentary system, respiratory system, vascular system, digestive system, excretory system, nervous system, musculoskeletal and endocrine system due to bacteria, parasites and viruses. Systemic pathology of shellfish: Major pathological changes due to infectious diseases in the integumentary system, lymphoid organ, gill, hepatopancreas, gut and other organs/of crustaceans; major pathological changes due to diseases in molluscans.

Unit 4. Fish Defence System and Immunology

Introduction to fish immunology: Phylogeny and ontogeny of the immune system, lymphoid tissues and cellular components of the immune system, T and B cells, mucosal immune system. Finfish immune mechanisms; antigen processing and presentation, T-cell activation and differentiation, B-cell activation, cytokines and MHC.Specific immune system of finfish: Memory function and immunological tolerance, antigens and antigenicity, antigen processing, superantigens, haptens. Antibody:structure, types, theories of antibody formation; regulation of immune response. Antibody- mediated and cell-mediated immunity: Cell-mediated immune responses and their components; antibody-mediated immune responses; polyclonal and monoclonal antibody production and application. Non-specific immune system of finfish: Phagocytosis; mechanism of phagocytosis. Complement system: function, components, complement activation. Shellfish immune mechanisms: Invertebrate defence mechanisms; trained immunity, quasi-immune response.

Unit 5. Aquatic Animal Disease Diagnosis

Introduction to fish disease diagnosis: Diagnostic features of important diseases of finfish and shellfish, different roles and levels of diagnosis in aquaculture, evolution of diagnostic techniques in aquaculture. Safety in microbiology laboratory; bio-safety levels and risk groups; techniques in sterilization, preparation of microbiological media, culture techniques, purification, preservation and maintenance of bacterial and fungal cultures. Microscopic techniques: Bright field, darkfield, phase contrast, fluorescence, and electron microscopy. Cell culture-based diagnostic methods: Principles of cell culture; development of primary cell culture; maintenance of cell lines. Different cell lines used for fish virus isolation, CPE. Protein-based diagnostic methods: Antibody-based diagnostic methods - immunohistochemistry, ELISA, western blotting, lateral flow assay. Hybridoma technology and monoclonal-antibody-based diagnosis. Nucleic-acid-based diagnostic methods: Nucleic acid amplification methods; types of PCR: reverse transcriptase-PCR, real-time PCR and other variants of PCR; In situ hybridization; dot blot assay; LAMP.

Unit 6: Fish Pharmacology and Therapeutic measures for fish diseases

Different chemicals and common therapeutants used in aquaculture; their mode of action, dose and dosage, methods of application; Phytotherapy, phage-therapy, nanoparticle-based drugs, antimicrobial peptides. Drug toxicity and poisoning, antimicrobial resistance and its impact on environment and human health. Pharmacokinetics and pharmaco- dynamics; residual effect and withdrawal period of various chemotherapeutants. Pharmacovigilance, immunophamacology, pharmacogenetics, OECD guidelines. Legislative framework of chemotherapy in aquaculture; drug regulation acts and other legal aspects. One health concept of OIE.

Unit 7. Epidemiology and disease surveillance

Epidemiological concepts and types, patterns of disease-epidemic curve, the importance of aquatic animal diseases. Disease surveillance, active and passive surveillance. Survey and data processing. Aquatic animal health information systems; national and regional strategic plan for aquatic animal health. National and international disease reporting: emerging disease preparedness.

39. FISH GENETICS & BREEDING

Unit 1. Principles of Fish Genetics and Breeding

DNA as a genetic material, genetic code and protein synthesis, chromosome manipulation, ploidy induction, sex reversal, gynogenesis; Recombination; Interference; Linkage disequilibrium; Cytogenetics and evolution; Karyotyping and chromosome banding. Historical development of genetics and breeding; Aim and scope of genetics and breeding; physical basis of heredity; Mendel's Principles: Scope, limitation, modifications to Mendel's ratios, multiple alleles; Epistasis; Chromosomal theory of inheritance; Genetic variation: Causes and measurement; Genetic basis of sex determination; Sex-linked, Sex-limited, and Sex-influenced traits; Y-linked inheritance; Chromosome manipulation: Ploidy induction, Sex reversal, Sex manipulation, Sex determination, Gynogenesis and Androgenesis; Chromosomal aberrations; Mutations- Natural and Induced, Mutagens, DNA and plasmid isolation, DNA replication..

Unit 2. Population Genetics

Genetics of population: Changes in allelic and genotypic frequency, gene and genotype frequencies and factors affecting them; Individual *vs* population, Qualitative *vs* quantitative traits, Effective population size, estimation of inbreeding, F statistics, Wahlund effect, Genetic similarity and Nei's genetic distance, Hardy-Weinberg principle; Systematic and dispersive forces changing gene and genotypic forces; Genetic bottle neck and mutation, genetic drift, Founder effect; population genomics, Least squares and BLUP methods.

Unit 3. Quantitative Genetics

Quantitative variation: Gene effects, Mode of inheritance and continuous variation; Population mean; Components of phenotypic value, Phenomics, Genotypic value, Average effect of gene and gene substitution; Estimation tools for population genetic parameters; Heritability: Effective heritability, different methods of estimation, variance of heritability, properties and applications of heritability; Repeatability, Maternal effects; Concept of co- heritability; Breeding value; Heterosis: Theories and estimation; Utilisation of non-additive genetic variance, genetics and environmental interaction, General Linear Mixed Models (GLMM).

Unit 4. Genetic Tools for Aquaculture Application

DNA Markers for genetic stock identification: Allozymes, RFLP, RAPD, AFLP, Microsatellites, SNPs, Type-I and Type-II markers, ESTs, MtDNA markers, Nuclear DNA markers and Fluorescence *in situ* hybridisation (FISH). Next Generation Sequencing Technologies; Application of genomics, and transcriptomics and Metabolomics in aquaculture; Applications of markers in identification of species, hybrids, and stocks; Epigenetics, Methylation, Application of markers in estimating the genetic diversity, population demography, phylogeny and phylogeography. Microbiome and Metagenomics, Application of markers in developing linkage maps; Application of genome editing tools; Genome-wide Association Studies (GWAS); QTL mapping and Marker Assisted Selection. Transgenics, GMOs and Biosafety. Gene editing, CRISPR/Cas9.

Unit 5. Breeding of Fish and Shellfish

Genetic basis for selection of fish for breeding, Methods of selection, Economic traits in farmed species, Recording economic traits; Study of growth curves and their components, Influence of non-genetic factors on economic traits; Formation of base population, Designing mating plans, Sire and Dam Evaluation, Selection for threshold characters, inbreeding effects,cross-breeding and hybridisation; Mating designs for selected traits; selection for disease resistance; mono sex; cryopreservation of gametes; Endocrine control of reproduction in fish and shellfish; Synchronization of spawning; Artificial reproductive technology, Surrogacy, Broodstock development and management; Biosynthetic hormones and analogue, Fish breeding guidelines, Policies, programs and economic analyses of breeding programmes- their present national and global status, prospectus and challenges. Release and registration of new varieties; Quality seed: classes, production practices and maintenance of pure seed; Seed purity standards; Seed quality and fish seed certification.

Unit 6. Fish Genetic Resources and Conservation

Fish genetic resources, Breeding strategies for threatened species; *In situ* & *ex-situ* conservation: Issues and strategies; IPR issues of genetic resources; Regulations regarding introduction of exotic germplasm; Export import rules and regulations on conservation of aquatic genetic resources; Fish quarantine – status, procedures, scope and significance Convention on Biodiversity and National Biodiversity Authority of India; Access and benefit sharing of aquatic genetic resources of India; Material Transfer agreement (MTA), Effect of climatic change on biodiversity; Evolution and genetic diversity, maintenance of genetic diversity in natural and captive populations; Genetic variability

and differentiation, equilibrium, null alleles, population genomics, outlier loci and adaptive variation in trait- related genes. IPR issues and Genetic resources; biodiversity laws and regulations for germplasm exchange; molecular tools for species identification; identification of farm escapees; fish quarantine; application of Genomics in conservation; Conservation endocrinology.

Unit 7. Bioinformatics

File Transfer Protocols; Work stations; Application of spreadsheets in maintaining fish breeding records and breeding data management; Fish breeding data bases; Primary and secondary structure database, Data input, import, export, modification; Data cleaning, manipulation and transformations; data normalization; Graphical analysis and representation of breeding data; data mining tools; Databases on DNA barcodes, DNA, RNA, and Proteins, NCBI GenBank; Protein Information resources; EST databases. Phylogenetic tree analysis, Tools in sequence alignment (pairwise and multiple) and sequence retrieval; sequence analysis using various *in silico* tools.

40. AGRICULTURAL CHEMICALS

Unit 1: General chemistry Surface chemistry, pH, Buffer solutions; Redox reactions, Chemical kinetics, Stereochemistry and chirality, diastereoisomerism, tautomerism, atropisomerism, asymmetric synthesis, nomenclature of organic molecules, displacement, elimination, addition, rearrangement, SNI and SN2 reactions, reaction involving free radicals,and carbene intermediates, Organic reagents and catalysts in organic synthesis, Beckmann, Claisen condensation, Arndt-Eistert and Wittig reaction. Chemistry of aliphatic, aromatic and heterocyclic compounds (Preparation, properties and uses of some important compounds)

Unit 2: Chromatography and spectroscopic techniques Basic principles and application of chromatography; column, paper, thin layer, and ion exchange chromatography; gas liquid chromatography (GLC); high performance liquid chromatography (HPLC); UV, FT-IR; NMR and mass spectroscopy; GC-MS and LC-MS techniques and their applications.

Unit 3: Chemistry of natural products Extraction of natural products; Classification, structure, chemistry, properties and function of carbohydrates, proteins, amino acids, enzymes, nucleic acids, vitamins, lipids, and natural polymers. Chemistry of terpenoids, alkaloids, phenolics, plant pigments, steroidal and triterpenic saponins and sapogenin; Plant derived nutraceuticals; Chemistry of natural antioxidants and food colorants and their application in human and crop health. Biosynthetic pathways of natural products,Metabolomics (Definition, Plant and microbial metabolomics, Metabolome analysis by GC- MS, LC-MS and NMR spectrometery, Application of metabolomics in different fields)

Unit 4: Naturally occurring insecticides: Natural pyrethroids, nicotine, rotenone, neem and karanj based botanical pesticides; semiochemicals; insect pheromones-types and uses, insect hormones, insect growth regulators

Unit 5: Synthetic insecticides, fungicides, nematicides and rodenticides History, scopeand principles of chemical insect control; Insecticides and their classification Chemistry of major groups of insecticides (organo-chlorine, organophosphorus, organo-carbamates, synthetic pyrethroids, neonicotinoids), fungicides (inorganics, dithiocarbamates, OP's,phenols, qummes, carboxamides, azoles, methoxyacrylates), rodenticides, Insect growth regulators; Chitin synthesis inhibitors, insecticide synergists, fumigants. Mode of action of different groups of insecticides, fungicides and nematicides.

Unit 6: Herbicides and plant growth regulators Physical, chemical and toxicologicalproperties of different groups of herbicides (pheoxyacids, carbamates, amides, tiazines, phenyl ureas, dinitroanilines, bipyridiliums, sulfonyl ureas), Herbicide safeners, Plant growth regulators -auxins, gibberellins, cytokinins, ethylene, abscisic acid; Brassinolides; Mode of action of different groups of herbicides.

Unit 7: Agrochemical formulations: Basic concepts of pesticide formulation -classification,solid and liquid formulations; preparation, properties, uses; controlled release formulations; Formulants -carriers/ diluents, surfactants, encapsulants, binders, anti-oxidants, stabilizers;

Unit 8: Pesticide residues Pesticide residues-concepts and toxicological significance; Experimental design, sampling, principles of extraction and clean-up from different substrates; Application of ELISA and radiotracer techniques in pesticide residue analysis; new cleanup techniques, QUECHERS, ASE (Accelerated solvent extraction); Multi-residue methods; Bound and conjugated residues; Method validation -linearity, LOD and LOQ,

Unit 9: Agrochemicals -regulation and quality control: Production, consumption and trade statistics of pesticides and fertilizers; banned and restricted pesticides, registration and quality control of pesticides; Laws, Acts and Rules governing registration and regulations of agrochemical production and use; key provisions of the Insecticides Act (1968), Environmental Protection Act (1986). Pesticide Management Bill, EPA, Food Safety and Standards Act, WHO, FAO, CODEX and national/international guidelines; Quality Control, Sanitary / Phyto-sanitary issues in relation to food safety, good laboratory practices, NABL Accreditation as per 17025:2017, Pesticide stewardship

Unit 10: Natural Resource Management : Soil, plant and microbial biodiversity, Characteristics and classification of natural resources; Major soil groups of India their characteristics, management strategies for natural resources; integrated pest and pesticide management; 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 fertilizersand fertilizer mixtures, liquid fertilizers, biofertilizers, integrated plant nutrient systems;benefits, disadvantages and environmental toxicity. Nitrification inhibitors to enhance nitrogen use efficiency, Hydrogels and their application in agriculture, soil conditioners and amendments, toxicity issues.

Unit 11: Environment pollution: Implications and remediation Problems of pesticide hazards and environmental pollution; Adverse effects of pesticides on micro-flora, fauna and on other non-target organisms; disposal of obsolete and outdated pesticides;

Unit 12: Data analysis Methods of statistical analysis as applied to agricultural data -standard deviation, standard error, accuracy and precision, analysis of variance (ANOVA), correlation and regression; T- test, chi-square (X2), F test., Probit analysis.

41. AGRICULTURAL METEOROLOGY

Unit 1: General Meteorology

Laws of radiation: Planck's law, Stephan-Boltzmann law, Wien's displacement law; Kirchhoff's law, Beer's law and Lambert's Cosine law, Solar constant, length of day; Atmospheric and astronomical factors affecting 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 and balancing forces; Gas laws, pressure gradient, isobars, hydraulic equation and its application; Coriolis force, geostrophic 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-Findeisen 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; Agromet observatory, AWS and analysis of weather data; Thermal - conductivity and diffusivity, resistance.

Unit 2: General Climatology

Elements of weather and climate; Seasonal distribution of radiation, rainfall, temperature sunshine hours, atmospheric pressure over India and world; Climatic classification - Koppen and Thornthwaite; Seasonal climatology over India; Mechanism of Indian monsoon; Climaticvariability, 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; Continental, maritime and monsoon climates, El-Nino, La Nina and their impact on Indian rainfall systems.

Unit 3: Agricultural Climatology

Definition and scope of agricultural climatology; Effect of thermal environment on growth and yield of crops; Cardinal temperatures; Thermo-periodism, photoperiodism; Vant Hoff's law, phenology of crops; Heat unit concept, thermal use-efficiency; Length of growing periodand its determination. Characterization of weather and climate related risks in agriculture such as drought, floods, heat stress, cold stress etc. Contingency planning for different weather aberrations; Selection of appropriate land use and cropping patterns: types and drivers of agricultural land use and cropping patterns based on climatic situation, Meteorological factors associated with incidence and development of crop pestsand disease such as rusts of wheat, potato blight, apple scab, locust etc.; Effect of climate on humans and animals, warm and cold season indices for comfort zones, role of weather in animal disease, productivity and conception rate and protection against weather hazards. Theories of weather modification; scientific advances in clouds and electrical behavior of clouds; hails suppression, dissipation of fog, modification of frost intensity and severe storms.

Unit 4: Micrometeorology and Biometeorology

Concept of micro, meso and macro meteorology; Micrometeorological processes near bare ground and crop surfaces; Shearing stress, molecular and eddy diffusion, forced and free convection; Boundary layer, frictional velocity, roughness length and zero plane displacement; Micrometeorology of crops, 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; Radiation distribution within crop canopy; Beer's Law. 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. Definition and scope of Aerobiometeorology, its role in forecasting pests and disease outbreak, insect movement in the atmosphere, intensification, Effect of weather and climate parameters on reproduction, growth, development, movements, food, habitat and dispersal of pests and diseases.

Unit 5: Evapotranspiration

Hydrological cycle and concept of water balance, concepts of evaporation and transpiration, 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; Advantage 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

Introduction to crop modeling; modelling concepts, theories and underlying principles; types of models, Empirical and statistical models, Crop weather analysis models and their use in crop yield assessments; Dynamic crop simulation models, e.g. DSSAT, Wofost, InfoCrop, APSIM, CropSyst, etc.; optimization, calibration and validation of models. Inputs of crop simulation models, modeling of crop growth and yield; forecasting of pests and diseases; advantages and limitation of models. Climatic change, greenhouse effect, CO_2 increase, global warming and their impact on agriculture; analyzing impact of climate change on agriculture. Remote sensing derived inputs; growth and yield prediction using crop models

Unit 7: Weather Forecasting for Agriculture

Weather forecasting and its types; Tools and methods of weather forecasting; Monsoon onset, withdrawal and rainfall forecasts and their importance in Indian agriculture; Meteorological satellites for weather forecasts; Early warning systems and their importance in crop management; Weather forecasting and agro-advisories; preparation of agro-advisory and its dissemination to farmers; use of ICT in communicating crop-weather information. Crop weather calendars:

Unit 8: Remote Sensing and GIS for Agricultural Meteorology

Characteristics of electromagnetic radiation and its interaction with matter; spectral featuresof earth's surface features; remote sensors in visible, infrared and microwave regions. Imaging and non-imaging systems; resolution of sensors; sensor platforms. Drone based imaging. Data acquisition system, data preprocessing, storage and dissemination; digital image processing and information extraction. Microwave remote sensing; visual and digital image interpretation. Digital techniques for crop discrimination and identification; crop stress detection; soil moisture assessment; satellite measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation. Soil resource inventory; land use/land cover mapping and planning; integrated watershed development; crop yield modeling and crop production forecasting. Concepts of GIS, definition, raster and vector data models; data compressiontechniques; projection systems and use of GIS in Agriculture. GPS concepts and uses in Agriculture.

42. AGROFORESTRY

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 m 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 overviewof global agroforestry systems. Classification of agroforestry systems: structural, functional, socio-economic and ecological; Diagnosis and design of agroforestry system; Land capabilityclassification and land use; Criteria of an ideal agroforestry design, productivity, sustainability and adoptability: Multipurpose tree species and their characteristics suitable for agroforestry. Importance of cattle, sheep and goat vis-a-vis agroforestry systems. Feed and fodder resources in agroforestry systems and livestock management. Role of nitrogen fiXing trees/ shrubs. Choice of species for various agroclimatic zones for the production of timber, fodder, fuel wood, fiber, fruits, medicinal and aromatic plants. Generic and specific characters of trees and shrubs for agroforestry. Fruit crop and small timber trees and their need and relevance in agroforestry, trees suitable for various assemblage and their planting plan in different agroclimatic zones and agroforestry system. Intercropping in fruit orchards like Apple, Walnut, Jack fruit, Mango, Sapota, Pomegranate, Orange, Citrus, Guava, *etc*. Modification in tending and pruning operations and canopy management. Fertility management,yield and quality improvement.

Unit 3

Plant management practices in agroforestry; Tree-crop interaction: ecological and economic; Concept of complementarity, supplementary 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 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 methodsfor breaking dormancy; Seed testing and germination tests; Seed certification and !STA 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 specie,,. 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 agedand 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 m 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, volumetables; Measurement of rangeland productivity; Forest enumeration: sampling methods, sample plots, surveys and photo interpretation; Concept and applicat1on of GIS andremote 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 m India.

Unit 12

Climate change: greenhouse effect, sources and sinks of greenhouse gases, majorgreenhouses 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 CO2 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.

43. AGRONOMY

Unit 1: Crop Ecology and Geography

Principles of crop ecology; Ecosystem concept; 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 India; 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 andallelopathy; Crop weed competition, weed threshold; Herbicides classification, formulations, mode of action, selectivity and resistance; Persistent of herbicides in soils and plants; Application methods and equipment; Biological weed control, bio- herbicides: Integrated weed management; recent development in weed management; Special weeds, parasitic and aquatic weeds and their management in cropped and non-cropped lands; weed shifts incropping systems; weed control schedules in field crops, vegetables and plantation crops; Role of GM crops in weed management; cost: benefit analysis of 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, functions and deficiency symptoms, nutrient interactions, diagnostic techniques with special emphasis on emerging deficiencies of secondary and micro-nutrients; Soil fertility and productivity and their indicators; features of good soil management; 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; 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, conservationcropping 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; Timeline 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 in india. 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.

Unit 6: Crop Production

Crop production techniques for cereals, millets, pulses, oilseeds, fiber crops, sugar crops, fodder & pasture crops, medicinal, aromatic & under-utilized crops and agro-forestry system including origin, history, distribution, adaptation, climate, soil, season, improved 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 (X2); 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; Method of statistical analysis for cropping systems including intercropping; Pooled analysis.

Unit 8: Sustainable Land Use Systems
Concept of sustainability; Sustainability parameters and indicator; Conservation agriculture (CA); climate change mitigation; Alternate land use systems; Types, extent and causes of wasteland; Shifting cultivation; Agroforestry, concept and importance, agro forestry systems; Agrostology, grassland ecology, problems and management of grassland; Agricultural and agro-industrial residues and its recycling, safe disposal; Allelopathy and biomass production; nutrient, water, weed, insect-pest and disease management in conservation agriculture; economic considerations in CA, adoption and constraints. Artificial intelligence: conceptsand application.

Unit 9: Basics of Soil and Water
Soil and water as vital resources for agricultural production; Soil-plant water relationship; Fate of rain water received at the soil surface, runoff and infiltration reciprocity, factors affecting infiltration, means to enhance in filterability 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 indicator.

Unit 10: Soil Water Relationship
Soil water relations, water retention by soil, soil moisture *ch*aracteristics, field capacity, permanent wilting point, plant available water and exchangeable water, Soil irrigability, classification, 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, watergains 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; Erodibility 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

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 watersupplies; Methods of irrigation, merits and demerits of various methods; Measurement of irrigation water, application and distribution efficiencies; Management of water resources (rain, canal and ground water) for agricultural production; Irrigation legislation; Water quality, conjunctive use of water, irrigation strategies under different situation of wateravailability, Socio-economic aspects of on-farm water management; Irrigation water distribution; 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 brakish waters in agriculture; Excess saltand 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; Management of problematic soils, role of amendments, and drainage.

Unit 14: Organic Farming

Organic farming: concept, definitions, components and types, its relevance to India and global agriculture and future prospects; Principles of organic farming; Organics and farming standards; Organic farming and sustainable agriculture; Management practices in organic farming; Selection and conversion of land, soil and water management; Soil fertility, components of organic nutrient management, ITKs and farmers' innovations in nutrient management; Water and fertilizer use efficiency; Nutrient recycling; Organic manures; Soil biota; Bio-fertilizers and biogas technology; Integrated organic farming systems; Multiple and relay cropping systems; Consumers' concerns on food quality and safety; Weeds, diseases and insect pest management; Socio-economic impacts; Marketing and export potential: Organic certification, standard and regulations; Principles and practices responsible for losses of organic agricultural produce; Spiritual values and ethics.

44. ENVIRONMENTAL SCIENCE

Unit 1:
Definition, scope and importance of environmental science and its interrelationship with other sciences and agriculture; Origin and evolution of the earth; concept of plate tectonics and continental drift theory; spheres of atmosphere: hydrosphere, Lithosphere and biosphere; Biogeochemical cycles; Components of environment - biotic, abiotic and social; Weather andclimate; Human Settlement, History; Effect of various developmental activities onenvironment. Concept of sustainability and sustainable development

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; Population - characteristics and measurement; Communities - habitats, niches, population dynamics, species and individual in the ecosystem; Diversity indices; Types characteristic features, structure and function of forest, grassland, plantation, desert, aquatic and agro-ecosystem; Ecological succession - types and causes; ecological footprints; virtual water trade and water footprints. Ecosystem services.

Unit 3:
Biodiversity concepts, levels and types, changes in tune and space, evolution, centres oforigin of crops, species concept; Significance of biodiversity; Keystone, Flagship, Umbrella, and Indicator species; Species reintroduction and translocation. Plant genetic resources, exploration and collection; Crop domestication, plant introductions; agrobiodiversity.Migration and utilization; IUCN clauses and concept of threatened and endangered species; Red Data Book, Biogeography; Principles and methods of conservation of biological diversity: in-situ and ex-situ. Causes of loss of biodiversity: introduction of exotics and invasive plants, role of national parks, wildlife sanctuaries, biosphere reserves; National and global conservation measures, institutions and conventions; Indian Biodiversity Act 2002, PPV&FRA 2001; Biodiversity and economics with special reference to India; Biodiversity in relation to global environmental changes; Biodiversity hot spots in India and world; Biodiversity and food 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 and controlling measures; Effects of air pollutants on crops, vegetation. animals and human health; Factors affecting plant response to air pollution; Acid rain, physiological and biochemical effects of SO_2, HF, PAN O_3 and emerging pollutants on vegetation, toxicity symptoms on vegetation; defence mechanism, sensitive and tolerant plant species to air pollutants. Concepts of diffusion and dispersion, Gaussian plume model, hydraulic potential; Darcy's equation; concepts of heat transfer – conduction – Convection; National and international laws and policies on air pollution; Air Quality Index; Air Pollution Tolerance index (APTI); 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; sources of water pollution, 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; e-waste. Emerging pollutants; persistent organic pollutants. Wetland conservation and management; eutrophication- types, effects and management; Biomagnification and its impact on loss of biodiversity; Physical, chemical and biological properties of wastes; Heavy metal contamination of environments, Ecotoxicology basic concepts; , Bioremediation; sampling of air, water and soil and methods for determination of different pollutants. Noise pollution: Sources and Control Measures. National and International laws and maximum permissible limits of air, soil, water and noise pollutants Artificial intelligence (AI) and machine learning (ML) in pollution control.
Effluent treatment processes for major industries viz. distilleries; paper and pulp, sugar, other agro-industrial wastes; Resource, product recovery, recycling and value addition to wastes; Biodegradation and bioconversion of organic wastes, composting, landfills; vermicomposting, mushroom cultivation etc.; sludge, fly ash, effluents and other agro industrial wastes, their types and sources, collection and transportation. Microbial, chemical and phytoremediation processes; safe disposal of waste. Role of microbes in waste recycling; Agro-waste processing and recovery of value added products.

Unit 5:
Climate change: Global warming and greenhouse effect, sources and sinks of greenhouse gases (GHG), major GHGs, analytical techniques of monitoring GHG in atmosphere; Global climate change - its evidences, history and future projections; extreme events. Impact of climate change on agriculture, forestry, water resources, soil processes, sea level rise, livestock, fisheries, coastal ecosystem and dynamics and pests and diseases and overallecological processes; Climate change and food security; Contribution of agriculture and forestry to climate change; International conventions and national initiatives on climatechange; Stratospheric ozone layer depletion-effect of UV radiation on plants and human health; Climate resilient agriculture, Adaptation and mitigation strategies of climate change including microbial interventions. Global dimming, agro biological effects of climate drivers (CO_2, temperature, rainfall), on crops; Carbon sequestration, Carbon trade – Cap and Offset, Carbon footprints, Life Cycle Assessment; Fundamentals of systems, models and simulation; types of models; modelling crop and soil processes; Use of Crop Simulation Model, AI and ML in climate change studies.

Unit 6:
Energy consumption pattern in urban and rural India; Conventional and non-conventional sources of energy, Types of renewable sources of energy; Generation of hydro-power, tidal energy, wind, solar, ocean thermal energy conversion, gasification: generation and application. Bioenergy: methods to produce energy from biomass, energy crops; Biofuel; Biogas production, challenges and opportunities and utilization of biogas slurry in agriculture. National bioenergy and biofuel policies and schemes. Potential of renewable energy sources in India, Integrated rural energy programme; national and international initiatives on renewable energy.

Unit 7:
Natural resources of India: land, soil, water and forest and their conservation and management including wildlife; Effects of deforestation on soil erosion; Land degradation; Wasteland: their extent, characteristics and reclamation; Mineral resources: use and exploitation, environmental effects of extracting and using mineral resources; Disaster management: floods, droughts, earthquakes· Tsunami, cyclones and landslides; Nuclear hazards;

Unit 8:
Environmental Assessment, Management and Legislation; Aims and objectives of EIA; Risk Assessment; Overview of Environmental Laws and Policies in India; National Forest Policy, 1988, National Water Policy, 2002, National Environmental Policy, 2006. Environmental Conventions and Agreements, etc. Environmental communication and public awareness;Environmental policy.

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 (X2) tests; Experimental designs - basic principles, completely randomized, randomized block, Latin square and split plot designs.

45. SOIL SCIENCES

Unit 1: Soil genesis, classification, survey and land use planning

Concept of land, soil and soil science. Composition of earth crust and its relationship with soils; Rocks, minerals and other soil forming materials; 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. Soil Taxonomy - epipedons, diagnostic subsurface horizons and other diagnostic characteristics, soil moisture and temperature regimes, categories and criteria for soil classification systems. Soil mineralogy and clay minerals-classification, structure, compostion, properties, genesis, transformation and identification techniques, role in plant nutrition, interaction with humus, pesticide and heavy metals. Interpretation of soil survey data for land capability and crop suitability classifications, Macro-morphological study of soils. Land evaluation and land use type concept and application. Application and use of global positioning system for soilsurvey. Soil survey- types, techniques. Soil series- characterization and procedure for establishing soil series, benchmark soils, major soils of India and soil correlations. Study of base maps: cadastral maps, toposheets, aerial photographs and satellite imageries. Use of geographical information system for preparing thematic maps.

Unit 2: Soil Physics

Soil physical constraints affecting crop production. Soil texture - textural classes. Soil structure - classification, soil aggregation and significance, soil consistency, soil crusting, bulk density and particle density of soils and porosity, their significance and manipulation. Soil water- retention and potentials. Soil moisture constants. Movement of soil water -infiltration, percolation, permeability, drainage and methods of determination of soil moisture. Darcy's law. Thermal properties of soils, soil temperature, Soil air- composition, gaseous exchange, influence of soil temperature and air on plant growth. Soil erosion by water, wind - types, effects, mechanics. Rain erosivity and soil erodibility. Runoff - methods of measurement, factors and management, runoff farming. Soil conservation measures, soil conservation in special problem areas

Characterization and evaluation of soil and land quality indicators; 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 covermapping and land use planning using conventional and remote sensing techniques; Concept of watershed - its characterization and management. Remote sensing and geographic information system in precision farming.

Unit 3: Soil Chemistry

Chemical composition of soil; Soil colloids - structure, composition, constitution of clay minerals, amorphous clays and other non-crystalline silicate minerals, oxide and hydroxide minerals; crystallography, space lattice, coordination theory; solubility and ionic products: computation and mineral formation, Charge development on clays and organic matter; pH- charge relations; Buffer capacity of soils. Soil organic matter fractions, clay organic interaction.

Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics. Inorganic and organic colloids- surface charge characteristics, diffuse double layer theories, zeta potential stability, coagulation/ flocculation, peptization, electrometric and sorption properties of soil colloid. Soil organic matter- fractionation, clay-organic interactions. Cation exchange- theories, adsorption isotherms, Donnan-membrane equilibriumconcept, clay-membrane electrodes and ionic activity measurement, thermodynamics, anion and ligand exchange- inner sphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis, sorption-desorption of oxy-anions and anions. Nitrogen, potassium, phosphate and ammonium fixation in soils and management aspects. Quantity/intensity relationship and nutrient availability. Chemistry of acid, salt-affected soil, Chemistry and electrochemistry of submerged soils and management aspects, geochemistry of micronutrients,. Basics of radioisotopes-radioactivity, monitoring radiation and isotopic techniques.

Unit 4: Soil Fertility

Essential elements in plant nutrition; Nutrient cycles in soil; Transformation and transport of nutrients (Macro and micro nutrients) in soil; Manures and fertilizers; Fate and reactions of fertilizers in soils; Chemistry of production of different fertilizers; Slow release fertilizers and nitrification retarders; Quality control of fertilizers.

Soil fertility evaluation - soil testing, plant and tissue tests and biological methods; Common soil test methods for fertilizer recommendation; Soil test-crop response correlations; Integrated nutrient management; Use of isotopic tracers in soil research; Nature, properties and development of acid, acid sulphate, saline and alkali and their management; Lime and gypsum requirements of soils, lime potential; Irrigation water quality - EC, SAR, RSC and specifications. Fertility status of major soil groups of India. Concept and application of soil health and soil quality.

Pollution: types, causes, methods of measurement, standards and management. Heavy metal toxicity and soil pollution; Chemical and bio-remediation of contaminated soils; Soil factors in emission of greenhouse gases; Carbon sequestration in mitigating greenhouse effect; Radio-active contamination of soil.

Unit 5: Soil Microbiology

Soil biota, soil microbial ecology, types of organisms. Soil microbial biomass, microbial interactions, unculturable soil biota. Microbiology and biochemistry of root-soil interface Phyllosphere. Soil enzymes, origin n, activities and importance. Soil characteristics influencing growth and activity of microflora. Microbial transformations of N, P, K, S, Fe and Zn in soil. Biochemical composition and biodegradation of soil organic matter and crop residues. Humus formation. Cycles of important organic nutrients, microbial transformations of pollutants in soil. Soil genomics; xenobiotics; Biodegradation of pesticides, organic wastesand their use for production of biogas and manures. Biofertilizers - definition, classification, specifications, method of production and role in crop production.

Unit 6: Analytical chemistry in soil

Concept of chemical analysis, Solution reactions, titrimetric analysis, concept of standard solution, Indicators: theory and applications. Methods of soil analysis - particle size distribution, bulk and Particle density, moisture constants, 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; Massspectrometry; Geiger Muller counter, solid and liquids scintillation counters.

Unit 7: Statistics

Experimental designs for pot culture and field experiments; Analysis of Variance (ANOVA) and Covariance; Statistical measures of central tendency and dispersion; Correlation and regression; Tests of significance - t and F' tests; Computer use in soil research.

46. AGRICULTURAL BUSINESS MANAGEMENT

Unit 1: General Management

Introduction to management; Evolution of management thought; Management functions; Managerial roles, careers and skills in Agri Business Management; Decision making; Organizational context of decisions; Decision making models; Management by objectives; Understanding and managing organisational culture; Organizational conflicts; Managing change; Leadership styles; Group dynamics; Introduction to human resource management; Human resource planning; Recruitment, placement and talent management; Training and development; Performance appraisal; Compensation; Labour relations; Dispute and grievance handling procedures; Contemporary issues in human resource management; Nature, scope and significance of organizational behaviour; Foundations of individual behaviour; interpersonal behaviour; Motivation-types and theories; Learning process, theories of learning; Attitude and behaviour; Information needs of organization, MIS and decision making; Applications of MIS in various functional areas of management with special reference to agribusiness; AI in Agri Business Management.

Unit 2: Marketing and Strategic Management

Core marketing concepts; Marketing orientation; Segmentation, targeting and positioning; Consumer behaviour and brand management; Marketing mix decisions; Product life-cycle; Product mix; Pricing strategies; Services marketing; New product development; Channel management; Wholesaling and retailing; Marketing information system; Integrated marketing communications mix; International marketing; International Product Life Cycle; New trends in marketing practices- digital marketing, social media marketing, societal marketing, influencer marketing, omni channel marketing; Strategic management concept and process; Types of business strategies; Tools and techniques for strategic analysis- Ansoff matrix, BCG matrix, Porter's generic strategies; Environment scanning and industry analysis-PESTEL Analysis, SWOT analysis, Competitor analysis; Porter's five forces model; Strategy formulation-Generic strategies, Turnaround strategies, Diversification strategy; etc.

Unit 3: Operations and Agri-Supply Chain Management

Production planning and control; Types of production systems and layouts; Process selection and facility layout; Operations strategy; Developing operations strategy; Elements of operations strategy; Business Process Reengineering; Competitive priorities; Production strategies; Service strategies; Productivity variables and productivity measurement; Production planning and control; Product selection; Product design and development; Capacity planning; Inventory management and models-EOQ, etc.; Benchmarking; Procurement management; Information systems in procurement, bidding process, procurement planning, budgeting and evaluations, negotiation, procurement audit, ethics and fraud; Quality assurance; Statistical process control; Quality management in Agribusiness processes - Pareto charts, TQM, Ishikawa charts, Fault tree analysis, Six Sigma; Lean Management; Supply chain-meaning and concepts; Supply chain management (SCM)- evolution, approach, elements, and conceptual model; Agri supply chain; Traditional vs modern supply chains; Demand forecasting and management in supply chain; SCM metrics and drivers; Elements of logistics; Third party logistics, Fourth Party Logistics; Fifth Party Logistics; Warehousing management: Distribution management and strategies; IT application in SCM-AI, Machine Learning, loT, Remote Sensing, GPS, Block chain, etc.; Value chain concepts and models; Managing global supply chain.

Unit 4: Accounting & Financial Management

Branches of accounting-cost accounting, financial accounting, managerial accounting; Accounting concepts, principles, standards and conventions; Advantages and limitations; Double entry system; Analysis of financial statements: Ratios, time series, comparative and common size statements, DuPont analysis, cash flow and funds flow analysis; Classification of cost; Marginal costing and Cost volume profit analysis; Standard costing and variance analysis; Budget and budgetary control; Tax system-GST, MAT; Objectives and functions of financial management; Capital budgeting-types and techniques; Cost of capital; Leverage analysis; Capital structure theories; Dividend- theory and policy; Management of working capital, receivables, cash, collections and disbursement; Investment of surplus cash; Risk and return concepts & analysis; Capital asset pricing model; Financial system in India-Banks, NBFCs, FinTech startups, Microfinance Institutions; Agribusiness financing in India; Venture capital financing.

Unit 5: Applied Agribusiness Economics

Basic economic principles; Theory of consumer behaviour, and its applications- Demand analysis; Demand function; Demand elasticity; Demand forecasting; Objectives of firms; Production, cost and supply analysis; Pricing under different market structures- perfect and imperfect competition (monopoly, monopolistic, oligopoly); Pricing methods and strategies- product pricing and input pricing; National income; Circular flow of income; Consumption, investment and saving; Money-functions, demand & supply; Inflation; Economic growth and employment; Business cycles.

Unit 6: Agribusiness Policies and International Trade

Role of agribusiness in Indian economy; Linkages among sub-sectors of agribusiness; Emerging trends in farm input sector, farm production, agricultural finance, agro-processing, international trade etc.; Institutional innovations-cooperatives, producer companies, private markets, contract farming, futures trading in agri commodities, e-NAM, etc; Policies and regulations-seed bill, fertilizer policy, pesticides bill, APLM act, agri- export policy, agri- price policy, Agri market infrastructure (AMI) Scheme, WDRA Act, corporate social responsibility; Importance of foreign trade for Indian economy; Theories of international trade-absolute and comparative advantage, terms of trade; Balance of payments; Foreign Exchange and Multiplier; Foreign Trade Policy; WTO and its implications; Agreement on agriculture; Tariff and non-tariff barriers, Anti-Dumping, Countervailing and safeguard measures, export procedures and export documentation; Export assistance and incentives in India; Intellectual Property Rights- Managing agricultural technologies for business- Patent, Geographic Indications, Trademark, etc.

Unit 7: Agricultural and Food Marketing

Dimension and classification of agricultural market; Market-structure, conduct, performance; Market functions; Marketed and marketable surplus; Marketing efficiency; Linkages between agriculture and food industry; Marketing boards-NDDB, NFDB, Coffee Board, Spice Board, Rubber Board, etc.; Regulated markets; Cooperatives in the agriculture and food sectors; Marketing channels and strategies for different inputs (Seed, pesticide, fertilizers, feed, farm machinery, etc.) and outputs in agri and allied sector; Organic food market; Market linkages for agri-inputs and agricultural produce; Post-harvest losses in agricultural commodities; Food quality standards (AgMark); HACCP; ISO; Food labeling & packaging; Food traceability; GAP/GHP/GMP; International Food Business, market entry strategies; Global food systems; Role of institutions and certification agencies in food marketing-APEDA, MPEDA, NPOP, India Organic, PGS lndia, FSSAI, NAFED, NECC, FCI, DMI, CACP, Agriculture Skill council of India (ASCI), NCDEX, MCX, etc.

Unit 8: Marketing Research and Quantitative Techniques

Research process and types; Research design; Data collection methods; Sampling techniques, Measurement scale; Questionnaire designing; Descriptive statistics, Bivariate analysis, Correlation, ANOVA, Multivariate statistical analysis techniques, correlation and regression analysis, hypothesis testing, interval estimation, prediction in linear regression model; Factor analysis, Cluster analysis, Logit and Probit models; Scaling techniques, Multidimensional scaling; Conjoint analysis. Linear programming problem formulation; Graphical Method and simplex method; Transportation and assignment problems; Inventory control models; Waiting line models; Decision making under risk and uncertainties; Game theory-two-person zero-sum game; Simulation; Decision trees; Pay off tables; Stochastic models, Neural networks, Markov process; Replacement Theory; Business and Research Ethics.

Unit 9: Project Management and Entrepreneurship Development

Project planning and formulation; Project feasibility-market feasibility, technical feasibility, financial feasibility, and economic feasibility, social cost-benefit analysis, project risk analysis; Project's life cycle and network analysis-PERT & CPM; Project report preparation; Entrepreneurship theories and models; Significance of entrepreneurship in economic development; Qualities of an entrepreneur; Entrepreneurial motivating factors; Business plan formulation-importance and essential elements; Stages of start-up business; Skill development and startup ecosystem for agriculture in context of Startup India, Skill India, Make in India. Development of women entrepreneurship; Social entrepreneurship; Innovative approaches to agripreneurship; Business Incubation; Steps and procedure to start a new business; Business incubation ecosystem in NARES; Business opportunities and challenges in different field of agriculture and allied sectors; Sources of financing; Government policy support to agri-preneurs.

47. AGRICULTURAL ECONOMICS

Unit 1: Economic Theory

Nature and tools of economic analysis; theory of consumer behavior ; production theory; costs theory; Theory of firm; Price determination under different markets, price discrimination, effect of taxation under different market conditions; Welfare economics market failure; National income; Consumption; Saving and investment, Classical, Keynesian, Neo-Classical, and Neo-Keynesian theory of output and employment determination, theory of business cycle, functions and demand for money; Inflation; IS-LM functions; General equilibrium analysis; Monetary and fiscal policies, recent developments in economic environment.

Unit 2: Agricultural Development and Policy

Sources of agricultural growth and development, challenges in economic growth and sustainable agricultural, theories of development; Role of economic, technological, social, political and environmental factors; Green GNP, nature, sources and impact of technological change; Agricultural development in Asia; Poverty, inequality and development; Growth models– Harrod-Domar, Neo-Classical, Rostow's growth stages, Lewis-fei-Ranis model, induced innovation model, land reforms; Theory of share tenancy; Institutions and development; Features of planning in capitalists, socialist and mixed economics; Role of infrastructure and technological change; Agricultural policy analysis and reforms– input and output price policy, rural and irrigation infrastructure; Credit policy etc; Policies and programmes for development of agro-industry, dairy and fisheries; Policy options for sustainable agriculture development, measurement of poverty and poverty alleviation programmes.

Unit 3: Natural Resource and Production Economics

Characteristics and classification of natural resources, sustainability issues in natural resource, property rights, externalities, transaction costs, need for collective action, role of economics in natural resources accounting, planning, management and policy formulation; Social welfare function; Allocation of renewable and non-renewable resources(forests, fisheries, minerals water, land etc.) under various market structure; Valuation of non-market resources; Government programmes for conservation and development of natural resources; Climate changes, mitigation and policies, environmental regulations; Principles of farm management-marginal returns, opportunity cost, input-output, output-output and input-input relationships; Time comparison and comparative advantage, cost principles, farm efficiency measures and financial analysis, farm planning and budgeting, farm records, measurement and management of risk and uncertainty in agriculture; 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, resource-use efficiency and returns to scale, frontier production function; Total factor productivity, decision making under risk and uncertainties.

Unit 4: Agricultural Finance and Project Management

Importance of agricultural finance, objective, functions and principles of agricultural finance, sources of capital acquisition; Rural credit structure-demand, supply, credit-gap; Classification of agricultural credit – sources and forms; Cost of credit/ capital; Credit appraisal- 3Rs, 3Cs and 7Ps of credit, estimation of credit requirement; Supervisory credit system, reforms in agricultural credit policy; Financial system in India-commercial banks, cooperatives; RRBs, micro-finance institutions (MFIs) global financial institutions; Innovations in agricultural financing-microfinance, Kisan credit cards; e-banking, credit inclusion, definition and characteristics of projects; Need for project approach for agricultural development; SWOT analysis and project identification, project life cycle, project feasibility-market technical, financial and economic feasibility, social cost-benefit analysis; Project risk analysis; Project scheduling and resource allocation; Financial and economic appraisal/measures, choice of discount rate, net present value (NPV), internal rate of return (IIR), benefit-cost ratio (BCR); network analysis – PERT & CPM; Fundamental of accounting and book-keeping; Analysis of financial statements-balance sheet, income statement cash flow statement.

Unit 5: Agricultural Marketing, Price Analysis and trade

Concepts of agricultural marketing; Marketing functions-processing, transportation, storage and warehousing; Channels of marketing agricultural produce-price spread and efficiency, structure, conduct and performance analysis; Market integration; Marketing institutions-role and functions; Government interventions including administered price policy; Regulated markets, market segmentation, supply chain and value chain analysis in agri commodities, buffer stock operations, price stabilization measures and policies etc; Price forecasting for crop area allocation, marketing of agricultural inputs, role of private sector in input and output marketing; Forward trading and futures market, Price discovery – Hedging and speculation, e-NAM, market intelligence,- commodity boards and contract farming; Marketed surplus models; Competitive and comparative advantage in trade, trade policies, models and agreements; Regulations and reforms for marketing and trade, WTO, SPS measures and competitiveness; Theories of international trade, Trade blocs, Trade Creation and Trade Diversion, trade and sustainability concerns.

Unit 6: Operations Research and Research Methods

Objective, types and process of research; Role and uses of quantitative technique in business decision making; Sampling techniques and sample size determination; Sampling and non-sampling errors; Index numbers, hypothesis testing; ANOVA, factor analysis, cluster analysis; Measures of central tendency, measures of variation, skewness and kurtosis; Correlation and regression, discriminant and dummy variable analysis; OLS, MLE estimation-assumptions and their violations, properties, simultaneous equations systems: Identification and estimation; Linear programming; Objective, assumptions, formulation of linear programming problem, simplex method; Primal and dual LP problems, variable resource and price programming, game theory.

48. AGRICULTURAL EXTENSION

Unit 1: Fundamentals of Extension Education and Communication

Extension Education and Advisory Services- concept, principles and approaches; Similarities and dissimilarities among extension education, adult education and continuing/distance education; Historical and emerging perspectives of agricultural, veterinary, animal husbandry and fisheries extension education in India and other countries; Community Development and Integrated Rural Development Programmes-concept, principles and objectives; Role of agricultural extension in different sectors of agriculture and rural development;National Agricultural Extension System and Reforms; Public extension systems– ATMA and KVK; National Mission on Agricultural Extension and Technology; Private extension system; Pluralism in extension; Research-Extension-Farmer Interface- Farming System Research & Extension; Agricultural Knowledge and Information System (AKIS); Farmers Field School, Participatory approaches, participatory technology development; Technology Assessment and Refinement; Programmes and schemes for agriculture, animal husbandry, dairy, fisheries, and rural development implemented by Govt. of India; Impact analysis of extension programmes; Concept, elements and models of communication; Credibility, fidelity, empathy and feedback in communication; Problems and barriers in communication; Distortion and noise in communication; Group and mass communication, Interpersonal and Intrapersonal communication, social networks in communication; Art & Science of public speaking Human behavioural dimensions in extension education- perception, attitude and emotions; Factors affecting attitude change; Theories of personality and motivation; Understanding of basic rural institutions, social structure, culture and norms; Social and technological change processes, group dynamics, concepts and theories of rural leadership.

Unit 2: Extension Methods & Agricultural Journalism

Concepts of andragogy and pedagogy; Human behavioural dimensions in extension-behaviorism, cognitivism, constructivism; Factors influencing human behaviour; Types of learning; Domains of learning-cognitive, affective and psychomotor; Learning theories; Experiential learning; Concepts and elements of teaching and learning processes; Principles of learning; Edgar Dale's Cone of experience; Classification and features of different extension methods; Selection, planning and use of Extension methods like demonstration, exhibition, farmers fairs, field days, tours, extension literature, etc.; Preparation and presentation of different projected and non-projected audio-visual aids; Basics of agricultural journalism; Types of publications-bulletins; Folders, leaflets, booklets, newsletters, popular and scientific articles; Basics of writing, readability and its indices: Principles of visual design, fundamentals of layout and design, preparation of radio/video script; Principles of photography and its use in extension, traditional media for communication in development programmes.

Unit 3: Information Communication Technologies

Concept of ICT and its role in agriculture and rural development; ICT tools-print and electronic media, community/ internet radio, e-mail, Internet, use of multimedia, use of mobile apps, video and teleconferencing, computer-assisted instructions, touch screens, micro-computers, web technologies and information kiosks; Social media- features and applications; Websites, portals, expert system, Decision Support Systems (DSSs) and apps related to agriculture, dairy, veterinary, fishery, and marketing, etc.; m-learning, e-learning; e-learning platforms– MOOCs, OER, etc.; Digital agriculture- applications of artificial intelligence (AI), IoT, GIS, GPS, Blockchain Technology; Big data analytics in extension; Market intelligence and information systems in agriculture, networking system of information and challenges in the use of ICT; Types of network-PAN, LAN, WAN, human computer interactions-meaning; Theories of multimedia learning- Sweller's cognitive load theory, Mayer's cognitive theory of multimedia learning, Schnotz's integrative model of text and picture comprehension, Van Merriënboer's four-component instructional design model for multimedia learning; Basic principles of multimedia learning.

Unit 4: Training & Human Resource Development

Human resources and their importance in agricultural development; Concept of human resource management; Training and development of human resources; Training Need Assessment– concept, methods and impact assessment; Training– concept and types; training process- different phases of training; Models of training; Designing training curriculum; Training strategies- academic strategy, laboratory strategy, activity strategy, personal development strategy, organisational development strategy; Training methods; Factors determining selection of methods; Need and principles of capacity development; Process of capacity development; Levels of capacity- individual, organization, enabling environment; Human resource development- manpower planning, role analysis, role efficacy, induction training, job enrichment, self-learning mechanisms, counseling, mentorship, performance appraisal and feedback; Career development; Evaluation of training- types, levels, and models.

Unit 5: Research Methodology in Extension Education

Types and stages of social research; Research problems and problem statements, hypothesis; Variables-concept and types; Research design- MAXMINCON Principle; Types of research designs- experimental, quasi-experimental, cross-sectional, longitudinal, case study, comparative; Mixed methods designs; Threats to internal and external validity; Measurement – meaning, postulates and levels of measurement; Reliability and Validity of instruments; Sampling designs- probability and non-probability sampling; Methods of observation-interviews and interviews schedules, semi-structured interviews, sociometry, semantic differential, Q methodology, projective techniques; Focus group discussion; Participant and non-participant observation; Techniques of scale construction- paired-comparison, equal appearing interval, summated rating; Item analysis; Scalogram analysis; Development of knowledge test; Methods of constructing indexes; Qualitative research; Parametric and non-parametric statistics for data analysis in social research; Tests of significance; Processing of data, coding-tabulation; Analysis and interpretation; Report writing; Ethics in social research.

Unit-6: Program planning, evaluation and impact assessment

Program planning and development-concepts and steps; Logic framework approach (LFA) for planning and management of program; Program Evaluation- concept, objectives, principles, criteria, and theories; Difference between monitoring and evaluation; Evaluation process; Steps in programme evaluation; Types of Evaluation; Objective oriented, management oriented; Context evaluation, input evaluation, process evaluation, product evaluation, consumer oriented evaluation, expertise oriented evaluation, adversary oriented evaluation, naturalistic and principal oriented evaluation, Goal free evaluation and meta evaluation; Levels of Bennett's hierarchy; Evaluation models- Logic model, Kirkpatrick's model, Stufflebeam's model; Programme management techniques; SWOT analysis, Bar Charts, Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM), differences between PERT and CPM, advantages and disadvantages; Defining impact and impact assessment; Impact assessment vs impact evaluation; Social impact assessment –stages and approaches; Theories of change; Criteria and indicators; Quantitative and qualitative techniques for impact assessment.

Unit 7: Extension Management and Organizational behaviour

Concept and principles of administration and management, classical and modern theories, schools of management thought; Functions of management- planning, organizing, staffing, directing and leading, controlling, coordinating, reporting and budgeting; Leadership styles and theories; Decision-making in organization; Organizational effectiveness, organizational climate, organizational development, job satisfaction and morale; Time management; Performance appraisal; Coordination at different levels of extension management, methods of coordination; Management by Objective (MBO) and Total Quality Management (TQM); Project Management Techniques;Power and Conflicts in Organizations; Organizational Communication-concepts, channels; Organizational climate, Organizational culture vs. climate; Characteristics of organizational culture, creating and maintaining organizational culture; Organizational change, individual and group behaviour in organization; Team building process; Problem solving techniques, & negotiation, motivational theories & techniques, work motivation; Transactional analysis; Managing Stress, conflict and Emotions; Creativity-concept and process; Interventions for organizational development-interpersonal interventions, team interventions, structural interventions, comprehensive interventions, mobilization and empowerment skills; Concept and strategies in mobilization, concretisation and empowerment of rural people.

Unit 8: Entrepreneurial Development

Entrepreneurship- concepts, traits, and theories; Entrepreneurial characteristics and motives; Entrepreneurial competencies; Entrepreneurial motivation- need for power; Achievement, affiliation and autonomy; Achievement motivation syndrome; Simulation games and exercises for developing entrepreneurial competencies– risk taking, self- efficacy, creativity, achievement planning, influencing process, problem solving; Entrepreneurship development cycle; Entrepreneurial environment- internal and external factors influencing emergence of entrepreneurship; Barriers to entrepreneurship; Women Entrepreneurship, social entrepreneurship; Programmes and agencies promoting entrepreneurship; Types and techniques of training for developing entrepreneurial activities in various areas; Agripreneurship-agri-clinics and agribusiness centers; Micro Finance, start-ups, SHGs, FPO, cooperatives.

Unit 9: Agricultural Innovation System and extension approaches

Innovation- concepts and attributes; Innovation generation process; Role of extension in agricultural innovation system, role of enabling environment- policies and institutions, innovation platforms; Role of innovation brokers, scaling up knowledge for innovation, identification, characterization, documentation, validation and upscaling of ITKs and grassroots innovations; Diffusion of innovations- concept, elements, models, and theories; Innovation development process (technology generation and promotion); Adoption- concept, process, models, adopter categories and their characteristics; Factors influencing adoption; Diffusion network-opinion leadership, models of communication flows; Communication network analysis and theories; Change agents; Concept and stages of innovation-decision process; Consequences of innovations; New approaches and domains of extension- demand-driven extension, market-led extension (value chain extension), farmers-led extension, group-led extension, public-private partnership based extension system; Participatory approaches for technology development and application; Engagement of voluntary and farmers' organizations in extension; Gender sensitive extension; Privatization of extension; Roles and approaches of extension for enhancing capacity of communities for climate change adaptation; Nutri-sensitive agriculture, agri-preneurship, agri-tourism, and urban and peri-urban agriculture; Extension and Sustainable Development Goals (SDGs); Stakeholders' analysis, linkages and strategic partnerships; Sustainable rural livelihood- sustainable livelihood approaches (SLAs).

Unit 10: Gender Sensitization and Empowerment

Concepts of Gender- gender roles, gender equality, gender equity; Gender relations, gender balance, gender bias, gender blindness, gender needs- practical and strategic, issues in agriculture and extension; Gender mainstreaming- approaches and methods; Gender analysis framework and tools; Gender empowerment measures; Dimensions and methodologies for empowerment; Gender impact assessment; Gender budgeting; Gender specific technologies; Gender dimensions in food and nutritional security: Women's empowerment-principles, framework and dimensions; Strategies and barriers for women empowerment; Empowerment through SHG, financial inclusion, micro-finance, internet and education; Women entrepreneurship; Public-private partnership for the economic empowerment of women; Building rural institutions for women empowerment; Digital women rights, constitutional provisions; Global and national policies and mission for empowerment of women; Government programmes and schemes for women.

49. AGRICULTURAL STATISTICS

Unit 1: Probability and Mathematical Statistics

Elements of measure theory, Borel field, Probability measure; Random variable, Axiomatic approach to probability; Laws of addition and multiplication; Bayes' theorem; Discrete and continuous variables; Mathematical expectation; Mathematical expectation of functions of random variables; Moment generating function, Characteristic function; Raw and central moments; Functions of random variables; Distribution function and its properties; Univariate and bivariate probability distributions; Conditional and marginal distributions; Independence of random variables; Transformation of random variables; Cauchy-Schwarz inequality, Jensen inequality, Markov inequality; Chebyshev's inequality; Bernoulli weak law of large numbers; Kolmogorov strong law of large numbers; Central limit theorem; Demoviere- Laplace central limit theorem; Bernoulli, Binomial, Poisson, Negative binomial, Geometric, Hypergeometric and Uniform distributions; Rectangular, Normal, Exponential, Gamma, Beta, Cauchy and Lognormal distributions; Bivariate normal distribution; Probability distributions of functions of random variables; Exponential Family of distributions; Mean and variance of above mentioned distributions; Sampling distributions; Distribution of mean, difference between two means and correlation coefficient; Central t, F and chi-square distributions, their properties and interrelationships; Variance stabilizing transformations; Correlation and regression; Multiple and partial correlation coefficients; Order statistics; Distribution of r^{th} order statistics; Joint distribution of several order statistics and their functions; Distribution of range and median.

Unit 2: Statistical Inference

Point estimation: unbiasedness, consistency, sufficiency, completeness; Neyman factorization theorem with application; Minimum variance unbiased estimator; Cramer Rao inequality; Rao Blackwell theorem; Methods of estimation: method of moments, method of minimum chi-square, method of maximum likelihood, their properties and applications; confidence interval estimation for parameters of normal, exponential, binomial and poisson distributions; Testing of hypothesis; Neyman Pearson lemma; Unbiased test; Uniformly most powerful unbiased tests and their constructions; One and two-sample tests about mean, variance, proportion, simple correlation coefficient and simple regression coefficient; Behrens-Fisher problem; Bartlett's chi-square test; Likelihood ratio test and its asymptotic properties; Chi-square tests the goodness of fit and independence; Non-parametric tests, one and two sample sign and Wilcoxon sign rank tests, run test for randomness, Wilcoxon-Mann- Whitney U test, Kruskal-Wallis and Friedman's tests, Kendall's coefficient of concordance; Elements of sequential analysis; Wald's sequential probability ratio test.

Unit 3: Multivariate Analysis

Concept of random vector, expectation operator, dispersion matrix, independence of random vectors; Multinomial distribution; Multivariate normal distribution, marginal, joint and conditional distributions; Sample mean vector and its distribution; Maximum likelihood estimates of mean vector and dispersion matrx; Tests of hypotheses about mean vectors; Wishart distribution and its properties; Hotelling's T^2 and Mahalanobis' D^2 statistics; Null distribution of Hotelling's T^2 ; Multivariate analysis of variance; Wilk's lambda criterion and its properties; Discriminant analysis, computation of linear discriminant function (LDF), classification between two multivariate normal populations based upon LDF and Mahalanobis' D^2 ; Canonical correlations; Factor analysis; Principal component analysis; Cluster analysis, similarities and dissimilarities, hierarchical clustering, single and complete linkage methods of clustering; Path analysis and computation of path coefficients; Multi- dimensional scaling; Hierarchical and non- hierarchical clustering algorithm.

Unit 4: Design of Experiments

Theory of linear estimation; Gauss Markoff theorem; Atkins transformation; Hypothesis testing and analysis of variance; Analysis of covariance; Random, fixed and mixed effects models; Basic principles of design of experiments; Orthogonality; Contrast, mutually orthogonal contrasts; Completely randomized, randomized complete block and latin square designs; Missing plot technique; Orthogonal and mutually orthogonal latin squares; Graeco latin square designs; Balanced incomplete block (BIB) designs, general properties, analysis without and with recovery of intra-block information, construction of BIB designs; Partially balanced incomplete block (PBIB) designs with two associate classes, general properties; Youden square designs; Cross-over designs; Factorial experiments, confounding in 2^n and 3^n factorial experiments, partial and total confounding; Fractional factorial designs for symmetrical factorials; Asymmetrical factorials; Split-plot and strip-plot designs; Combined analysis of experiments; Designs for fitting first order and second order response surfaces, second order rotatable designs; Multiple comparison procedures; Sampling in field experiments.

Unit 5: Sample Surveys

Complete survey vs sample survey; Probability sampling vs purposive sampling; Sampling error; sample space, sampling design, sampling strategy; Confidence interval; Simple random sampling with and without replacement, estimation of population mean and population proportion; Inverse sampling; Stratified random sampling, optimum allocation, number of strata, construction of strata boundaries; Determination of sample size; Ratio, regression and product methods of estimation; Separate and combined ratio estimators; Cluster sampling; Multi-stage sampling with equal probability of selection of Units at each stage; Two-phase sampling; Successive sampling over two occasions; Probability proportional to size sampling - Cumulative method and Lahiri's method of selection; Horvitz Thompson estimator, ordered and unordered estimators, sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran; Inclusion probability proportional to size sampling; Systematic sampling; Probability proportional to size systematic sampling; Non-sampling errors, sources and classification, non-response in surveys; Response error, interpenetrating sub-samples, imputation methods; Warner's randomized response technique.

Unit 6: Statistical Genetics

Physical basis of inheritance, segregation and linkage; Analysis of segregation, detection and estimation of linkage for qualitative characters; Amount of information about linkage; Combined estimation, disturbed segregation; Gene and genotypic frequencies; Random mating; Hardy-Weinberg law of equilibrium; Disequilibrium due to linkage for two pairs of genes and sex-linked genes; Forces affecting gene frequency; Equilibrium between forces in large populations, polymorphism; Fisher's fundamental theorem of natural selection; Random genetic drift; Effect of finite population size; Polygenic system for quantitative characters; Average effect of gene; Average effect of gene substitution; Dominance deviation; Breeding value; Epistatic interaction deviation, Genotype-environment correlation, genotype-environment interaction and its application; Multiple allelism in continuous variations; Maternal effects; Different components of genetic variance and their partitioning; Effect of inbreeding on quantitative characters; Heterosis; Inbreeding depression; Effect of inbreeding on mean and variance of quantitative characters; Resemblance between relatives; Phenotypic and genetic covariance between different relatives; Concept and estimation of genetic parameters; Heritability, repeatability and genetic correlation; Response due to selection, selection index and its applications in plant and animal genetic improvement programmes; Correlated response to selection; Restricted selection index; Survival analysis.

Unit 7: Regression Analysis

Simple and multiple linear regression models and their analysis; Estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation; Polynomial regression; Use of orthogonal polynomials; Use of dummy variables; Regression with ordinal data; Selection of variables, stepwise and stagewise regressions; Regression diagnostics; Adequacy and validation of models; Examination of residuals-specification error, auto- correlation, Durbin-Watson statistic, heteroscedasticity, multicollinearity; Weighted Least Squares; Components of time-series; Fitting of different trend models; Autocorrelation and partial auto-correlation functions; Correlogram; Determination of cyclical variations; Periodogram analysis; Linear Stationary models-auto-Regressive, moving average and mixed processes; Linear non-stationary models; Forecasting; Indirect Least Squares; Pooling of cross-section and time-series data; Demand and supply curves; Determination of demand curves from market data; Engel's curves; Pareto curves.

Unit 8: Mathematical Methods in Statistics and Optimization Techniques

Limit and continuity; Differentiation of functions, successive differentiation, partial differentiation; Mean value theorems, Taylor and Maclaurin's series; Integration of rational, irrational and trigonometric functions; Differential equations of first order, linear differential equations of higher order with constant coefficients; Simple interpolation; Divided differences; Numerical differentiation and integration; Group, ring, field and vector spaces, subspaces, basis, Galois field, Fermat's theorem and primitive elements; Linear independence and dependence of vectors, row and column spaces; Submatrices and partitioned matrices; Determinant, rank and inverse of a matrix; Determinant and inverse of partitioned matrices; Special matrices - unitary, similar, Hadamard, circulant, Helmert's, Idempotent and Orthogonal; Eigenvalues and eigenvectors; Spectral decomposition of matrices; Kronecker and Hadamard product of matrices, kronecker sum of matrices, permutation matrices, full rank factorization; Generalized inverses, Moore-Penrose inverse, applications of generalized inverse;

Generalized inverse of partitioned matrices; Solutions of linear equations, equations having many solutions; Spectral decomposition of matrices; Quadratic forms; Optimization techniques and soft computing: Classical optimization techniques; Constrained optimization; Optimization and inequality; Numerical methods of optimization; Direct search method, sequential search method, random search method, simplex search method, gradient method and method of steepest ascent; Linear programming techniques - simplex method, duality and sensitivity analysis; Two-person zero-sum game and linear programming; Integer programming; Statistical applications; Non- linear programming; Kuhn-Tucker conditions; Quadratic programming; Elements of multiple objective programming; Dynamic programming; Optimal control theory; Soft computing tools - Artificial Neural Network, support vector machines and probabilistic reasoning; Genetic algorithm, decision tree, Bayes classifiers, fuzzy logic; Rough set; Simulation methods for various probability models; Resampling techniques; Jackknife and Bootstrap; Monte Carlo simulation.

50. HOME SCIENCE

Unit 1: Human Nutrition, Health and Interventions

Balanced diet-food groups, food pyramid; Macro and micronutrients in human nutrition-carbohydrates, proteins, lipids, vitamins, minerals and water-requirements, sources, functions, metabolism and effects of deficiency and toxicity of the nutrients; Inborn errors of metabolism phytochemicals, antioxidants, prebiotics and probiotics, functional foods and nutraceuticals; Drug and nutrient interaction; Diet & nutritional therapy in disorders of obesity, underweight, gastrointestinal tract, kidney, liver, heart, lungs, cancer, diabetes mellitus, food allergies and intolerances; Major public health and nutritional problems in india-causes, magnitude and distribution; Assessment of Community Nutritional status by standard methods; National nutrition policy, national and international organizations programmes to combat malnutrition; Nutritional epidemiology, public health aspects of human nutrition; Objectives, principles and importance of nutrition education, nutrition monitoring and surveillance; Nutrition and physical fitness, nutrition in emergencies and disasters.

Unit 2: Food Science and Processing Technologies

Technologies Need & Scope of Food Science, methods of cooking-merits & demerits, factors affecting cooking; Sensory evaluation and consumer acceptability, food fortification, enrichment and supplementation; Food additives and preservatives; Anti- nutritional factors & toxicants in foods; Food hygiene and sanitation, Food-borne illnesses, infections and food poisoning; Food adulteration, food standards, laws & regulations for food safety; Post - harvest losses, food spoilage and its causes; Food processing techniques, effects on nutritional value; Quantitative and qualitative changes during and processing of foods; Principles and methods of food processing, drying, concentration, freezing, fermentation, irradiation, canning, sterilization, pasteurization storage of p~~erish~~hable and non-perishable foods, traditional and modern food storage; New product development - nanotechnology; Food service management of institutional level-hospital, educational institutions, social and special institutions; Perspectives of food service-menu planning, food cost analysis; Organic and genetically modified foods.

Unit 3: Textile Science, Fashion Designing and Garment Production

Natural and Man-made fibers: Classification and Processing; Testing and quality control of textiles and apparel; Its importance, textile performance standards, fiber, yarn and fabric testing; Dyes and pigments – classification**,** dyeing techniques (solution dyeing, yarn dyeing, piece and garment dyeing), styles (direct, resist and discharge) and methods of printing (block, screen, stencil, roller, transfer printing); Principles of weaving- looms, basic weaves (plain, twill and satin), decorative/ fancy weaves (jacquard, dobby, leno, double cloth, warp and weft figuring, pile weave); Knitting (principles and classification); Finishes – principles, classification and methods of finishing; Stain removal, washing, care and storage of clothes; Anthropometric measurements (importance and techniques); Clothing construction (basic principles of drafting, flat pattern and draping), principles of pattern making through flat pattern and draping; standards of good fit, grading and alteration of basic block; Clothing requirements for different age groups, factors affecting clothing choices and fashion trends; Use of CAD in the textile industry; Role and importance of textile and garment industry in Indian economy; Marketing of textiles and clothing- 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; Textile and environment-banned dyes, eco-friendly textiles, contamination and effluent treatment, eco-label and eco marks; Zero waste designing, upcycling and recycling.

Unit 4: Human Development and Family Dynamics

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; Role of family, school and peer interaction in the development of the child; Theories of child/human development; Socio-cultural aspects of population growth and population policies; Developmental programmes for women and children; 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; Dynamics of marriage and family relationships; Parenting styles and community education; Premarital association, premarital guidance and counseling; Approaches to study family- developmental social, psychological and educational; Family disorganization, family crises and family therapy; 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 challenges; Early Childhood Care and Education. Curriculum Designs and Educational Philosophies; Methods of child study, Method of Developmental Assessment-APGAR, Anthropometric measurements, Brazelton Neonatal Behavioural Assessment Scale (BNBAS), Baley Scale of Infant Development (BSID), Stanford Binet Intelligence Scale, Weschelar Scale of Intelligence (WPPSI, WAIS, WISC), Vineland Social Maturity Scale, Adaptive Behaviour Scale, Anthropometric, Thematic Apperception Test (TAT), Raven Progressive Matrices (RPM), Children Apperception Test (CAT), Peabody Picture Vocabulary Test (PPVT), The Differential Ability Scales-II (DAS-II); Guidance and counseling-across lifespan and for caregivers; Health and well being across life span development; Research methods- data collection and classification, coding, tabulation, inferential and descriptive statistics.

Unit 5: Family Resource Management and Consumer Science

Systems approach to Family Resource Management, concept, planning, resources, communication, process of management art principles and interior enrichment, housing and space design, types of house plans, economy in construction, building materials, building regulations-norms and standards, household energy and equipment, family finance and consumer education; Process of management; Decision making process; Application of management process to time, money and energy for work simplification; Application of Mundel's classes of change in household work, agricultural and allied tasks; Energy crisis, its causes and implications for energy management in homes; Equipment, tools and accessories for rural and urban houses; Guidelines for budgeting; Banking, e-banking and insurance; Credit; Consumer rights, consumer protection act and other laws; 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 and household furnishing – types, selection, care and maintenance; Wall and window types- treatments; Floor and floor coverings; Lighting-functions, natural and artificial light; Flower arrangement, tools and accessories used; Functional design and arrangement of work places for different occupational activities; Ergonomics ergonomic designing of furniture and equipment; Work and work station design Determining physiological cost of work; Planning interiors for people with special needs; Environment and health hazards due to pollution; Concepts of household and farm waste and its utilization techniques; Environmental education and rain water harvesting; Entrepreneurship development, creativity & innovation, enterprise, enterprise policy & program, Business plans.

Unit 6: Home Science/Community Science Extension Education and Communication Management

Home science extension education: concept, principles, philosophy, objectives and approaches; 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; Leadership-concept, types, identification, training and mobilizing local leaders for community participation; Problems of women leaders; Panchayati Raj-philosophy, concept, functioning and scope; Extension methods and audio-visual aids; Classification, selection, use and production; Designing of AV AIDS for transfer of communication; Concept, functions, key elements theories and models of communication; Barriers to communication; History of communication; Advanced techniques in mass communication and participatory communication- theories and models, designing and developing participatory messages; Concept, need and constraint of community-based learning; Concept, steps, principles and theories of programme planning; Application of programme planning for Home Science Extension/ Extension Education and Communication Management through PERT and CPM; Evaluation- concept, significance, methods and tools for monitoring and evaluation; Development programmes, viz. Integrated Rural Development Programme (IRDP), Development of Women and Children in Rural Areas (DWCRA), Training of Rural Youth for Self-Employment (TRYSEM); Role of Krishi Vigyan Kendras (KVKs), Role of Non- governmental Organizations (NGOs) in extension, SWOT analysis of development programmes; Programs and agencies promoting women as entrepreneurs; Types and techniques of training for developing entrepreneurial activities in home science/community science areas; Self help groups- concept, organization, mobilization and functioning of SHGs for sustainability; Important extension training institutes in India; Women in agriculture: Role of women in agriculture and allied sectors; Women friendly tools and implements; Women and gender issues.

51. FARM MACHINERY & POWER

Unit 1: Farm Mechanization and Equipment

Status of farm mechanization in India; power availability on farms and trends in mechanization. Functional requirement, principle of working, constructional features and operation of animal and power operated equipment for land development, tillage, sowing, planting, transplanting, fertilizer application, inter-cultivation, plant protection, harvesting, threshing, mowing, chaff cutting and baling; special equipment for crops such as vegetables, sugarcane, cotton, groundnut, potato, fruits and orchard crops and plantation crops like coconut, areca nut, cashew nut etc.

Unit 2: Farm Machinery Design

Design and selection of machinery elements viz. gears, pulleys, chains and sprockets, belts, bearings, couplings and springs and fasteners. farm machine system characteristics and evaluation, dynamic balancing and stability of farm machines, force analysis on agricultural tools and implements, pull, draft, unit draft and power of farm equipment, design of soil working tools for sowing and planting; design of fertilizer applicators, inter-cultivation equipment, harvesters and threshers; pneumatic and hydraulic controls, machine learning, IoT, robotics, mechatronics, construction and operation of farm equipment, selection and operation of drones.

Unit 3: Farm Machinery Testing, Evaluation and Management

Calibration of seed drills, planters, plant protection equipment; methods of testing and performance evaluation of tillage equipment, seed drills and planters, fertilizer applicators, sprayers and dusters, harvesting and threshing equipment, 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; matching power-implement system, estimation of energy and power requirements, reliability of farm machinery, measurement of power of engine, electric motors and their characteristics including batteries; familiarization with standards formulation and its need, different organizations for standards and their role in standardization of farm equipment, measurement of specification of different farm equipment.

Unit 4: Engines and Tractor Systems

Engineering thermodynamics, power cycles, fuels; various systems of IC engines; operations, adjustment and troubleshooting 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; emissions and control of pollutants; mechanical and power steering; tractor chassis mechanics, hitching systems, hydraulic controls for tractors, automatic position and draft control; tractor performance tests, operation and maintenance tractors and power tillers.

Unit 5: Ergonomics and Safety

Anthropometry in equipment design, physiological cost and effect of work on physiological responses, fatigue 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 - causes and methods for alleviating the effect on soil and crop responses.

Unit 7: Energy in Agriculture

Conventional and renewable energy sources in agriculture; solar radiation and its measurement; characteristics of solar spectrum; solar energy collection for thermal and PV application as well as its storage; solar photovoltaic conversion and SPV powered systems. Types of wind mills and their applications; thermo-chemical conversion of biomass, direct combustion, pyrolysis and gasification, chemical conversion processes, carbonization, briquetting, pelletization and densification of biomass; bioconversion into alcohols, methyl and ethyl esters, organic acids,; types of biogas plants, biogas properties, uses and distribution, alternate fuels for IC engines; energy requirement in agricultural production systems, energy ratio and specific energy value, inflow and outflow of energy in unit agricultural operation, energy audit, accounting and analysis.

Unit 8: Manufacturing Technology

Specification of ferrous, non-ferrous, alloys and composite materials including composition, production techniques and selection for farm equipment, workshop practices applied in prototype production, common tools and press operations, metal cutting and machining, jigs, fixtures and gauges, casting and die-casting processes; basic joining processes, weldingprocesses, weldments testing and metallurgy; basic machines selection for farm equipment workshop and its planning.

Unit 9: Instrumentation and Measurement Techniques

Mechanical measurements, sensors and transducers types and their application, theory of strain gauges and their use, signal transmission and processing, signal conditioning and monitoring, data acquisition and storage, dynamic measurements; measurement of temperature, pressure, strain, force, torque, power, sound level, vibrations etc.; determination of fuel properties of different liquid and gaseous fuels, measurement of fluid flow rates etc.

Unit 10: Machinery for Precision Agriculture

Importance of precision agriculture. Mapping in farming for decision-making; Geographical concepts of Precision Agriculture; Understanding and identifying variability; Geographical Position System (GPS) Basics (Space Segment, Receiver Segment, Control Segment), Error and correction, Function and usage of GPS. Introduction to Geographic Information System (GIS), function and use of GIS, IDI devises usage in Precision Agriculture Yield monitor, variable rate applicator for fertilizers, seed, chemicals etc. Remote sensing Aerial and satellite imagery; above-ground (non-contact) sensors; data analysis, concepts of data analysis, resolution, Surface analysis. Analysis of applicationinterpretive products (map, charts, application map etc.); Electronics and Control Systems for Variable rate applications, Precision Variable Equipment, Tractor-Implement interface technology, Environmental Implications of Precision Agriculture; Spatial Analysis, Variable Rate Application, Reducing of negative environmental impact.

52. COMPUTER APPLICATIONS & IT

Unit 1: Computer Organization and Architecture

Computer Organization and Architecture – Boolean Algebra, Minimization of Boolean Functions, Number System, Basic concepts of floating-point number system, Sequential and Combinational Circuits, Flip flops – types, Race Condition and Comparison. Input/ Output Unit, Memory Organization, ALU and Control Unit, Instruction and Execution Cycle in CPU, Introduction to Microprocessors, Interrupts, CISC and RISC Architecture.

Unit 2: Programming Languages & Data Structure

Programming Languages (Java, C++, Python), Computer Algorithms, Flow Charts, Building Blocks, Control Structures, Arrays, Object Oriented Programming Concepts, Memory Allocation, File management. Internet Programming – Hyper Text Markup Language (HTML) and XML, Building Static and Dynamic Web Pages, Client Side and Server Side Scripting Languages, Mobile Apps, Database Connectivity, Data Structure: Representation of Character, String and their Manipulation, Linear List Structure, Stack, Queue, Heaps, Linked list, Arrays. Tree: Representation of Tree Structures and Different Tree Traversal Algorithms, Graph, Sorting and Searching Algorithms.

Unit 3: Software Engineering

Requirement Analysis and Specification; Software Development: Phases, Process Models, Project Structure, Project Team Structure, Types of Metrics, Measurement, Software Quality Factors, Project Cost Estimation, Project Scheduling, Quality Assurance Plan and Project Monitoring Plans, Gantt Charts, PERT and CPM, Coding Tools and Techniques, Software Testing and Maintenance, CASE Tools, Object Oriented Analysis and Design, UML Modeling and Diagrams.

Unit 4: Networking and Operating System

Types of Networks, Network topology. Data Communication: Concepts of Data, Signal, Channel, Bandwidth, bit-rate and baud rate. Analog and Digital Communications, Asynchronous and Synchronous transmission. ISO-OSI Reference Model, TCP/IP Reference Model – Data Link Layer Function and Protocols: Framing, Error Control, flow control; sliding window protocol, IP-v4 & IP-v6, Dual Stack, Network infrastructure and Security- switches, routers, firewall, intranet, internet, Virtual Private Network. Internet standards and Services, Cryptography, Authentication and firewalls, Adhoc networks. Operating system – Process Management: Inter-Process Communication, Process Scheduling; Memory management: Swapping, Virtual Memory, Paging and Segmentation; Device Management: Deadlocks, Semaphores; File systems – Files, directories, Security and Protection Mechanisms: Basics of Unix/Linux/Windows Server Configuration.

Unit 5: Compiler Construction

Theory of Computation: Models of computation- Finite Automata, Pushdown Automata, Non-determinism and NFA, DPDA and PDAs and Languages accepted by these structures. Grammars, Languages, non-computability and Examples of non-computable problems. Context Free Grammars (CFG), Linear Bounded Automata (LBA), Turing Machine (TA).

Compilers – Regular Expression, Finite automata, Formal languages, Finite State Machines, Lexical Analysis, Semantic Analysis, Parsing Algorithms, Symbol tables, Error Handling, Types of Languages.

Unit 6: Data Base Management System

Definition and Features, Data Models, Relational Database: Logical and Physical Structure, Relational Algebra, Relational Calculus, Database Design, Normalization, Concurrency Control, Security and Integrity, Query Processing and Optimization, Backup and Recovery; Distributed Databases – Concepts, architecture, Design; Structured Query Language (SQL),Concepts and Principles of Data Warehousing, Data Warehousing Design and Schema, Spatial Databases, GIS Concepts and Principles, Big Data Concepts & Architecture.

Unit 7: Computer Graphics

Raster Scan and Random Scan Graphics; Continual Refresh and Storages Displays; Display Processors and Character Generators; Colour Display Techniques. Frame Buffer and Bit Operations, Raster graphics, Points, Lines and Curves, Scan Conversion; Line-Drawing Algorithms; Circle and Ellipse Generation; Polygon Filling; Conic-Section Generation. Anti- Aliasing; Two-dimensional viewing; Basic Transformations; Co-ordinate systems; Windowing and Clipping; Segments; Interactive Picture-Construction Techniques;Interactive Input/Output Devices. Three-Dimensional Concepts: 3-D Representations andTransformations; 3-D Viewing; Algorithm for 3-D Volumes, Spline Curves and Surfaces.

Unit 8: Artificial Intelligence and Soft Computing

Introduction to Artificial Intelligence (AI); Knowledge: General Concept of Knowledge,Knowledge Based System, Representation of Knowledge, Knowledge Organization and Manipulation, Acquisition of Knowledge, Ontologies. Symbolic Approach: Syntax and Semantics for Prepositional Logic (PL) and First Order Predicates Logic (FOPL), Properties of Well-Formed Formulas (wffs), Conversion to clausal form, Inference Rules, Resolution Principle, Non deductive inference methods. Search and Control Strategies: Blind Search, Breadth-first search, Depth – First search, Hill Climbing Method, Branch and Bound Search. Games theory, Theorem Proving, Natural Language Processing, Robotics. Data Mining:Supervised, unsupervised and Association Rule Mining, Artificial Neural Networks, Deep Learning, Genetic Algorithms, Fuzzy Logic. Expert Systems: Introduction to Expert System, and its Characteristics, Application and Importance, Rule Based System Architecture; Software Agents.

Unit 9: Statistics, Modeling and Simulation

Frequency distribution, Measures of Central Tendency, Dispersion, Skewness and Kurtosis. Theory of Probability. Random variable and mathematical expectation. Correlation and regression. Basic Principles of Design of Experiments. Analysis of Variance. Completely randomized design (CRD), Randomized complete block design (RCBD), Latin Square Design (LSD), Split Plot and Strip Plot Design. Probability Distributions: Binomial, Poisson, Normal Distributions and their Applications. Concept of sampling, Sampling vs. Complete Enumeration, Sampling from a Finite Population, Simple Random Sampling. Generation and Testing of Random Numbers, Simulation of Stochastic Events and processes, Discrete Event Simulation.

Unit 10: Bioinformatics

Basics of Bioinformatics, Basic Molecular Biology; Introduction to the Basic Principles of Structure/Function Analysis of Biological Molecules; Genome Analysis; Different Types and Classification of Genome Databases (HTGS, DNA, Protein, EST, STS, SNPs, Unigenes etc.) Role of Bioinformatics in Genomics; Nature of Genomic Data; Overview of Available Genomic Resources on the Web; NCBI/ EBI/ EXPASY etc; Nucleic Acid Sequence Databases; GenBank/EMBL/ DDBJ; Database Search engines: Entrez, SRS. Overview/Concepts in Sequence Analysis; Pairwise Sequence Alignment Algorithms: Needleman & Wunsch, Smith & Waterman; BLAST, FASTA; Scoring matrices for Nucleic Acids and Proteins: PAM, BLOSUM, Dynamic Programming Algorithm, Multiple Sequence Alignment: PRAS, CLUSTALW. Sequence Based Gene Prediction and its Function Identification, SSR, SNPs and Various Markers for Identification of Genetic Traits, Gene Expression. Phylogenetic Analysis Algorithms; Maximum Parsimony, Distance based: UPGMA, Neighbour-Joining.

53. LAND & WATER MANAGEMENT ENGINEERING

Unit 1: Groundwater Development, Wells and Pumps

Water resources of India, Irrigation potential and contribution of groundwater, utilizable groundwater resources and level of groundwater development in the country, scope of groundwater development, Aquifer types and determination of aquifer parameters; Principles of groundwater flow, interaction between surface and groundwater, natural and artificial groundwater recharge; Well Hydraulics of fully and partially penetrating wells; Design,construction and development of irrigation wells; Well interference and multiple well systems; 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 GIS and Remote Sensing 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, Computation of energy loss, sequent depths and specific energy curve, Hydraulic jump and its classification; Study ofcritical flow, uniform flow, gradually varied flow, rapid varied flow, spatially varied flow andunsteady flow and their computations; Principles of pipe flow and pipe flow problems;Theories and methods of open channel design.

Unit 3: Soil, Plant, Water and Atmosphere Relationship

Soil moisture characteristics and its measurement, field capacity, permanent wilting point, plant available water and extractable water; Soil and land irrigability classifications, factors affecting profile water storage; Determination of soil water content, computation of soil waterdepletion, soil water potential and its components, hydraulic head; Field water budget water: gains and water losses from soil, deep percolation beyond root zone, and capillary rise; Evapotranspiration (ET) and irrigation water requirement, critical stages of crop growth in relation to irrigation; Irrigation scheduling; Soil-Plant-Water relationship, Water movement through soil plant atmosphere system. Crop adaptation to water deficit conditions, morpho-physiological effect of water deficit; Drought tolerance and mechanisms of drought tolerance. Management strategies to improve crop productivity under limited water supplies; Contingentcrop 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 and its different components, Measurement and analysis of hydrologic data. Probability concepts, distributions and applications. Intensity duration frequency analysis. Hortonian and saturation overland flow theories; Rainfall and run off relationships, stream gauging and runoff measurement; Different methods of surface runoff estimation, hydrographs, synthetic unit hydrograph, IUH, unit hydrograph theory and its application, SCS-curve number method, stochastic hydrology, time series analysis; Flood routing methods and calculations; Soil loss measurement techniques. Soil loss estimation models such as: Empirical models (USLE and its revisions), WEPP and EPIC models. Design of temporary and permanent soil and water conservation structures, including gully control structures; Software for soil loss estimation, sediment transport and deposition, and reservoirsedimentation; Design and construction of farm pond and check dams; Cost analysis of water harvesting structures. Seepage theory; Design of earthen dams and retaining walls, slope stability analysis; Mathematical models and simulation of hydrologic processes; Application of remote sensing and GIS in soil and water conservation; Satellite data availability, processing and analysis for soil and water conservation.

Unit 5: Watershed Management

Watershed concept, Identification and characterization of watersheds. Hydrological and geomorphological characteristics of watersheds; Land capability and irrigability classification, land use land cover and soil maps; Principles of watershed management;Quantitative evaluation of watershed management techniques. Development of watershed management plans, its feasibility and economic evaluation; Land levelling and grading,machineries and equipment for land levelling; Rainfed agriculture and command area development (CAD) programmes; Use of remote sensing and GIS in watershed management. Dryland water management technologies; Floods and drought modelling and management plans.

Unit 6: Irrigation Water Management
History of irrigation and irrigation water management in India. Classification of irrigation projects in India. Crop water demand and irrigation water requirement; Soil water depletion, plant indices and climatic parameters. Crop modelling and water production function; Irrigation software: CROPWAT, Aqua Crop; Irrigation methods: Surface and 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. Operation and maintenance of sprinkler and drop irrigation system; Cropping pattern change analysis using GIS and remote sensing; Irrigation efficiency and economics of different irrigation systems; Application, distribution and water use efficiencies; Agronomical 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; Irrigation water measurement: velocity-area method, water meters, weirs, notches, flumes, orifices, etc. Use of artificial intelligence and sensors in irrigation water management; Water rights and legal aspects. Irrigation water users' association (WUA) and responsibilities.

Unit 7: Management of Degraded, Waterlogged and other Problematic Soils and Water Present status of degraded soils and their distribution in India. Water quality criteria and use of brackish waters in agriculture; Excess salt and salt tolerant crops; 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 andisobaths 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 and interstate disputes; Environmental considerations in land and water resources management; Management strategies for degraded and water-logged areas and problematic soils and waters.

54. BIOINFORMATICS

Unit 1: Concepts in Computing

Fundamentals of Computing, Introduction to Operating Systems, WINDOWS, UNIX/Linux operating systems, Batch Processing, Multi-programmed Batch System, Time Sharing System, Distributed System, Real Time System, Dead lock, CPU scheduling, Computer Security, Visualization techniques, Viewing in three dimension, Image Processing with emphasis on biological systems, Computer Networking, Security of the network, Network topology and architecture, Hierarchical networks, TCP/IP family of protocols, Parallel & High performance computing, Cloud computing

Unit 2: Programming Languages

Programming in C, Variables and operators, Control Flow statements and loops, Arrays and Pointers, string, Functions, File handling in C, Overview of Object Oriented Programming using Python: class and objects, functions and operator overloading, inheritance, Introduction to PERL, BioPerl modules, Web technology using PHP and Python.

Unit 3: Database Management System and Biological Databases

Definition, purpose, advantage, components of Database System; Data Models; Three level Architecture for Database System –internal, conceptual and external levels; Role of Schemas, Client/Server architecture; Relational Databases: Relational data models (binary, ternary, quaternary & n-ary relations), Primary and secondary keys, Data Definition Language; Data Manipulation Language; Structured Query Language; Classification of biological databases; Nucleic acid, protein, genome and structural databases; tools and databases for sequence submission and retrieval; Concepts of Bigdata and NoSQL.

Unit 4: Mathematics and Statistics

Coordinate geometry: Basic concepts of 2D and 3D geometry; Vector algebra– Addition and subtraction of vectors, Dot and cross product; Matrix algebra: basic definitions, matrix operations, transpose of a matrix, inverse of matrix, Eigen values, Eigen vectors; Introductionto Probability and Statistics, Conditional probability, Bayes' theorem; Random variable, mathematical expectation; Frequency distributions, Descriptive Statistics; Probability Distributions: Binomial, Multinomial, Poisson and Normal Distribution; Introduction and properties of 't', Chi-square and F distributions; Hypothesis testing; Basic concepts of Simple Random sampling and Stratified random sampling; Correlation and regression; Cluster Analysis-Hierarchical and Non-Hierarchical methods, Principal Component Analysis;Hidden Markov Models.

Unit 5: Biochemistry, Molecular Biology and Biotechnology

Biochemistry: Hydrophobic, electrostatic and van der Waals forces, General introduction to physical techniques for determination of structure of biopolymers, Structure, properties and functions of amino acids, proteins, and nucleic acids, Anatomy of Proteins - Secondary structures, Motifs, Domains, Tertiary and quaternary structures, Classification of Protein topologies, Helices and sheets, Helix-coil theory, Conformation of polypeptides and side chains, molten globules, enzymes and folding pathways; Molecular Biology and Biotechnology: Nucleic acids as genetic material, Genetic code, Genome organization and regulation in prokaryotes and eukaryotes, DNA replication, transcription and translation, recombinant DNA technology, Site directed mutagenesis, Mutation, RNA editing, RNAprocessing;

Unit 6: Genomics and Proteomics

Genomics: Classical ways of genome analysis, Evolution of sequencing technologies, Genomic libraries, Physical mapping of genomes; Genome sequencing strategies: Sequencingby synthesis, ligation, single molecular sequencing; Microarrays analysis and applications; Next generation sequencing technologies, Sequence assembly and annotation, exome sequencing; Genome structural and functional annotation; Functional genomics; Candidate gene identification, Linkage analysis, genotyping analysis; Whole genome analysis and comparative genomics; ncRNAs; Genome Editing; Proteomics: Mass spectrometry and analysis, peptide identification and protein interface; Metabolomics for elucidating metabolic pathways; Applications of genomics and proteomics in agriculture;

Unit 7: Analytical Bioinformatics

Introduction, origin, history of Bioinformatics; Bioinformatics applications in agriculture; Basic concepts of sequence similarity, Sequences alignments: local and global alignment, pairwise and multiple sequence alignment, Dynamic programming-Needleman and Wunsch, Smith-Waterman algorithms; Scoring matrices: PAM & BLOSUM, Motifs and Patterns;Analysis of nucleotide and protein sequences: Pre-processing of NGS data, Bowtie, BWA, HISAT, FM Index, Assembly assessment measures, Quantification of gene expression: RPKM, FPKM, TPM; ncRNA analysis; Phylogenetic analyses: Types of phylogenetic trees, Tree-Building Methods: Character-based and Distance-based methods; Tree Evaluation: Bootstrapping; Introduction to systems and network biology; Tools and models for GWAS and Genomic Selection; Data mining & Knowledge discovery, Machine learning techniques: Supervised and unsupervised learning, Artificial Neural Network, Support Vector Machine, Random Forest; Deep Learning;

Unit 8: Molecular Modelling and drug designing

Concepts of Protein Modelling, Molecular mechanics, Force Fields, Local and global energy minima, Energy minimization techniques; Algorithms in predicting secondary structure of proteins- Chau-Fasman algorithm, Protein folding energy landscape; Protein structure prediction: *ab initio*, homology modeling and fold recognition methods, Ramachandran plot; Visualization tools: Rasmol, SwissPDB, PyMol, QMol; Techniques of MD Simulation, Simulated annealing; RNA Secondary Structure prediction techniques, Algorithmic perspective of RNA folding; Drug designing: Receptor-based and ligand-based drug design, Design of ligands, docking, Classical SAR/QSAR, Molecular descriptors, Pharmacophore mapping and applications.

Unit 9: Data structures and Algorithms

Linear and non-linear data structure: Linked list, Stack, Queues, Trees-Terminologies, Binarytrees, Tree traversal (Pre-order, In-order, post-order), AVL trees, Graph theory, Depth-first search and Breadth-first search algorithms; Algorithms and complexity, Iterative and recursive algorithms, Big-O Notation, Algorithm design and analysis techniques, Greedy Algorithms, Randomized Algorithms, Divide-and-Conquer approach, Searching and Sorting algorithms;

55. FOOD 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; Food fortification, Composition and related quality factors for processing; Methods of food preservation such as heat processing, pasteurization, canning, dehydration, freezing, freeze drying, fermentation, microwave, irradiation and chemical additives; Refrigerated and modified atmosphere storage; Aseptic preservation, hurdle technology, hydrostatic pressure technology and microwave processing; Use of non-thermal technologies (microfiltration, bacteriofugation, ultra high voltage electric fields, pulse electric fields, high pressure processing, irradiation, thermosonication), alternate-thermal technologies (ohmic heating, dielectric heating, infrared and induction heating) and biological technologies (antibacterial enzymes, bacteriocins, proteins and peptides) in food processing. Super critical fluid extraction; Cold plasma technology.

Unit 2: Technology of Foods of Plant Origin

Post harvest handling and storage of fresh fruits and vegetables; Preparation of fruits and vegetables for processing. Minimally processed products. Cold chain logistics; ZECC (Zero Energy CoolChambers), CCSR (Charcoal cool storage Rooms) 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 foods. Preparation and utilization of fruits and vegetables juices in non-fermented/ fermented/ aerated beverages, health drinks. Membrane technology; Chemistry and manufacture of pectin, role in gel formation and products like jellies and marmalades; Technology of preservatives, pickles, chutneys and sauces; Nature and control of spoilage in these products; Re-structured fruits and vegetables. By products utilization of fruits and vegetable processing industry; Processing methods of frozen fruits and vegetables, IQF products, packaging, storage and thawing. Role of pectinases; Tomato products such as juice, puree, paste, soup, sauce and ketchup. Other convenience foods from fruits and vegetables; Beverages, tea, cocoa and coffee processing; Medicinal and aromatic plants: their therapeutic values; Spice Processing viz. cleaning, grading, drying, grinding, packaging and storage; Oleoresins and essential oils and extraction.

Structure, composition of different grains like wheat, rice, barley, oat, maize and millets; Anti-nutritional factors in food grains and oilseeds; Milling of grains; Wheat flour/semolina and its use in traditional/non-traditional foods like breads, biscuits, cakes, doughnuts, buns, pasta goods, extruded, confectionary products, breakfast and snack foods; Rheology of wheat and rice flour. Preparation of vital wheat gluten and its utilization. Instant ready mixtures; Enzymes (amylases and proteases) in milling and baking; 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; Significance of 13-glucans. Milling of oats and its processing into flakes, porridge and oatmeal. 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 theirimportance in Indian diet; Milling and processing of pulses viz. germination, cooking, roasting, frying, canning and fermentation. Use in traditional products, protein concentrates and isolates; Modified starches and proteins; Oilseeds: edible oilseeds, composition and importance in India. Oilseed processing. Oil extraction and its processing, by-products of oil refining. 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. Millets: composition, nutritional significance, structure and processing. Dairy analogues based on plant milk.

Unit 3: Technology of Foods of Animal Origin

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 flavoured 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. EMC (Enzyme modified cheese), Enzymes in dairy processing. 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.

Scope of meat, fish and poultry processing industry in India. Chemistry and microscopic structure of meat tissue; Ante mortem inspection. Slaughter and dressing of various animals and poultry birds. Post mortem 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; Meat tenderization and role of enzymes in meat processing; Utilization of by-products; Zoonotic 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 waste management; Total quality management, good management practices, HACCP and codex in food. International and National food laws; US-FDA/ISO-9000 and FSSAI; 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; Non-destructive food quality evaluation methods.

Unit 5: Food Engineering/Packaging and Labelling

Unit operations of food processing viz. grading, sorting, peeling and size reduction machineries for various unit operations, energy balance in food processing; Automation in different unit operations of food processing: Raw food material sorting, grading, size reduction, mixing and agitation, thermal processing, dehydration,packaging, CIP, quality control; 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; Nutritional labelling requirements of foods; Requirements and functions of containers; Principles of package design. Time Temperature labels and indicators.

Unit 6: Food Microbiology & Biotechnology

Fermentation technology, fermented food products (animal and plant based), microbial spoilage of foods, bacterial growth curve, hurdle technology; Fermenter and bioreactors: Transport phenomenon in microbial systems, types of reactors, working principles, aeration and agitation, sterilization and sanitation, advances in continuous fermentation, developments in solid-state fermentation for food applications; Role of biotechnology in productivity of plants, livestock and microbes for improved nutrition and quality; Use of biotechnology in production of food additives viz.preservatives, colorants, flavours. Use of biotechnologically improved enzymes in food processing industry, biomass production using industrial wastes; Single cell proteins, Food contaminants viz. aflatoxins, botulism; Food intoxication and infection; Consumer concerns about risks and values, Biotechnology and food safety.

Unit 7: Flavour Chemistry Technology

Flavour composition of foods/beverages (identification and quantitative analysis of the flavour precursors and their products, characterization of the staling reaction using stable isotopes). Flavour composition of foods/beverages in relation with maturation and microbial activity/ or the processing conditions (e.g. fermented dairy products, beer, wine, honey, fruits). Analysis of odour-active compounds of food/beverages (Charm analysis; Synthesis of flavour by microorganisms and plant cells. Lipid derived flavours. Investigation of equilibrium of key flavour compounds that govern the flavour stability of beverages. Natural antioxidant constraints in spices; Role of microorganisms in flavour development; Flavor emulsions, flavour composites, essential oils and oleoresins; Flavor encapsulation and stabilization.

Unit 8: **Consumer Sciences and Food Product Development**

Consumer Sciences, Food Product Development, Health Foods Socio-cultural, psychological and economical consideration for foodappearance, Domestic and export marketing; Consumer trends and their impact on new product development. Product development *viz.* to conceiveideas, evaluation of ideas, developing ideas into products, test marketing and commercialization; Role of food in human nutrition; Nutritional disorders, natural contaminants and health hazards associated with foods; Diet therapy. Functional properties of foods: Dextrinization, Gelatinisation, Crystallisation, gelation, foaming, coagulation, denaturation and syneresis, foaming, emulsification. Therapeutic / Engineered / Fabricated and Organic foods/ Nutraceutical and functional foods. Nutrigenomics: concept of personalized medicine. Use of nanotechnology in functional food industry.

56. AGRICULTURAL STRUCTURE AND PROCESS ENGINEERING

Unit 1: Heat and Mass Transfer

Basic laws of thermodynamics, thermodynamic properties and processes, energy equations, heat, work, heat engine, heat pump, refrigeration and steam tables; Modes of heat transfer, heat exchanger; Mass transfer and mass-heat-momentum transfer analogies; Fluid statics, fluid dynamics, continuity equation and Bernoulli's theorem; Dimensional analysis and simulation. Simulation models and mathematical modeling. Finite difference analysis, Finite element analysis.

Unit 2: Farm Structures, Farmstead Planning and Plant Design

Farmstead planning, survey and data collection for information bank. Analysis ofdata, Lay outs; Cost estimation and appraisal; project development; Time, motionand input analysis, Flow charts & drawings, Case studies; Farm electrification, load estimation and selection of equipment; Standby power units, their selection, maintenance and operation. Farm fencing, Safety devices including fire-fighting. Benefit-cost analysis; house hold electrical wiring. Illumination, transmission and distribution of electricity. Rural water supply and sanitary structures, sceptic tank design, piggery, poultry, piggery, and other animal house structures; environment control; rural road culverts and nallah structures, Rat proof godowns, piggery, poultry and other livestock structures; Feed stuff storage structures, Farm workshop, Machinery and implement sheds; biogas plant. Greenhouse construction, operation and maintenance; economics of green house production. Plant size, Product and process design, Process flow charts, analysis of plantcost and profitability, Preparation of project report and its appraisal.

Unit 3: Storage Engineering

EMC, sorption and desorption isotherms, water activity and psychrometry; Storage environment and its interaction with stored product; Factors/parameters influencing the shelf life of the stored product, quality deterioration mechanismsand their control; Storage practices (including fumigation) 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, modern storage system; Quality analysis of stored produce; Storage structures for animal feed, silage etc; Chilling rooms, walk-in cooling rooms for perishables. BIS standards on practices and design of systems for food grains and other commodities, CAP storage, hermetic storage etc.

Unit 4: Material Handling Packaging and Transport

Bulk conveying equipment *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 equipment; Packaging material characteristics and selection; Packaging techniques and equipment for liquid, powder and granular materials, and horticultural produce. Refrigerated containers and trucks for perishable foods. Safety standards in handling, packaging and transport of agricultural produce. Types of packaging materials, barrier properties, CFB Boxes, modifiedatmosphere packaging, smart and active packaging, Edible films, Antioxidant and antimicrobial packaging, Micro and nano-encapsulation cold chain management. Refrigerated containers and trucks for perishables; Damage and losses during transportation.

Unit 5: Post Harvest Operations

Grading, cleaning, washing, sorting, shelling, dehusking, decortication, milling, polishing, pearling, drying (Osmotic, evaporative and freeze drying), pasteurization and sterilization of liquid foods, size reduction cryogenic grinding, granulation, crystallization, filtration, membrane processing,microfiltration, ultra filtration, nano-filtration, reverse osmosis, evaporation, distillation, mixing, clarification, coagulation, mechanical separation, sedimentation, screw pressing/ expelling, leaching, extraction, palleting , extrusion and industrial fermentation

Unit 6: Processing Technology and Processing Equipment Design

Pre-milling/conditioning treatments; Theory of grain drying, thin layer and deep bed drying, Process technology and machinery for cereals, pulses, oil seeds, fruits, vegetables, flowers, spices, condiments, plantation crops, animal products, sea-foods, fiber crops, animal feed, natural resins and gums, Bioprocess engineering, enzyme reaction kinetics, Industrial fermentation and processing, down-stream processing, bio-separation; Minimal processing offruits and vegetables, high pressure processing, Ohmic heating, ultraviolet light, pulsed electric field, pulsed light field, micro and nano encapsulation of food ingredients, Food nanotechnology, Seed processing and technology, Agricultural byproducts/residue utilization, Waste disposal of food processing plants, different methods and equipment; Process equipment and machinery auditing;

Design of grain cleaners, graders, dryers, parboiling plants, size reductionmachines, bioreactors, fermenters, centrifuges, cyclones, heat-exchanger, evaporators, filters, extrusion cookers. Computer aided design and analysis of machines and machine components. Materials, manufacturing processes, design of elements and selection of standard parts.

Unit 7: Engineering Properties and Quality of Biomaterials

Uniqueness of bio-materials and physical characteristics *viz.* 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; Food additives and derived substances, factors affecting toxicity, designing safety in products and processes, establishing safe raw material supply; Organoleptic and sensory evaluation of product quality; Determination of protein, oil content, carbohydrates, color, hardness, texture, nutritive value, bio-availabilityand microbial loads, non-destructive quality evaluation techniques; Measurement techniques and instruments for food quality determination, destructive and non-destructive quality evaluation, UV VIS NIR spectroscopy, X-ray, CT, NMR, machine vision; Maturity, ripening stages and indices of fruits and vegetables.

Unit 8: Agri-Project Planning and Management

Project development, market survey and time motion analysis; Selection of equipment, technology option, techno-economic feasibility; Processing in production catchment. Product and process design, PERT, CPM, transportmodel, simplex, linear and dynamic programming, operation log book. Material balance and efficiency analysis, performance testing, performance indices, energy requirement and consumption; Marketing of agricultural products, market positioning. BIS/FSSAI/ISO/ CODEX/GMP/HACCP standards or guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed, food safety management and system traceability.

Unit 9: Aquaculture Processing Technology & Structures Design

Inland fish farming and associated considerations, Site selection for aquaculture design of dykes, sluice, channels etc., Fish Physiology and micro-climatic considerations, Aeration & feeding systems, Design of fish rearing structures, Hatcheries, containers for live fish, fingerlings, fish seeds; Aquaculture in recirculatory systems, oxygen and aeration, sterilization and disinfection. Recirculation of water, Reuse systems, water exchange, Design of re-use systems. Inlet and outlet structures, water treatment plants.

Unit 10: Dairy Engineering, Instrumentation and Process Control

Principles of dairy equipment design, Design of Vessels, Design of milk storage tank, Design considerations for Heat exchangers, Design of reaction vessels, evaporators, pasteurizers, cream separators, Homogenizers, Butter churn, Drum dryer, Spray dryer; Dairy product processing; Vapour compression refrigeration system, Vapour absorption refrigeration system, Heat pumps, Design of refrigeration equipment, Design of cold storage and air conditioning system. Advanced dairy processes, their operations & design, UHT processing, Adsorption and Sorption processes, Electrodialysis, Aeration and gas transfer, Dairy plant maintenance; Static and dynamic characteristics of lnstruments, Transducer elements, Intermediate elements, indicating and recording elements. Measurement of motion, force, torque, power, temperature, humidity, pressure and flow. Physical and chemical sensors, biosensors, Fuzzy logic, neural networks and control. Monitoring of plant parameters through internet, Data loggers, Data Acquisition systems (DAS), Introduction to Direct digital Control (DDC), supervisory control and Data Acquisition Systems (SCADA), Virtual Instrumentation

57. VETERINARY ANATOMY

Unit 1: Gross Anatomy

Ox as a "Type" animal and structures of other domestic animals (horse, dog, pig, sheep, goat and poultry) 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. Aorta 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. Formation of thoracic, abdominal and pelvic cavities; reflection of these cavities. Organs of digestive system and associated glands, respiratory system, urogenital system (in male and female). Nervous system (central nervous system, peripheral nervous system and autonomic nervous system). Major nerve blocks. Topographic location of organs in domestic animals in relation to their surgical sites (for carrying out surgical procedures i.e. laryngotomy, oesophagotomy, gastrotomy,rumenotomy, cystotomy, urethrotomy, caesarian section, exploratory laparotomy, mammectomy, thoracotomy, thoracocentesis etc) and clinical examination (palpation, percussion auscultation), site to record temperature, pulse, palpable lymph nodes, collection of blood and pregnancy diagnosis. Endocrine glands-pituitary, adrenal, thyroid and parathyroid glands of ox. Organs of sense- eye, internal ear, integument and hoof. General principles of biomechanics during locomotion and weight bearing. Radiographic techniques, radiographic visualization of organs of thoracic, abdominal and pelvic cavity. Postmortem examination and collection of material for teaching and research.

Unit 2: Anatomy of Fowl

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

Unit 3: Microanatomy

Definition of histology and preparation of histological slides, Microscope and microscopy. Light and ultra-structural picture of animal cell, Basic tissues of the body-epithelium, connective tissue, muscular and nervous tissue in general. Light and ultrastructure of important organs of digestive system viz; tongue, tooth, oesophagus, stomach, intestine, liver and pancreas. Respiratory organs viz; nasal cavity, larynx, trachea, and lungs. Urinary organs- kidney, ureter, urinary bladder and urethra. Genital organs of male- testis, epididymis, ductus deferens, Accessory sex glands in male- prostate, seminal vesicles and bulbourethral gland and penis. Genital system in female- ovary, oviduct, uterus, vagina, vulvaand 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. Light and ultrastructure of nervous system.

Unit 4: Developmental Anatomy and teratology

Embryology and its scope in veterinary practice Gametogenesis, classification of eggs fertilization, cleavage, gastrulation and establishment of three germ layers. Intra and extra embryonic membranes of chick and mammals. Placentation in mammals. Morphogenesis andhistogenesis of digestive, respiratory, musculoskeletal, urinary and genital organs, bloodvascular and nervous systems in mammals and chicks. Development of eye, ear and endocrine glands.

Unit 5: Anatomical Techniques (Gross, Histological and Histochemical)

Embalming fluid and its preparation, Embalming techniques, Museum techniques including preparation of dry specimens, wet specimens, transparent specimens, corrosion cast, plastinated specimens, taxidermy, gross staining of brain specimens, alizarin technique for bone and cartilage. Preparation of tissues for microtomy and light microscopy using different fixatives, Different staining methods for routine light microscopy and special staining methods, Frozen sectioning techniques and staining methods for enzymes, carbohydrates, lipids, proteins, pigments, cytoplasmic granules, nucleic acid, muscular and nervous tissue. Silver staining, differential staining for cell types, Natural and synthetic dyes, Metachromatia and supravital staining. Chemical composition of living cells.

Unit 6: Wild life and forensic Anatomy

Introduction, scope and importance of anatomy of wild animals origin, evolution and classification of wild mammals and birds, morphological adaptations of wild mammals and birds, radiography and ultrasonography as a tool to study wild life anatomy, skeletal system, digestive, respiratory, reproductive and urinary systems of elephant, wild carnivores, wild ruminants, wild primates, cervidae family. Cardiovascular system, nervous system and sense organs of wild animals, Anatomy of wild birds, application of wild life anatomy in forensic veterinary medicine, clinical anatomy of captive wild animals.

58. AGRICULTURAL PHYSICS

Unit 1: Basic agricultural Physics

Conservation of mass, energy and momentum; Forces in nature; Measurement of heat, specificheat, heat transfer processes; Huygens' principle, reflection, refraction, diffraction, polarization,interference and scattering of light waves; Optics theory, principles of optical instruments;Change of phase and polarization, electricity and magnetism; Elasticity, stress-strain relationship, moduli of elasticity, Hook's law and strength of materials; Hydrostatic pressure,surface tension, capillary rise and contact angle, Hydrodynamics- laminar and streamline flow,Poiseuille's equation, Stoke's law, equations of state, Laws of thermodynamics; Free energy,Entropy and concept of negative entropy; Van't Hoff Equation.

Unit 2: Soil Physics

Factors and processes of soil formation; Physical properties of soils; Soil texture, mass- volume relationship; Soil structure, aggregation. porosity, pore size distribution; Soil water measurements, Soil water potential; Soil water retention and movement under saturated and unsaturated conditions; Characterization of the Vadoze zone, Infiltration, redistribution andevaporation of soil water; Field water balance and water use efficiency; Irrigation methods surface and pressurise irrigation systems-Merits and demerits; Groundwater recharging; Soil aeration; Thermal properties of soil and heat transport and measurement techniques; Inf1uence of soil water, temperature and aeration on crop growth andtheir management; Solute transport insoils, Soil quality indices, Soil physicalconstraints andtheir management. Soil tilth and tillage, Resource conserving technologies and Conservationagriculture; Dynamics of soil physical environment under diverse soil and cropmanagement.Concepts of Soil health card, digital soil mapping

Unit 3: Soil and water conservation and watershed management

Hydrologic cycle, precipitation, infiltration and surface runoff; Measurement and analysis of hydrological data; Probability concepts, intensity, duration and frequency analysis; Rainfall-runoff relationships; runoff measurement, surface runoff estimation, hydrographs; Soil erosion- its types, extent & control options; Soil loss measurement and estimation, Universal Soil Loss Equation and its modifications; principles of soil and water conservation; Soil and water conservation measure for arable and non-arable land; Watershed - its concept, characterizationand management, Integrated watershed management; land capability classification; Rainwaterharvesting and recycling;

Unit 4: Radiation Physics

Basics of electromagnetic spectrum and its interaction with matter; Laws of radiation: scattering, reflection, transmission, absorption, emission; Diffuse and specular radiations; Photo-electriceffects; Radiation units, flux, intensity, emittance, inter conversion of radiometric units; Energybalance of land surfaces. Atomic Theory; Radioactivity and radioactive laws, alpha-, beta-, andgamma- rays, detection and measurement of radiation; Properties of X-rays; Bragg's law; Nuclear fission, fusion, nuclear reactions, neutron moderation, nuclear energy, atomic power; Isotopesand its application; UV-Visible, IR, NMR, EPR spectroscopy, X-ray diffraction; Applications ofradioactivity in agriculture.

Unit 5: Plant Biophysics and Nanotechnology

Introduction and scope of plant biophysics; Structure and properties of water; strong and weak molecular interactions, Experimental techniques used for separation and characterization of biomolecules sedimentation, ultra- centrifugation, diffusion, osmosis, viscosity, polarization and electrophoresis, chromatography; Fiber physics; Basic spectroscopic techniques, Chlorophyll fluorescence; photosynthesis, transpiration, thermal imaging, Applications of electromagneticfield in agriculture; Nanostructures, Properties and characterization of nanomaterials; Nanoformulations, Nanobiology, Nanotoxicology; Nanosensors, Application of nanotechnology in agriculture.

Unit 6: Remote Sensing

Principles of remote sensing, remote sensing systems — active and passive, sensors and platforms; Imaging and non-imaging systems; satellite characteristics, spatial, spectral, radiometric and temporal resolutions, multispectral, hyperspectral, thermal and microwave remote sensing; spectral signatures of natural targets and its physical basis, spectral indices;; Air borne remote sensing; Digital image processing; formats, pre-processing, enhancement, classification; National and International satellite

systems for land, weather, ocean and other observations; Applications of remote sensing in agriculture and natural resource management; — crop acreage, crop yield, irrigation management, soil type and properties, abiotic/biotic stress in crops, precision agriculture, soil and water conservation and watershed management, management of degraded, waterlogged and other problematic soils, crop insurance, applications of drones in agriculture.

Unit 7: Geo-informatics

Principles and concepts: Hardware and software requirements; Geographic information system (GIS) - Definition, components; Maps and projections, principles of cartography; Basic geodesy: Geoid /Datum/Ellipsoid; Projections and coordinate systems, types and scales; Accuracy of maps; Rasterand Vector data models; DBMS and RDBMS; Geostatistical analyses; Spatial interpolation - Thiessen polygon; Inverse square distance; Kriging; Digital Elevation Mode1; Different spatialand temporal analysis and modelling; Principles of GPS, DGPS; Errors in GPS data and correction; GPS constellations; Geoinformatics applications in agriculture and natural resourcemanagement.

Unit 8: Atmospheric physics

Weather and climate: atmosphere and its constituents; Meteorological elements and their measurements; Heat balance of the earth and atmosphere; Climatic classification systems; Climatology of India, agro-ecological regions; Monsoon, western disturbances, cyclones, droughts; Wind system, precipitation, cloud, pressure pattern; Atmospheric stability; Weatherforecasting: numerical weather prediction; El Nino, La Nina and ENSO; Greenhouse gases, Globalwarming, and climate change; Impacts, adaptation and mitigation of climate change in agriculture; Physiological response of crop plants to weather (light, temperature, CO_2, moisture and solar radiation); Heat units, thermal time and thermal use-efficiency and their applications; Micro-, meso- and macro-climates; Modification of microclimate; Exchange of mass, momentum andenergy between surface and atmosphere, exchange coefficients; Richardson number & Reynolds'analogy; Boundary layer; Eddy covariance techniques; Wind profile; Radiation distribution withinplant canopy; Role of surface albedo, photo-chemical pollution and aerosols in modifying micro- climate, Boundary layer; Concept of evapotranspiration: potential, reference and actual evapotranspiration, crop coefficient; measurement of evapotranspiration. Energy balance of landsurfaces.

Unit 9: Mathematical modelling and Data Analytics

Applications of matrices, determinants, differentiation and integration; Numerical modelling: finite difference and finite element; Iterative technique, Fourier analysis, Infinite series and Taylor series; Probability, probability distribution and applications in agriculture; Measures of centraltendency and dispersion; correlation and regression, Spatial statistics: Variogram and interpolationtechniques; Analysis of Variance (ANOVA) and Covariance; Statistical Design of AgriculturalExperiments; Test of Significance (t-Test, F test, Chi-square test). Surface modelling; Fundamentalsof dynamic simulation, systems, models and simulation; Mechanistic, stochastic and deterministicmodels; Model calibration, validation, uncertainty and sensitivity analysis; Simulation models for water, heat, and solute movement in two- and three-dimensional porous media; Modelling rootwater uptake; Crop weather models and its application in crop yield estimation, biotic and abiotic stress characterization; Advantage and limitations of modelling.

59. ELECTRONICS & INSTRUMENTATION

Unit-1: Transducers and Applications

Introduction to Measurement Systems: General concepts and terminology, measurement systems, sensor classification, static characteristics of measurement systems-Range, accuracy, linearity, resolution, noise, repeatability, precision and sensitivity etc. Estimation of errors. Dynamic characteristics of measurement systems. Zero-order first-order and second-order measurement systems and response. Measuring Devices: Displacement: Resistive Potentiometer, Resistive strain gauges inductive displacement transducer, CapacitiveDisplacement Transducers, Piezo Electric Transducers, Ultrasonic Methods. Temperature: Thermal expansion methods, Thermo electric, radiation methods-thermal and photon detectors based thermometers. Pressure: Methods of pressure measurement: Dead weight gauges and manometers, elastic transducers, high pressure measurement. Flow: Anemometers, velocity sensors obstruction meters, averaging Pitot tubes, Rota meters, Electromagnetic, Vortex shedding, Ultrasonic Flow meters. Velocity and Acceleration: Seismic displacement, velocity and acceleration pickups (Accelerometers). Gyroscopic angular displacement and velocity sensors. Force and Torque: Methods of force measurement and characteristics, Bonded strain gauge, Variable Reluctance, Piezo Electric Transducer, Torque measuring on rotating shafts. Humidity, Density and Radiation Measurement: Capacitive Impedance and Piezoelectric Hygrometers. Differential Pressure, U-tube and ultrasonic Densitometers and pH measurement: Ion Selective Type. Radiation Fundamentals-Radiation Detectors - Radiation Thermometers and Optical Pyrometers. Digital Sensors: Position encodes, variable frequency sensors-quartz digital thermometer, SAW sensors, digital flow meters, sensors based on semiconductor junctions: thermometers based on semiconductor junctions, magneto diodes and magneto transistors, photodiodes andphototransistors, charge-coupled sensors.

Unit-2: Signal Conditioning Circuits

Bridges: The Wheat Stone Bridge - Single Variable Element, Two Single Variable Element& Four Single Variable Element, Excitation, Readout - bridge amplifier, instrumentation Amplifier, minimize common mode voltage, Isolator, Chopper Amplifier Interference: Local Problems, Subsystems Problems - grounding mechanisms, Outside & Local Interface - guard circuit, Analog Filtering - Design of 1st order & 2nd order filters, Operational Amplifiers, Instrumentation Amplifiers, Isolation Amplifiers, System Solutions Offsetting & Linearizing:Offsetting - use of bridge in offsetting, 4 - to - 20 mA Current Transmission - typical 4 - 20 mA Transmission, isolated 4 - 20 mA Transmission, basic 0 to 10 V to 4 to 20 mA Translation circuit, Non Linearity & Linearizing - Digital Linearizing & Analog Linearizing Thermoswitches & Thermocouples Interfacing: Thermo switches, Ambient Referenced Thermocouples, Isolated Thermocouple Measurement, Thermocouple to Frequency, Thermocouple to 4 - to - 20 m A Temperature Transmitter, Isolated Multiplexing of Thermocouples RTD's Interfacing: Single Op - Amp Interface, using a Signal Conditioner, Bridge configuration using 3 -wire RTD, Linearizing RTD Circuits, Current Transmitters for RTD Outputs, RTD Based Precision controller Thermistor Interfacing: Simple InterfaceCircuits, High - Resolution Differential Thermometer, Current Transmitters, Thermistor to Frequency Conversion Semiconductor Temperature Transducers Interfacing: T - to - F Conversion using Diodes, Absolute Temperature - to - current Conversion, Temperature Control Circuits, Multiplexed Applications, Isolation, 4 - to - 20 m A Current Transmission Pressure Transducer Interfacing: Strain Gauge Based Transducers, Potentiometer toFrequency Transducer, Interfacing High level Semiconductor Transducers, Isolated Pressure Transmitter, Pressure Control System. Force Transducer Interfacing: Spring Driven Rheostat, Strain - gauge & Signal Conditioner, High Resolution Load Cell Platform Interface, Strain Gauge to Frequency Conversion, Isolators & Transmitters Flow Meter Interfacing: Differential Pressure Flow meters, Frequency output Flowmeters, Anemometers, Hinged Vane Flowmeter, Thermal Flow Meter, Transmission & Readout Level Transducers Interfacing: Float & Potentiometer, Optical Sensing & Thermal Sensing Miscellaneous Applications: 4 - to - 20 m A Transmission, Topics on Filtering, Programmable - Gain Isolator, High - Performance Floating Data Amplifier, Isolated All - Electronic Multiplexing, Pulsed - Mode Bridge Excitation

Unit-3: Process Control Instrumentation

Introduction: Incentives for process control, Design aspects of process control system, Process degree of freedom. Mathematical model of first order processes: level, pressure and thermal processes - Second order process: Interacting and non-interacting processes, - Time and frequency response analysis. Basic Single Loop Control Actions: Characteristics and dynamics of Discrete

Control Modes: ON-OFF, Multi Speed, Floating Controllers. Characteristics and dynamics offeedback control modes: Proportional, Integral and Derivative control modes - P+I, P+D and P+I+D control modes. P-1-D Controller Tuning and Stability Analysis: Tuning of Controllers: Evaluation criteria - IAE, ISE, ITAE, Tunings - Process reaction curve method - Ziegler Nichols method - Damped oscillation method.Design of Lead, Lag compensators, stability analysis MIMO Systems -Multi-loop Control: MIMO Systems: Dynamics of Distillation column and Heat exchangers processes, Multi loopControllers: Feed-forward control - ratio control- cascade control - adaptive - split-range control - multivariable control - examples from distillation column and boiler systems. Modem control practices in: Power plants, pharmaceuticals and petrochemicals industries. Final Control Element: /P converter - pneumatic and electric actuators - valve positioner - control valves -characteristics of control valves - inherent and installed characteristics -control valve sizing - cavitation and flashing -selection criteria.

Unit-4: Data Acquisition Systems

Data Loggers and Data Acquisition Systems: Data acquisition systems-configurations components, analog multiplexes and sample and hold circuits-specifications and design considerations. DACs: specifications - characteristics, types of DACs (serial, parallel, direct and indirect). Hybrid and monolithic DACs. ADCs: specifications - characteristics, types of ADCs (serial, parallel, direct and indirect). Hybrid and monolithic ADCs. sigma-delta ADCs',Hybrid DAS - Schematic diagram - configurations - specifications. Error Budget of DACs and ADCs: Error sources, error reduction and noise reduction techniques in DAS. Error budget analysis of DAS. Case study of a DAC and an ADC. Data Acquisition Hardware and Software: Specifications of Hardware-IO analog signal range, gain for analog input and resolution in ADC converter, resolute\ion in DAC and counter chips, sampling frequency andmaximum update rates, triggering capacity. Digital lines and ports, data acquisition VIs. Distributed AND Stand Alone Data Loggers: Introduction, methods of operation-programming and logging data using PCMCIA cards, standard alone operation- direct and remote connection to the host PC, standalone logger/controller hardware interface-RS232C, RS485 standard, communication bottlenecks and system performance, using Ethernet toconnect data loggers. IEEE 488 Standard: Introduction, characteristics, physical connection configurations, device types, bus structure, GPIB hand shake, device communication, IEEE 488.2, standard commands for programmable instruments. Display Systems: LCD Flat panel displays, Digital storage CROs, Plasma displays, Projection systems. Analyzers - Spectrum Analyzers - guidelines, various triggering techniques, different types of spectrum analyzers, Recorders. Display devices and Display systems, Logic Analyzers - State and time referenceddata capture. Scalar and Vector Network analyzers.

Unit-5: Virtual Instrumentation

Virtual Instrumentation: Historical perspective, advantages, block diagram and architecture of a virtual instrument, data-flow techniques, graphical programming in data flow, comparison with conventional programming. Development of Virtual Instrument using GUI, Real-time systems, Embedded Controller, OPC, HMI / SCADA software, Active X programming. VI Programming Techniques: VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O, Instrument Drivers, Publishing measurement data in the web. VI Chassis Requirements: Common Instrument Interfaces: Current loop, RS 232C/ RS485, GPIB. VISA and IVI. Application of Virtual Instrumentation: Instrument Control, Signal Measurement and generation: Data Acquisition. Advanced LabVIEW Data Concepts: Advanced file I/O, Configuring INI files, Calling code from other languages, Fitting Square Pegs into round holes: Advanced. Connectivity in Lab VIEW: Lab VIEW web server, E-mailing data from Lab VIEW, Remote Panels, Self-describing data, shared variables, talking to other programs and objects, talking to other computers, database, report generation. Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion control.

Unit-6: Analytical Instrumentation

Electrochemical Instruments: Basic concepts of Analytical instrumentation, Electro chemical instruments- pH meter, Conductivity meter, Dissolved oxygen analyzers using Polarographic principle - sodium analyzer- silica analyzers- Polarographic Instruments. Absorption Spectrophotometers: UV, VIS spectrophotometers - single beam and double beam instruments - instrumentation associated with the above spectrophotometers - sources and detectors. IR SPM-sources and detectors for IR spectrophotometers, FTIR, Raman Spectroscopy, Interpretation & Analysis. Emission Spectrophotometers: Flame emission and atomic absorption spectrophotometer - Atomic emission spectrophotometer - sources for Flame Photometers and online calorific value

measurements. Gas and LiquidChromatographs: Basic principle of gas chromatography, liquid chromatography, HPLC different types of columns, detectors, recorders and associated equipment, Salient features of liquid chromatography, Detectors used. Principle of Nuclear Magnetic Resonance: Instrumentation associated with NMR spectrophotometer- Introduction to mass spectrophotometers, Principle of electron spin resonance (ESR). Gas Analyzers: Flue gas analysis using thermal conductivity principle, Katharometer - oxygen analyzers using paramagnetic principle, Zirconium oxide cells, Pollution Monitoring Instruments. Industrial analyzer circuits; CO monitors - Nox analyzer - Sox Analyzer - H2S analyzer system,Nuclear Radiation Detectors: GM counter, Scintillation counter, Ionization chamber - Solid state detector, Gamma Spectrometry, Industrial application of radiation measurement. Thermal Analyzers: Differential Scanning Calorimetry (DSC), Derivative Thermo Gravimetric Analyzers (DTGA).

Unit-7: Real Time and Embedded Systems

Introduction: Embedded systems overview, design challenge, processor technology, IC technology, Design Technology, Trade-offs. Single purpose processors RT-levelcombinational logic, sequential logic (RT-level), custom single purpose processor design (RT-level), optimizing custom single purpose processors. General Purpose Processors and Communication Interface: Basic architecture, operation, Pipelining, Programmer's view,

development environment, Application Specific Instruction-Set Processors (ASIPs)- Micro Controllers and Digital Signal Processors. Need for communication interfaces, RS232 /UART, RS422 / RS485, USB, Infrared, IEEE 1394 Firewire, Ethernet, IEEE 802.11, Blue tooth. Introduction to RTOS and Basic Design: Architecture of the Kernel, Tasks and Task scheduler, Interrupt service routines, Semaphores, Mutex, Mailboxes, Message Queues, Event Registers, Pipes, Signals Principles, Semaphores and Queues, Hard real time scheduling considerations, Saving memory and power an example RTOS like µC - OS (Open Source) Embedded S/W Development tools. Real Time Operating Systems: Timers, Memory Management, Priority inversion problem, Embedded operating systems Embedded Linux, Real-time operating systems, RT Linux, Handheld operating systems, Windows CE. Design Technology: Introduction, Automation, Synthesis, Parallel evolution of compilation and synthesis, Logic Synthesis, RT synthesis, Behavioral Synthesis, Systems Synthesis and Hardware/ Software Co- Design, Verification, Hardware/Software co-simulation, Reuse property codes.

Unit-8: Digital Image Processing

Introduction: Fundamentals steps of Image processing, Components of an Image processing system, Image sampling and quantization, relationship between the pixels. Gray level transformation, Smoothing and sharpening spatial filters, Smoothing and sharpening frequency domain lters, Homo morphic filtering. Image Transforms: 2-Dimensional Orthogonal and Unitary Transforms-I-Dimensional DFT-2-Dimensional DFT- CosineTransform- The Sine Transform- The Hadamard Transform- The Haar Transform- The Slant Transform -The KL Transform- The Singular Value Decomposition Transform. Image Enhancement: Basic Gray Level Transformations-Image Negatives, Log transformations, Power-law Transformations, Piecewise-Linear Transformation Functions- Histogram Processing-Histogram equalization, Histogram matching, local Enhancement, Use of Histogram Statistics for Image Enhancement-Enhancement using Arithmetic/Logic Operations-Image Subtraction, Image Averaging. Image Segmentation: Edge linking and boundary detection, Thresholding- Global and Adaptive, Region based segmentation, Segmentation by morphological watersheds, color segmentation. Colour Image Processing: Colour Fundamentals- Colour Models- Pseudocolour Image Processing- Basics of Full- Colour Image Processing - Colour Transformations- Smoothing and Sharpening - Colour Segmentation - Noise in Colour Images - Colour Image Compression Morphological Operations: Dilation and erosion, Opening and closing, Hit or Miss transforms, Morphological algorithms, Extensions to gray scales images and its applications. Imagecompression: Compression models, Error free coding, lossy coding, compression standards, color image compression, Introduction to fractals.

Image Representation and Description: Representation-Chain codes, Polygonal Approximations, Signatures, Boundary Segments, Skeletons- Boundary Descriptors- simple descriptors, shape numbers, Fourier Descriptors, statistical moments -Regional Descriptors- simple descriptors, topological descriptors, texture, moments of two- dimensional functions. Image Degradation/Restoration: Unconstrained and Constrained Restoration- Restoration in the presence of Noise Only-Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Estimating the degradation Function-Estimation by Image Observation, Estimation by Experimentation, Estimation by Modeling- Inverse Filtering- Minimum Mean Square Error (Wiener)

Filtering- Constrained Least Squares Filtering- Geometric Mean Filter Geometric Transformations- Spatial transformations, Gray-level Interpolation.

Unit-9: Microcontroller, PLC, SCADA Programming and their Applications Microcontroller: Architecture, programming and applications, Programmable Logic Controller (PLC) Basics: Definition, Overview of PLC systems, input/output modules, Powersupplies and Isolators. Basic PLC programming: Programming On-Off inputs/ outputs.Creating Ladder diagrams, Basic PLC functions, PLC Basic Functions, register basics. PLC Intermediate and Advanced Functions: Arithmetic functions, Number comparison functions, Skip and MCR functions, data move systems. Utilizing digital bits, sequencer functions, Matrix fu ctions. PLC Advanced Functions: Analog PLC operation, Networking of PLC, Applications of PLC: Controlling of Robot using PLC, PID control of continuous processes etc. HART and Field Bus:

Introduction-Evolution of signal standard – HART Communication Protocol - Communication Modes - HART (Highway Addressable Remote Transducers) modes-Control system interface HART commands - HART Field Controller - Field Bus Architecture Basic requirement of field bus standard fieldbus topology, CAN bus." SCADA: Basic building blocks of computer control system - SCADA - MTU and RTU, Casestudies On SCADA.

Unit-10: Robot Design and Control

Robot Fundamentals: Definitions, History of robots, present and future trends in robotics, Robot classifications, Robot configurations, Point to Point robots, Continuous Path robots, Work volume, Issues in design and controlling robots Repeatability, Control resolution, spatial resolution, Precision, Accuracy, Robot configurations, Point to Point robots, Continuous Path robots, Work volume, Applications of robots. Drives used in robots- Hydraulic, Pneumatic and Electric drives, Comparison of drive systems and their relative merits and demerits. Manipulator Kinematics: Matrix Algebra, Inverse of matrices, rotational groups, matrix representations of coordinate transformation, transformation about reference frame and moving frame Forward & Inverse Kinematics examples of 2R, 3R & 3P manipulators, Specifying position and orientation of rigid bodies Euler's angle and fixed rotation for specifying position and orientation Homogeneous coordinate transformation and examples D-H representation of kinematics linkages Forward kinematics of 6R manipulators using D-H representations Inverse kinematics of 6R manipulators using D-H representations, Inverse Kinematics geometric and algebraic methods.
Robotics Dynamics: Velocity Kinematics, Acceleration of rigid body, mass distribution Newton's equation, Euler's equation, Iterative Newton -Euler's dynamic formulation, closed dynamic, Lagrangian formulation of manipulator dynamics, dynamic simulation, computational consideration. Autonomous navigation and Trajectory Planning: Introduction, general considerations in path description and generation, joint space schemes, Cartesian space schemes, path generation in runtime, planning path using dynamic model point to point and continuous trajectory, 4-3-4 & trapezoidal velocity strategy for robots. Robot Sensors: Internal and external sensors, position- potentiometric, optical sensors, encoders - absolute, incremental, touch and slip sensors velocity and acceleration sensors, proximity sensors, force& torque sensors, laser range finder, camera. Micro-controllers, DSP, centralized controllers, real time operating systems. Robot Controllers: Essential Components-Drive for Hydraulic and Pneumatic actuators, H-bridge drives for DC Motor with overload, over current and stall detection methods, example of a micro-controller/ microprocessor based- robot Controller. Micro-robotics and MEMS (Microelectro mechanical systems), fabrication technology for Micro-robotics, stability issue in legged robots, under-actuated manipulators. Robot Vision: Introduction, Image acquisition, Illumination Techniques, Image conversion, Cameras, sensors, Camera and system interface, Frame buffers and Grabbers, Image processing, low level & high level machine visionsystems.

Unit-11: Speech Processing

Introduction to speech processing - its necessity. Digital models for speech signals: process of speech production, acoustic theory of speech production, and models of speech production, auditory knowledge. Digital representation of speech waveform: sampling speech signals, quantization, delta modulation, differential PCM, code conversion, other new methods of coding. Fundamentals of speech analysis: background of speech processing tools, spectrographic analysis, short time analysis, time frequency analysis, homomorphic analysis. Linear predictive coding of speech: basic principles, solutions of LPC equations, prediction error, application of LPC parameters. Fundamentals of speech recognition: current state of speech recognition systems, techniques and problems for noisy speech recognition, statistical and speech model based methods. Speech enhancement: spectral subtraction, noise masking, and comb filtering, statistical modeling.

60. TEXTILE MANUFACTURE & TECHNOLOGY

Unit 1. Basic concepts

Introduction to Textile Manufacture Sciences. Basics of polymer science, fibre manufacturing processes, physical, mechanical and chemical properties; chain and step growth polymerization methods, polymer's macromolecular architecture, molecular weight of polymers, copolymerization, cross-linked polymers, general structure and characteristics of polymers, properties of fibre forming polymers, and their applications

Unit 2. Textile Fibres

Introduction to textile fibres and its classification; Extraction of natural fibres; Principle and working of ginning; Structure and morphology of natural fibres, Manmade and synthetic fibres:Viscose, Acetate, Acrylic, Nylon, polyester, High Performance Fibres. Principle of melt spinning, wet spinning, dry spinning, dry-jet-wet spinning and gel spinning; Post spinning operations such as drawing, heat setting, spin finish and its applications; Texturing methods. Structure-property relations of fibres; Use of natural and man-made fibres; Production and consumption of natural and synthetic fibres. Grading and marketing of natural fibres. Superabsorbent polymers and fibres. Principle of electrospinning. Nano fibres and its applications.

Unit 3. Yarn manufacture, structure and properties

Concepts and working principles of opening, cleaning and blending; blow-room machines, carding, combing, roller drawing for cotton spinning; Spinning of natural fibres (cotton, jute, wool, silk) and its blends, Blending of man-made fibres with natural/synthetic fibres and theirspinning; Woollen spinning and semi-worsted and worsted systems: gill box / drawing;Periodic mass variation in sliver and auto-leveler; Principles of drafting, twisting, and bobbin/cop building on roving and ring frame; Modern developments in ring spinning; Principle of ring doubler and two for-one twister; Relationship between single yarn twist and folded yarn twist; Principles of compact, rotor, air-jet, air-vortex, friction, wrap and twist-less spinning processes and their structure-property relationship.

Cotton fibre selection through bale management. Forces on fibres during opening and cleaning processes and its effect. Technological considerations in the design of high production card. Card wire geometry, Roller slip. Roller eccentricity and vibration. Blending of fibres, evaluation of blending efficiency. Analysis of forces on yarn and traveller. Spinningtension in ring and rotor spinning. Spinning geometry, Twist flow in ring and rotor spinning. End breaks during spinning.

Influence of fibre configuration and orientation on yarn properties; Fibre packing density of yarn; Yarn twist and its relation to yarn properties. Stress-strain relation, Mass irregularity and fibre migration in yarns. Specialty yarns: Design, manufacture, characterization andapplication of Hybrid yarns, High bulk yarns, Electro-conductive yarns, technical sewing threads, Coated yarns, Reflective yarns and Elastomeric yarns.

Unit 4. Fabric manufacture, Structure and Properties

Introduction to various fabric forming principles: weaving, knitting, nonwoven and braiding.Stages of woven fabric manufacturing: winding, warping, sizing, drawing and tying in and weaving. Winding: principles, precision and random winding, digicone winding, yarn tensioning and clearing. Warping: direct and sectional warping. Sizing: size materials, sizing machines, process and quality control, modern trends. Drawing and tying in. Basic fabric designs: plain, matt, rib, twill and satin, drafting and lifting plans. Primary motions of shuttle looms: cam shedding, cam designs, dobby and jacquard systems, picking systems, loom timing, beat up, sley eccentricity. Secondary and auxiliary motions: take up, let off, warp and weft stop and warp protecting motions.

Principles of weft insertion systems in shuttle-less weaving machines (projectile, rapier,water-jet and air-jet); Principles of multiphase and circular looms; Geometry of plain knitted fabric loop. Fundamentals and classification of weft (plain, rib, interlock and purl) and warp (pillar, tricot, atlas, inlay and nets) knitting; Different knit stitches such as loop, tuck and float; structures and their properties, weft and warp knitting machines. Nonwovens: Definitions and classifications, production technology, selection criteria and important properties of fibres used, different types of web information and bonding techniques, production and properties of needle punched, adhesive bonded, thermally bonded, hydroentangled, spun bonded and meltblown fabrics. Braided structures: Types of braiding processes, classification of braids, braid geometry, structure-property relationship, over braiding.

Specialty fabrics: 3D fabric, spacer fabric, profile fabric, multi-axial fabric, auxetic fabric/textile, leno structure, Multi-functional fabrics.

Unit 5. Textile testing

Standard conditions for textile testing; Physical and chemical methods of fibre identification and blend estimation; Methods of investigating fibre structure such as density, x-ray diffraction, birefringence, optical and electron microscopy such as SEM, IR. spectroscopy, thermal methods such as DSC, DMA, TMA and TGA; Mechanical properties of fibres; Fibre testing instruments, equipment & standards; Calibration; Fibre structure-property correlation. Testing methods: Measurement of length, fineness and crimp of fibres; Determination of maturity, foreign matter, and moisture content of cotton; Principles of AFIS, HVI etc.;Measurement of twist, linear density and hairiness of yarn; Evenness testing of silvers, rovings and yarns; Analysis of periodic variations in mass per unit length; Uster classimat; Spectrogram and V-L curve analysis; Tensile testing of fibres, yarns and fabrics; Automation in tensile testers; Tearing, bursting and abrasion resistance tests for fabrics; Pilling resistance of fabrics; Bending, shear and compressional properties of fabrics, fabric drape and handle (KESF, FAST etc); Crease and wrinkle behavior; Fastness characteristics of textiles; Matching of shade; Air, water and water-vapour transmission through fabrics; Thermal resistance of fabrics; Testing of interlaced and textured yarns; Special tests for carpets and nonwoven fabrics. Testing of special yarns (textured yarns, core yarn, ropes, braids etc). Testing of special fabrics (different types of nonwovens, carpets, different types of technical textiles like bullet proof fabrics, UV protective fabrics, EMS fabrics)

Unit 6. Textile chemical processing

Textile Chemical Processing: Natural and added impurities in Textiles, singeing, desizing, scouring, bleaching, mercerization of cotton; Carbonisation, scouring and bleaching of wool, Degumming of silk and Assessment processes; principles of dyeing and printing of textile materials, basic characterstics of dyes, chemical structures of dyes, classification, dyeing of cotton, polyester, wool/nylon; Methods of printing, preparation of printing pastes, Direct discharge and resist printing styles; Introduction to chemical and mechanical finishes; chemical finshes for hand modifications; Easy oil, water and soil repellency; Fire retardant and antimicrobial finishes; Dye-fibre interaction; Thermodynamics and kinetics of dyeing; Beer-Lambert's law; Kubelka-Munk theory and its application in colour measurement system; Advance in mechanical finishes – calendaring raising, and softening. Principles and chemistry of Chemical finishes - easy care, antimicrobial, anti UV, antistat, softening, Flame retardant, water repellent. Principle of repellency, oil, water and soil, self-cleaning textiles. Wellness finishes for aroma, health and hygiene. New technologies - microencapsulation, plasma, nano technology. Finishing of technical textiles. Membranes and laminates. Multi - functional finishing.

Unit 7. Garment manufacturing and smart textiles

Different methods and principles of developing basic patterns viz. drafting, flat pattern method and draping. Traditional textiles and costumes of India and their influence on contemporary trends in fashion. Structural and applied designs in apparels. Sewing techniques and their applications in manufacturing of apparels/garments. Apparel standards, specification. Application of art principles in textile designs.

Definition, classification and applications of functional and smart textiles; Smart and Intelligent textiles: Passive and Active functionality, stimuli sensitive textiles, Electronic textiles: wearable computers, flexible electronics. Perceptions of sensations related to mechanical, thermal and moisture stimuli. Thermal transmission: Thermoregulatory mechanisms of human body, heat transfer theories, thermal conductivity of fibrous materials, steady state measurement techniques for heat transfer, transient heat transfer mechanism: warm-cool feeling. Moisture transmission: transfer of liquid moisture and vapour transfer through fibrous materials.

Unit 8 : Technical textiles:

Fibres, yarns and fabric structures in technical textiles and their relevant properties. Filtration: Textile and other filter media for dry and wet filtration. Mechanisms of separation. Requirements for good filter media and filtration. Fiber and fabric selection for filtration. Geotextiles: Types and application of geosynthetics. Functions and application areas of geotextiles. Fibres and fabric selection criteria for geotextile applications. Mechanics ofreinforcement, filtration and drainage by geotextiles. Soil characteristics. Methods of long- term prediction of geotextile life and survivability in soil. Automotive Textiles: Applicationof textiles in automobiles. Requirement and design for pneumatic tyres, airbags and belts. Methods of production and properties of textiles used in these applications. Sewing threads, cords and ropes: Types, method of production and applications. Functional requirements, structure and properties. Miscellaneous: Functional requirements and types of textiles usedfor paper making, agricultural, architectural, packaging and footwear.

Unit 9 : Concept of sustainability in textile:

Green processing technologies - Enzyme biotechnology, plasma technology in textiles; waterless dyeing technologies, low liquor dyeing, Low-salt reactive dyes, Reducing waterand energy consumption - Efficient liquor extraction, Low wet pick up and drying technologies. Combined dyeing and finishing, Textile recycling: polymer, fiber, yarn, fabric and garment. Industrial hazardous waste management. Laws related to environmental protection specially with reference to textile industry, Compliance, certification, social accountability and ethical practices. standards for labelling, textile labels and environmental labelling; life cycle analysis of textiles.

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