SYLLABUS FOR THE ALL INDIA COMPETITIVE EXAMINATION FOR ADMISSION TO DOCTORAL DEGREE PROGRAMMES AND THE AWARD OF JRF/SRF (PGS)

01 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 relation to plant breeding methodology. Apomixes, incompatibility and male sterility systems and their use in plant breeding. Epigenetics.

Unit 2: Economics Botany and Plant Breeding Methods

Origin, distribution, classification, description and botany of cereals (wheat, rice, maize, sorghum, pearl millet, small millets); pulses (pigeonpea, chickpea, black gram, green gram, cowpea, soybean, pea, lentil, horse gram, lab-lab, rice bean, lathyrus, lima bean; oilseeds (groundnut, sesamum, castor, rapeseed mustard, sunflower, safflower, niger, linseed); fibre and sugar crops, fodder and green manures; Breeding methods for self-pollinated, cross-pollinated and asexually propagated crops. Combination, recombination and transgressive breeding. Single seed descent. Populations, their improvement methods and maintenance, Hybrid breeding and genetic basis of heterosis. Ideotype breeding. Mutation breeding, Concept of tree breeding. Speed breeding methods, Pre-breeding, Reverse Breeding.

Unit 3: Genome Organization and Cytogenetics of Crop Plants

Chromosome number, structure, function and replication. Sex determination & sex linkage. Recombination and crossing over. Molecular and cytological mechanism of crossing over. Karyotype analysis.Chromosomal theory of inheritance. Cell cycle and its regulation. Banding techniques. *In situ* hybridization. GISH and FISH Special types of chromosomes. Chromosomal interchanges, inversions, duplications and deletions. Polyploids, haploids, aneuploids, their utility and their meiotic behaviour. 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, sorghum, *Brassica*, groundnut, cotton, *Vigna*, potato and sugarcane. Cytogenetic techniques for gene location and gene transfer, Construction and use of molecular marker based chromosome maps.

Unit 4: Quantitative and Biometrical Genetics

Quantitative characters. Multiple factors inheritance. Genetic control of polygenic characters. Genetic advance and types of selection their effects on population mean and variance. Metric characters under natural selection. Repeatability and asymmetry of response. Breeding value. Dominance and interaction deviations. Hardy Weinberg law and changes in gene frequency due to migration, mutation and selection. 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, stability of performance and stability analysis. Heterosis and its basis (Genetic, biochemical and physiological). Mating system and mating design- diallel, line X tester, NC-I NC-II and NC-III designs, approaches to estimate and exploit components of self and cross pollinated crops. . GGE biplot analysis, Principal component analysis, AMMI and GGI analysis.

Unit 5: Genetic Engineering and Biotechnological Tools in Plant Breeding

Somatic hybridization, micropropagation, somaclonal variation, *in vitro* mutagenesis. Anther culture. Cryopreservation. Genetic and molecular markers, generation of molecular markers and their application in genetic analyses and breeding. Molecular markers in genetic diversity analysis and breeding for complex characters. Gene tagging, QTL mapping, MAS, MARS and MABB. Vectors. DNA libraries, DNA fingerprinting, DNA sequencing. Nucleic acid hybridization and immunochemical detection. Chromosome walking, Recombinant DNA technology, Gene cloning strategies. Gene transfer methods. Artificial synthesis of gene. Genetic transformation, transgenics and cisgenics. Antisense RNA, RNAi and micro RNA techniques in crop improvement. Genome editing using CRISPER/cas, Genomic selection, RNA Seq analysis,

Unit 6: Plant Breeding for Stress Resistance and Nutritional Quality

Genetic and molecular 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 using biotechnological tools (MAS, MARS and MABB and transgenics). Biofortification.

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. Types of genetic resources. Centres of diversity of cultivated plants. Genetic erosion and genetic vulnerability. Convention on Biological Diversity and International Treaty on Plant Genetic Resources for Food and Agriculture. Intellectual Property Rights and its different forms for protection of plant genetic resources. Biodiversity Act. Protection of Plant

Varieties and Farmers' Rights Act and its features. System of variety release and notification. Types of seeds and seed chain. Maintenance breeding- nucleus and breeder seed production. 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. Designs of experiments - basic principles, completely randomized design, randomized block design and split plot design. Complete and incomplete block designs. Augmented design, Grid and honeycomb design. Hill plots, unreplicated evaluation. Data collection and interpretation.

02 SEED SCIENCE & TECHNOLOGY

Unit 1 : Seed Biology

Floral biology, mode of reproduction, sporogenesis, pollination, fertilization, embryogenesis, fruit and seed development and physiological and harvestable maturity. Apomixis, parthenocarpy, polyembryony and somatic embryoids and synthetic seeds. Seed structure of monocot and dicot. Seed maturation and maturation drying in orthodox and recalcitrant seed. Seed chemical composition. Seed dormancy - types, causes, methods to overcome dormancy. Seed germination - phases, types and requirements. Physiological and biochemical changes in germinating seed. Role of hormones in dormancy and germination.

Unit 2 : Seed Production

Genetic purity - concept and factors responsible for deterioration of varieties. Maintenance breeding. Generation system of seed multiplication. Seed production agencies - public and private. Compact area approach / seed village concept in seed production. Seed Replacement Rate, Seed Multiplication Ratio, Seed Renewal Period, Varietal Replacement Rate. Seed production planning. 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. Techniques of hybrid seed production - emasculation and pollination, detasseling, male sterility, sex expression, self-incompatibility and chemical hybridizing agents. Principles and methods of seed production of varieties and hybrids of cereals - wheat, paddy, sorghum, pearl millet and maize; pulses - chickpea, pigeon pea, green gram, black gram, soybean and cowpea; oilseeds - groundnut, brassica, sesame, sunflower and castor; fibre crops - cotton and jute; vegetable crops - tomato, brinjal, okra, chilli, cabbage, cauliflower, radish, knol khol, turnip, carrot and cucurbitaceous crops; important forage legumes - lucerne, desmanthus and grasses - cumbu napier and fodder sorghum ; plantation crops - coffee, tea, rubber, cocoa, cardamom, coconut and pepper. Disease free clonal propagation of crops - potato, sugarcane, tapioca, fruit crops - mango, citrus. apple, pear, plum. Clonal propagation of annual and perennial flowers like rose, gladiolus, chrysanthemum, marigold, dahlia, phlox and petunia. Clonal standards and degenerations. Micro propagation.

Unit 3 : Seed Processing

Principles of seed processing. Processing sequence for different crops. Layout of seed processing unit. Seed drying - principles and methods. Pre-cleaning, grading, upgrading, seed treatment and packaging. Working principles of seed processing machines *viz.*, cleaner cum grader, specific gravity separator, indented cylinder separator and seed treater. Seed quality maintenance during processing. Seed enhancement techniques - seed coating, pelleting and priming.

Unit 4: Seed Quality Control

Seed legislation - the Seeds Act 1966, Seed Rules 1968, Seed Control Order, 1983 and Seed Bill 2004. Seed certification - history, concept, organization, phases and Indian minimum seed

certification standards. Field inspection principles and methods. Inspection at harvesting, threshing and processing. Pre-and post-processing quality testing of seed. Seed testing concepts and objectives, its role in seed quality control. Seed sampling, seed moisture testing, purity analysis, germination testing, tolerance limit and seed testing equipments. Quick viability test and seed standards. Seed vigour, its significance and testing methods. Testing for genuineness of varieties – principles and methods based on seed, seedling and plant characters, biochemical techniques - electrophoresis of proteins and isoenzymes and DNA fingerprinting. International Seed Testing Association (ISTA), its role in development of seed testing procedures, rules and seed quality assurance for international seed trade. OECD seed certification guideline - agricultural and vegetable crops.

Unit 5 : Seed Storage

Seed storage - principle - purpose and types - short, medium and long term storage. Factors affecting seed storage and role of moisture, temperature and relative humidity. Viability nomographs. Longevity of orthodox and recalcitrant seeds. Seed deterioration causes and methods of control. Physiological, biochemical and molecular changes in seed ageing. Controlled storage. Germplasm storage. Cryo preservation. Seed storage containers, types - safe moisture content. Storage structures. Methods of stacking and their impact on seed quality. Seed storage godown maintenance and sanitation. Management of carry over seed.

Unit 6 : Seed Health

Significance of seed health. Procedures for seed health test and rules. Externally and internally seed - borne pathogens, mode of infection, development and spread, methods of detection. Important seed-borne diseases of cereals, oilseeds, pulses, fibre crops, vegetables and their control measures. Quarantine and International procedures of phytosanitary certificates. Important storage pests, their identification, monitoring and detection. Use of pesticides, botanicals, mycotoxins for seed treatments. Carry over infestation, principles of fumigation and safe use of fumigants.

Unit 7 : Seed Industry Development and Marketing

National and International seed industry development. Role of OECD and WTO in International seed trade. International Seed Federation (ISF). Market survey, demand forecasting, pricing policies, marketing channels, planning and sales promotion. Economics of seed production. Role of Government, semi Government, cooperative and private sectors in seed trade. Responsibilities of seed companies and dealers in Seed Act. Seed import and export.

Unit 8 : Protection of Plant Varieties

Plant Variety Protection (PVP) and its significance. International Union for the Protection of New Varieties of Plants (UPOV) and its role in development of Plant Breeders Rights and Seed Industry Development. UPOV 1978 and 1991 Acts. Plant Breeders Rights and exceptions to it. Breeders exemption and farmers privilege. Plant patent v/s Plant breeders rights. Impact of PVP

on seed supply system. Protection of Plant Varieties and Farmers' Right Act, 2001, its essential features. Criteria for protection of different types of plant varieties. DUS testing principles and application. Breeders, Researchers and farmers rights. Compulsory licensing. Indian Biological Diversity Act, its essential features. Access to Biological resources, benefit sharing.

3 ECONOMIC BOTANY & PLANT GENETIC RESOURCES

Unit 1: Biodiversity and Plant Genetic Resources

Biodiversity- an overview, genetic, species and ecosystem diversity; determinants of biodiversity ,species richness and endemism, agriculture as friend and foe of biodiversity, harmonizing biodiversity, conservation and agricultural development, origin and history of agriculture; dynamics of domestication; centers of crop plant origin and diversity; geographical distribution of crops of Indian origin, plant genetic resources management (importance and usefulness of germplasm, germplasm conservation, threat of genetic vulnerability, global concerns) *in situ* conservation of genetic resources, collecting genetic resources and managing genetic resources, biotechnology and germplasm conservation.

Unit 2: Exploration and Germplasm Collecting

History and importance of germplasm exploration; distribution and extent of prevalent genetic diversity; phyto-geographical regions/ecological zones and associated diversity; mapping eco-geographic distribution of diversity, threatened habitats, use of flora. Concept of population and gene pool, variations in population and their classification, gene frequencies in populations, rare and common alleles, gene pool sampling in self- and cross-pollinated and vegetatively propagated species, non-selective, random and selective sampling strategies. Strategies and logistics of plant exploration and collection, coarse and fine grid surveys, practical problems in plant exploration, use of *in vitro* methods in germplasm collection. Ethnobotanical aspects of PGR, crop botany, farming systems, collecting wild relatives of crop plants. Post-exploration handling of germplasm collections, collection and preservation of specimens, importance and use of herbaria and preparation of herbarium specimens. Present status and future strategies in collecting of major crops of Indian origin such as rice, maize, sorghum, sesame, brassica, okra, eggplant, cotton, mango, etc.

Unit 3: Germplasm Exchange and Plant Quarantine

History, principles, objectives and importance of plant introduction; Prerequisites, conventions, national and international legislations and policies on germplasm collection and exchange.

Plant quarantine- introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India; Pest risk analysis, pest and pathogen information database; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses, phytoplasma etc.). Detection and identification of pests including use of recent techniques like ELISA, PCR etc., Symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities. Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust. Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs

or GMOs, Indian regulatory system for biosafety.

Unit 4: Principles and Methods of Germplasm Conservation

In situ and *ex situ* conservation: concept of biosphere reserves, gene sanctuaries, on-farm conservation, field genebanks, botanical gardens, herbal gardens, *in vitro* repositories cryo-banks and DNA banks, Short-, medium- and long-term conservation, concept of base, active and working collections, seed structure and function, physiological and genetic changes during storage, theories of aging, viability equations, predicting storage life of seeds, dormancy and germination. Genebank management: acquisition, accessioning and processing of germplasm samples for storage, genebank standards for various crops, ISTA, AOSA, IPGRI guidelines, monitoring and regeneration of plant germplasm. Design of storage facilities, maintenance and operation of storage modules. Information management in genebanks, strategies for revival and rescue of rare genetic material.

Unit 5: Principles and Practices of Germplasm Regeneration and Evaluation

Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces. Germplasm characterization/evaluation procedures; evaluation of germplasm for specific traits; key issues for the improvement of characterization, evaluation and use of plant genetic resources; concept of core collection. Measuring diversity using agro-morphological data; gene markers and their use in PGR management. Evaluation and maintenance of wild relatives of crop plants; genetic enhancement/pre-breeding and use of alien/unadapted genetic resources in crop improvement.

Unit 6: Biotechnology in Plant Genetic Resource Management

History and importance of Tissue culture, Tissue culture media, Sterilization techniques, *In vitro* clonal multiplication, Somatic embryogenesis, Meristem culture and virus elimination, *In vitro* conservation –Introduction and principle, Strategies for *in vitro* short- and medium-term conservation, *In vitro* collection, *in vitro* exchange of germplasm.

Plant Cryopreservation-Introduction, Principle of cryotolerance, Techniques of cryopreservation: slow cooling, desiccation, pre-growth, encapsulation-dehydration, vitrification, droplet freezing, Cryoprotectants, Cryopreservation of seeds and pollen, Cryopreservation of *in vitro* cultures, Application of *in vitro* cryopreservation techniques, Management of *in vitro* and cryobanks, Genetic stability of *in vitro* conserved and cryopreserved germplasm, Importance of database for *in vitro* and cryopreserved germplasm.

Unit 7: Economic Botany

Origin, evolution, botany, cultivation, genetic resource activities and utilization of genetic diversity of important crops of cereals, millets, legumes, forage and fodder crops, medicinal and aromatic plants, beverages, oil yielding plants, spices and condiments, wood and timber yielding taxa, fumigatory and masticatory plants, vegetable crops, sugar, starch and cellulose yielding

plants, rubber yielding plants, insecticidal and herbicidal plants, fruits and nuts, flowering agents, gums and resins, fiber yielding plants, under-utilized and under-exploited plants, new crops, pseudo-cereals, important taxa in agro-forestry, horticulture and floriculture, processing and use of crop residues.

Unit 8: Information Management in Plant Genetic Resources

Statistical techniques in management of germplasm, developing core collection, estimation of sample size during plant explorations, impact of sampling on population structure, Sequential sampling for viability estimation, introduction of binomial, normal and negative cumulative normal, use of Probit scales, viability equations and nomograms, estimation of sample size for storage and viability testing,

Germplasm documentation; basics of computer and operating systems, database management system, use of statistical softwares, pictorial and graphical representation of data; Introduction to communication network.

Unit 9: Plant Taxonomy

Classical and modern species concepts, differentiation and evolution of species and biosystematics -variation within species, population genetics, phenotypic plasticity, environmental effects on populations, Modern evidences for Morphology and Anatomy, Embryology and Palynology; Biogeography and Cytotaxonomy; Modern evidences for Comparative studies on phytochemistry, Chemotaxonomy; Molecular taxonomy methods; Numerical methods in taxonomy; Biosystematic approaches in plant taxonomy- some Indian case studies, Taxonomy of cultivated plants: Taxonomy of cultivated plants with particular emphasis on Indian groups: Hybrids, domesticated species, wild-cultivated continuum; Tools of taxonomy for identification of plant species and variation patterns therein; Field and herbarium methods; Floristic and monographic works; Systematic and evolutionary studies, Taxonomic databases: Taxonomic databases and documentation methods.

Unit 10: Plant Biosecurity

History and Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases, National Regulatory Mechanism and International Agreements/Conventions viz. Agreement on Application of Sanitary and Phytosanitary (SPS), Measures/ World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agro-terrorism event, mitigation planning, integrated approach for biosecurity, Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops.

Unit 11: Fundamentals of Molecular Biology for PGR Management

Structure and function of DNA, genome organization, Tools for genetic manipulation, Introduction to molecular markers, classification and comparison of markers, basis for DNA polymorphism and principles of generating molecular markers, - RFLP, PCR, sequencing; Principles, merits and demerits of RAPD, ISSR, SSR, SCAR, SCOT, SRAP, AFLP, SNPs markers; data handling and statistical analysis, Overview of molecular marker applications, Introduction to transgenics, monitoring strategies and methods for detecting transgenics.

04 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.

Detection and Diagnosis of pathogens in seeds and other planting materials: Nucleic acid probes, Southern, Northern and Western hybridization, ELISA, ISEM and PCR. 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, Freeze dryer, Nano drop, GC-MS, HPLC, Thermocycler.

Unit 3: Physiological and Molecular Plant Pathology

Altered metabolism of plants under biotic and abiotic stresses. Molecular mechanisms of pathogenesis: elicitors, recognition phenomenon, penetration, invasion, primary disease determinant. Enzymes and toxins in relation to plant disease. Mechanisms of resistance, Structural and Biochemical defense mechanisms. R-Genes, Phytoanticipins. Phytoalexins. PR proteins, Hydroxyproline rich glycoproteins (HRGP). Antiviral proteins. SAR and ISR. HR and active oxygen radicals. Elementary genetic engineering. Management of pathogens through satellite, antisense - RNA. Ribozymes, coat protein, RNA interference, plantibodies, hypovirulence, cross protection. Useful genes and promoters, plant transformation techniques, biosafety and bioethics.

Unit 4: Mycology

Classification of fungi (According to the Classification – Kirk *et al.*, 2008). Life cycles of important phytopathogenic 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 elementary bacterial genetics and variability: transformation, conjugation, transduction. Biology of extra chromosomal elements: plasmid borne genes and their expression.

Bacteriophages: lytic and lysogenic cycles. Prokaryotic inhibitors and their mode of action. Economic uses of prokaryotes. Morphology, biochemical characteristics, reproduction and life cycle of phytoplasma and other fastidious prokaryotes.

Unit 6: Plant Virology

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

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. Decision support system, cloud computing, GPS, GIS and GS in plant disease epidemiology.

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, medicinal and ornamental crops with special reference to etiology, disease cycle, perpetuation, epidemiology and management. Postharvest diseases in transit and storage; aflatoxins and other mycotoxins and their integrated management.

Unit 10: Bacterial and Viral Diseases of Crop Plant

Crop diseases of cereals, pulses, oilseeds, sugar crops, vegetables, fruits, plantation and fiber crops caused by bacteria, viruses, viroids, phytoplasmas and other fastidious prokaryotes. Mode of transmission and pathogen vector relationships. Epidemiology and management.

Unit 11: Management of Plant diseases

General principles of plant quarantine. Exotic pathogens and pathogens introduced into India. Sanitary and phytosanitary issues under WTO, TRIPS and PRA. Genetic basis of disease resistance and pathogenicity: gene for gene hyphothesis;; 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. Biotechnology for crop disease management.

05 NEMATOLOGY

Unit 1: History and Economic Importance

History and development of Nematology at National and International level. Position of nematodes in animal kingdom. Economic importance of nematology; distribution of economically important nematodes (*Pratylenchus, Radopholus, Hirschmanniella, Meloidogyne, Heterodera, Globodera, Rotylenchulus, Tylenchulus, Ditylenchus, Anguina, Aphelenchoides, Tylenchorhynchus, Helicotylenchus, Hoplolaimus, Scutellonema, Paratylenchus*, etc.). Beneficial nematodes. (entomopathogenic nematodes – *Steinernema* and *Heterorhabditis*), Parasites of insects (*Mermis, Agamermis, Romanomermis)*. Entomopathogenic nematodes. Importance of saprophytes in organic matter recycling. Nematodes as indicators of pollution and toxicity. Predacious Nematodes.

Unit 2 : Nematode Taxonomy and Morphology

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

Unit 3 : Nematological Techniques

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

Unit 5 : Plant Nematode Relationships

Types of parasitism in nematodes. Classification of nematodes based on feeding habit. Nature of damage caused by various groups of plant parasitic nematodes and mechanisms involved.

Pathotypes and races of root knot, cyst and burrowing nematodes. Histopathological changes due to root knot and cyst nematode infestation including syncytia, giant cell formation and their modification etc. Mechanism of nematode resistance and tolerance in plants and its assessment. Physiological, biochemical and molecular changes in plants due to nematode infections.

Unit 6 : Nematode Physiology and Cytology

Chemical composition of nematodes. Principles of nematode physiology. Physiological functions of cell; organelles. Physiology of respiration, digestion, excretion, reproduction, growth and development. Physiology of moulting, hatching and nematode survival. Chemoreception in nematodes. Biology of root knot, cyst, Reniform, citrus, burrowing and lesion nematodes. Nematode as biological models - *Caenorhabditis elegans*. Cytological changes in plants due to infection including syncytia, giant cell formation and their modification etc.

Unit 7: Nematode pests of crops

Major nematode parasites and management in cereals (rice, wheat and barley), millets (sorghum, and maize), pulses (redgram, blackgram, greengram cowpea and chickpea),oilseeds (castor, groundnut and gingely), fibre crops (cotton and jute), vegetables (tomato, brinjal, bhendi, chilli and potato), cole crops (cabbage, carrot, cauliflower), beet root, sugarbeet, tapioca, tobacco, tuber crops (yam, dioscorea), fruits (banana, citrus, grapevine, guava, papaya, pomegranate), spices and plantation crops (turmeric, pepper, betelvine, arecanut and coconut), flower crops (crossandra, jasmine, carnation, rose, gerbera, chrysanthemum, eustoma and tuberose) and medicinal and aromatic plants, (medicinal coleus, geranium and patchouli), mushroom.

Unit 8 : Nematode Management

Principles and methods of nematode management - physical, cultural biological, chemical and legislative (plant quarantine), Nematicides (including those of biological origin) - history, classification, formulations, application and mode of action. Host resistance for nematode management. Resistance sources for different nematodes. Integrated nematode management. Nematode management in protected cultivation.

Unit 9: 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 10 : Statistics

Frequency distribution. Measures of central tendency and dispersion: mean, median, mode, standard deviation etc. Population distributions: normal, binomial and Poisson. Correlations:

regression, partial and multiple. Tests of significance: t, F and Chi square and randomized block, Latin square and split plot designs, their analysis and interpretation.

06 AGRICULTURAL ENTOMOLOGY/ENTOMOLOGY

Unit 1: Systematics

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

Unit 2: Morphology

Body wall, its structure, outgrowths, endoskeleton, Body regions, segmentation, sclerites and sutures, Insect Colors. 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, physiology and modifications of Digestive, Circulatory, Respiratory, Reproductive, Nervous, Excretory systems, Endocrine system and Sense Organs. 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, diapause, population structure and dynamics, distribution and dispersal. Principles of biogeography and insects biodiversity. Assessment of diversity indices. Biotic potential and environmental resistance. Climate change and adaptations. Ecosystems, agroecosystem analyses, ecological niche, their characteristics and functioning. Intra and inter specific relationship; competition, predator-prey and host-parasitoid interactions. Food chain, food web and trophic relations. Life table studies, population models. Arthropod population monitoring, pest forecasting. Causes of pest out breaks.

Unit 5: Biological Control

Importance and scope of biological control, history of biological control: Biocontrol agents-parasitoids, predators, insect pathogens and weed killers. Important entomophagous insect Orders and Families. Ecological, biological, taxonomic, legal and economic aspects of biological control, phenomena of multiple parasitism, hyperparasitism, superparasitism and their applied importance. Principles and procedures of using exotic biocontrol agents. Utilization of natural biocontrol agents: conservation, habitat management and augmentation. Mass multiplication techniques and

economics. Effective evaluation techniques, Biocontrol organizations in world and India. Successful cases of biological control of pests. Use of biotechnological tools in enhancing the potentials of Bio-Control Agents.

Unit 6: Chemical Control and Toxicology

History, scope and principles of chemical control. Insecticides, classification and mode of action - Conventional and IRAC. Formulations of insecticides. Penetration of insecticides. Physical, chemical and toxicological properties of different groups of insecticides. rodenticides, insect growth hormones. Insecticide induced resurgence. Combination insecticides. Pesticide hazards and environmental pollution. Safe use of pesticides, precautions, first aid treatments and antidotes. Insecticides Act 1968, Functions of CIB & RC, registration and quality control of insecticides. Evaluation of toxicity, methods of toxicity testing, determination of LD 50, LT 50, RL 50 etc. Pesticide residues in the environment and their dynamics of movements, methods of residue analysis. Good laboratory practices. Pharmacology of insect poisons. Metabolism of insecticides; detoxification enzymes and their role in metabolism. Selectivity of insecticides insecticide resistance; mechanism, genetics and management of insecticide resistance.

Unit 7: Host Plant Resistance

Principles of HPR. Basis of resistance (Antixenosis, Antibiosis, Tolerance). Host plant selection by phytophagous insects. Biophysical and biochemical bases of defense against phytophagous insects. Genetics of Resistance: vertical resistance, horizontal resistance, oligogenic resistance, polygenic resistance. Biotype development and break down of resistance. Tritrophic interactions, induced resistance. Breeding for insect resistant crops and evaluation techniques. 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: Novel Approaches in Pest Control

Behavioural control: semiochemicals 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. Genetic improvement and genetic engineering of bio control agents. Pest management in organic agriculture. Pest management in precision agriculture.

Unit 9: Integrated Pest Management

History, concept and principles of IPM. Components of IPM: Host plant resistance, cultural, mechanical, physical, chemical, biological, genetic and behavioural control etc. System approach, Agro ecosystem and cropping system vs. IPM. Concept of damage levels- Economic threshold levels (ETL), Economic injury levels (EIL) and their determination. IPM strategies for field and horticultural crops. IPM case histories. Constraints and Strategies of IPM implementation. Plant quarantine laws and regulations.

Unit 10: Pesticide Application Equipment

Types of appliances: sprayers, dusters, fog generators, smoke generators, soil injecting guns, seed treating drums, flame throwers, etc. Types of nozzles, international classification, their uses, spray patterns, particle size, measurement, drift and non target effects of pesticides. Maintenance of appliances. Aerial application-principles, guidelines, factors affecting the effectiveness, systems, advantages and disadvantages.

Unit 11: Pests of Field Crops and their Management

Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of cereals, millets, nutricereals, oilseeds, pulses, fibre crops, green manures, sugarcane and tobacco. Pests of importance: locusts, termites, hairy caterpillars, cut worms white grubs and invasive alien pests. Vertebrate and molluscan pests.

Unit 12: Pests of Horticultural Crops and their Management

Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of vegetables, fruits, plantation crops, spices, condiments, medicinal and aromatic crops, ornamentals, underutilized and exotic fruits. Pest management under protected cultivation. Pests of mushrooms. Vertebrate and molluscan pests.

Unit 13: Pests of Stored Products and their Management

Principles of grain storage. Storage structures, bulk storage and bag storage their merits and demerits. Grain drying methods and aeration. Storage losses, sources of infestation, factors influencing losses. Insect pests in storage, biology, and nature of damage. Non-insect pests (rodents, birds, mites) and their nature of damage. Management methods: Physical, Mechanical, Chemical, Biological, Behavioural, Legal and special storage methods. Microflora in storage environment and their control. Regulated and quarantine pests. Integrated management of storage pests.

Unit 14: Insect and mite vectors of Plant Diseases

History of vector pathogen interactions, important vectors of plant diseases, ecology of vector pathogen interaction Common insect and mite vectors *viz*., aphids, leaf hoppers, plant hoppers, whiteflies, thrips, psylids, beetles, weevils, flies, 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. Role of climate change in vector borne diseases.

Unit 15: Honey Bees and Bee-keeping

History of bee-keeping. Honey bees and their economic importance. Bee products. Bee species, their behaviour, habit and habitats. Bee Keeping: bee pasturage, hives and equipments, seasonal

management. Bee poisoning. Bee enemies including diseases and their management. Quality analysis of honey. Pollinators and their role in production of various crops. Conservation of pollinators.

Unit 16: Silkworms and Sericulture

Silkworm species, salient features, systematic position. Production techniques of mulberry, muga, eri and tassar silkworms. Nutritional requirements of silkworms. Sericulture: rearing house and appliances, silkworm breeds, principles of voltinism and moultinism, seed production and its economics. Different molecular approaches in developing silkworm breeds. transgenic silkworm-Mulberry pests, diseases and their management. By products of sericulture and its value addition, uses in pharmaceutical industry. Enemies and diseases of silkworms and their management. Sericulture organization in India.

Unit 17: Lac Insect

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

Unit 18: Helpful and Useful Insects

Pollinators and their role in production of various crops. Conservation of pollinators. Pollinators, insects as food, soil fertility improving agents, scavengers. Use of insects and insect products in medicines. Insects as bio-indicators. Usefulness of insects in scientific investigations

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. Use of software packages like SPSS, SAS, etc. for the above tests and designs of experiments for analysis.

07 SERICULTURE

Unit 1: Mulberry Crop Production

Mulberry genetic variability and distribution–varieties–Soil suitability–Climatic requirements and constraints – Propagation methods – Planting methods – inter cropping - population geometry – growth analysis - Soil fertility – fertilizer recommendation – integrated nutrient management – organic farming - Water management – Weed management -Problem soils and management – Rain fed mulberry - *Chawki* garden maintenance – Training and pruning –Leaf quality-concept and assessment–preservation–Sericulture in integrated farming system–Resource management in mulberry crop production–Mechanization-machineries in sericulture-Pests, diseases and nematodes of mulberry and their management.

Unit 2: Mulberry and Silkworm Breeding

Germplasm-collection-conservation-evaluation and utilization-choice of parental genotypes for selection and hybridization –inter varietal and interspecific hybridization and polycross-clones-clonal Selection-Breeding for quality-genetic relationship between mulberry and silk worm genotypes-environmental interactions. Biotic and abiotic stresses- selection of suitable host genotypes for stability and responsiveness across the environments – selection for different situations like drought and salinity-breeding for tree types-selection of genotypes-responsive to pruning - innovative breeding approaches - tissue culture/micro propagation of mulberry plants-contribution of National and International Institutes - Distinguishing characters of released varieties- production of nucleus and breeders planting materials. Silkworm - present status of silkworm breeding - establishing a silkworm breeding programme - introduction of exotic gene source. In breeding techniques-crossbreeding techniques for hybridization-different methods-mutation- convergent crossing-diallel selection-selection of good inbred combiners. Selection for single trait and multi traits-breeding for tolerance to pathogens, early maturity, high temperature, post cocoon characters–breeding for biochemical parameters and sex-limited characters–recent advances in silkworm breeding.

Unit 3: Silkworm Biology

Position of sericigenous insects in class insecta-silkworm integument-moulting process–exoskeleton–structure and Function-Body regions-head and its appendages in silkworm-mouth Parts-Types of antenna and mouth parts in silkworm and other insects–Cephalic glands. Thorax and its appendages-modification of legs in silkworm and in other insects-type of wings and venation in *Bombycidae* and *Saturnidae* - Abdomen and its appendages - male and female genitalia in silk moths–male–female reproductive system–spermatogenesis–oogenesis– unusual types of development. Morphology and anatomy of eggs of silkworm–Diapause–physiology of diapause–biochemical changes - stages of development in diapausing and non-diapausing eggs - principles underlying breaking diapause and cold storage. Structure and function of silk gland-protein requirement in silkworm–composition of amino acids in silk gland-transamination-chemistry of fibroin, sericin and P25-biosynthesis of silk-role of food supplementation on silk yield. Structure and function of digestive system–circulatory system-respiratory system–

excretory system – endocrine system - role of JH and anti JH analogues/ phytohormoens in cocoon production.

Unit 4: Silkworm Protection

Insect pathology–history–Concepts-Silkworm diseases-pathogenicity-kinds of infection-symptoms and pathologies associated with various diseases-classification of non-infectious and infectious diseases-poisoning due to gases-tobacco poisoning–nutritional and genetic diseases. Silkworm viruses-resistance of silkworm breeds against viral infection-role of antiviral and viral inhibitory factors- non-inclusion viruses. Miscellaneous flacherie diseases - Bacterial diseases – etiology – epizootology – bacterial toxicosis- symptoms - management of bacterial diseases. Protozoan diseases-biodiversity-symptoms–detection–monitoring and management-silkworm mycoses – types of fungal diseases –- symptoms and management - disinfection and hygiene – disinfectants – mode of action. Pests of silkworm-uzifly-external morphology, biology, symptoms and management practices– pests of grainage-non-insect pests-mite-nematode-rodents' symptoms and management practices.

Unit 5: Silkworm Nutrition

Insect nutrition-nutritional requirements of silkworm larva-nutritional composition of mulberry leaves-feeding physiology of silkworm. Carbohydrate requirement - carbohydrate metabolism - lipid metabolism - synthesis of fatty acid in *Bombyx mori* – Amino acid requirement. Transamination – silk proteins physio-chemical properties - fibroin and sericin synthesis-supplementation of nutrients for high silk yield. Role of water soluble and lipid soluble vitamins-growth factor–role and requirement of minerals- larval excretion. Dry matter economy–intestinal flora of silkworm–Artificial diet–nutrient management through food supplementation.

Unit 6: Non-Mulberry Sericulture

Status of vanya silk industry in India–History–Types of non-mulberry silkworms–Distribution and eco races of non-mulberry silkworms- Maintenance of germplasm of non-mulberry silkworms – *Eri* silkworm-morphology and voltinism–and their host Plants-Castor for dual purpose. Tasar silkworm-food plants and cultivation practices–large scale Plantations-*Terminalia arjuna* and *Terminaliato mentosa*-Pests and diseases on food plants and their Management-Rearing of different non-mulberry Silkworms-Pests and diseases of non-mulberry silkworms–Management practices. Muga silkworm-food plants and cultivation practices–Pests and diseases on food plants and their management - Rearing technology – Economics of rearing–Marketing System-Silk reeling techniques—Recent advances in non-mulberry silk industry–Biotechnological approaches.

Unit 7: Silk Reeling Technology

Cocoon marketing–price fixation–sorting, mixing, drying and stifling–Cocoon cooking–principle and methods. Types of reeling machines. Comparative output of each device – advantages and disadvantages of different reeling devices. Reeling water quality. Silk throwing and weaving-processes involved in winding, doubling, twisting, rewinding for warp and weft-

hank Making-Wet processing–degumming and bleaching by alkali and enzyme methods-dyeing-different dyes - warping and weaving - printing - block, hand screen tables Grading of silk–standards–silk exchange- by products and its uses.

Unit 8: Silkworm Seed Cocoon and Egg Production

Status and strategies of silkworm egg production - Morphology - Embryology – Biochemical changes in Eggs-Seed cocoon-preservation-selection-sorting-sex separation-cocoon melting. Moth emergence-sexing-pairing and depairing-egg Laying-Handling of eggs-embryological tools- diapausing and non-diapausing eggs - Acid treatment -preservation schedule - incubation/Black boxing technique- bivoltine seed production. Seed crop monitoring-agencies-seed Organization-Seed Acts-licensing procedures-pests of grainage – pebrine diagnosis and management- cocoon melting – seed acts.

08 PLANT BIOCHEMISTRY/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 function of carbohydrates, proteins, lipids and nucleic acids. Components of immune system, Prostaglandins.

Unit 2: Intermediary Metabolism

Anabolism, catabolism and their regulation. Metabolism of carbohydrates – 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 sterols and phospholipids.Protein degradation by proteases and ubiquitin-Proteasome System, Amino acid metabolism – catabolism of amino acids, transamination and deamination, urea cycle, biosynthesis of amino acids. Conversion of amino acids into bioactive compounds. Metabolism of nucleic acids-degradation and biosynthesis of purines, pyrimidines and nucleotides. Integration of carbohydrate, lipid and amino acid metabolism. Signal transduction mechanisms. Role of G-proteins, cyclic nucleotides and calcium in transduction. Disorders of lipid, carbohydrate, nucleic acid, amino acid metabolism. Inborn errors of metabolism. Secondary metabolites,Alkaloids, Phenolics and Isoprenoids, biotransformation and over expression. Role of oligosaccharides and polysaccharides in cellular metabolism.

Unit 3: Enzymes, Vitamins and Hormones

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

Unit 4: Molecular Biology

Structure of DNA and RNA Replication, transcription and translation. Post-transcriptional and translational modifications. Transcriptional and translation control of prokaryotes and eukaryotes. Features of genetic code in prokaryotes and eukaryotes. Gene expression - operon model, induction and repression, control of gene expression in prokaryotes and eukaryotes. Chloroplast and Mitochondrial genomes. Replication of viruses. Mutagens, oncogenes and carcinogenesis. General principles of recombinant DNA technology, restriction enzymes. Methods of gene transfer-plasmid and viruses as vectors, DNA and protein sequence analysis, oligonucleotide synthesis, genomic and cDNA library construction, site-directed mutagenesis, transposon tagging, chromosome walking. Basics of genome organization. Computer application in molecular biology, primer designing, sequence analysis and phylogenetic analysis. Benefits of gene manipulation in agriculture, nanobiotechnology, bio-chips.

Unit 5: Techniques in Biochemistry

Principles of optical, phase contrast, fluorescence and electron microscopy, spectrophotometry, UV and VIS, fluorimetry, turbidometry and atomic absorption spectrophotometry. Radioisotopic techniques – scintillation counters and autoradiography and their application in biological sciences. Electrophoresis - general principles and application, gel electrophoresis, isoelectric focusing, pulsed field gel electrophoresis, immunoelectrophoresis. Chromatographic techniques - paper, thin layer, column chromatography, GC and HPLC. Centrifugation - principles of sedimentation in various rotors, differential centrifugation, density gradient centrifugation and ultracentrifugation. PCR, Quantitative PCR and application of RFLP, RAPD, AFLP, microsatellite and mitochondrial and ribotyping techniques.. Southern, Northern and Western blotting, ELISA. Microarray and DNA chips. MALDI-TOF and metabolite profiling techniques such as ICP-MS. X-ray diffraction, IR, NMR, FTIR, GC-MS, LC-MS. Preliminary methods of statistical analysis as applied to agricultural data – standard deviation, standard error, ANOVA, correlation and regression.,

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

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

Unit 7: Photosynthesis

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

Unit 8: Plant Metabolic Processes

Uptake and metabolism of mineral nutrients in plants. Sulphur metabolism. Nitrogen cycle, nitrate and nitrite reduction, denitrification, symbiotic and non-symbiotic nitrogen fixation. Biochemical and physiological role of hydrogenase. Chemoautrotrophy in rhizobia and nitrifying bacteria. Cell cycle. Growth regulation in plants. Role of oligosaccharides and polysaccharides in cellular metabolism. Metabolism of cyanogenic glycosides and glucosinolates.

Unit 9: Plant Molecular Biology

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

Unit 10: Plant Biotechnology/Genetic Engineering

Totipotency, application of tissue culture for plant improvement, cryopreservation. Protoplasm fusion. General principles of gene cloning. Isolation and characterization of plant genes and promoters. Different methods of gene transfer –direct and vector mediated. Gene silencing. Site directed mutagenesis. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement – nutritional and processing quality improvement, shelf life enhancement, insect-pest resistance (insect, viral, fungal and bacterial diseases), abiotic stress tolerance and herbicide resistance, Biosafety and IPR issues. Genome editing techniques and tools.

09 PLANT PHYSIOLOGY/CROP PHYSIOLOGY

Unit 1: Cell Organelles and Water Relations

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

Unit 2: Metabolic Processes and Growth Regulation

Energy and work, free energy and chemical potential, redox reactions and electrochemical potential. Enzyme classification and mechanism of action, factors affecting enzyme action. Gene expression and protein turnover. Photosynthesis, translocation and respiration as key processes regulating carbon metabolism and plant growth. Photosynthesis and bioproductivity. Photochemical process-Chloroplast, its structure, CAM plants and their significance. Rubisco structure and regulations, Photorespiration and its significance, CO2 fixation as a diffusive process, effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides. Translocations of photosynthates and its importance in sink growth. Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance. Nitrogen metabolism. Inorganic nitrogen species (N2, N03, NH3) and their reduction, protein synthesis, nucleic acids. Sulphate uptake and reduction. Lipid metabolism-storage, protective and structural lipids. Secondary metabolites and their significance in plant defence mechanism. Growth and differentiation, hormonal concept of growth and differentiation, plant growth hormones (auxins, gibberellins, cytokinins, ABA, ethylene, etc.), biosynthesis of growth hormones and their metabolism, synthetic growth regulators, growth retardant, apical dominance, senescence, fruit growth, abscission, photo-morphogenesis, photo-receptors, phytochrome, physiology of flowering, photoperiodism and vernalisation.

Unit 3: Crop Productivity and Modelling

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

crop growth. Light, temperature and VPD, effect of photoperiod and thermoperiod on duration of growth stages. Ideotype concept-selection- indices for improving crop productivity.

Unit 4: Abiotic Stress Responses in Plants

Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, interactions between biotic and abiotic stresses. Drought 21 characteristic features, water potential in the soilplant-air continuum. Development of water deficits, energy balance concept, transpiration and it's regulation – stomatal functions/VPD. Physiological process affected by drought. Drought resistance mechanisms: Escape, dehydration postponement (Drought avoidance), Dehydration tolerance, and characteristics of resurrection plants. Osmotic adjustment Osmoprotectants, stress proteins. Water use efficiency as a drought resistance trait. Molecular responses to water deficit stress perception, expression of regulatory and function genes and significance of gene products. Stress and hormones-ABA as a signaling molecule – Cytokinin as negative signal. Oxidative stress: reactive oxygen species (ROS) – role of scavenging systems (SOD, catalase etc.). High temperature stress: tolerance mechanisms- role of membrane lipids in high temperance tolerance. Functions of HSPs chilling stress; effects on physiological processes. Crucial role of membrane lipids. Salinity: species variation in salt tolerance. Salinity effects at cellular and whole plant level, tolerance mechanisms. Breeding for salt resistance. Heavy metal stress: aluminum and cadmium toxicity in acid soils. Role of phytochelatins (heavy, metal binding proteins).

Unit 5: Plant Growth Regulators and Plant Development

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

Unit 6: Mineral Nutrition

Importance of mineral nutrition in plant growth. Classification and essentiality criteria. General mechanisms - concept of apparent free space and nature of bio-membranes. Dual mechanism and other concepts of ion uptake. Short distance transport-pathway from external solution (Apoplasm) to sieve across the root cortical cells-factors contributing to xylem loading. Long distance transport in xylem and phloem, xylem unloading in leaf cells. Uptake and release of mineral nutrients by foliage. Rhizosphere and root biology, root growth, influence of microorganism in nutrient acquisition, release and uptake by plant roots. Yield and mineral nutrition-concept of nutrient use efficiency, Mineral nutrition under adverse soil situations-drought, salinity, acidity etc. Heavy metal toxicity and concept of phytoremediation. Interaction of phytohormones and nutrients. Molecular aspects- uptake and transport, role of transporter genes, genetics of nutrient uptake, identification and transfer of genes for tolerance to nutrient deficiencies, etc. Soil less culture – Hydroponics - Role of Macro, Micro and beneficial nutrients- Identification of nutrient deficiencies and toxicities.

Unit 7: Climate and Climate Change

Climate-Analytical methods to determine long term changes in environment- Tree ring, cellulose, stable carbon isotope discrimination, stable 18O discrimination for hydrological changes. Likely changes in climate in future and its impact on crop and ecosystems. The greenhouse gases and global warning. CO2 as an important greenhouses gas, global carbon deposits, fluxes in the sinks and sources. Approaches to contain atmospheric CO2 level. Effect of elevated CO2 on plant growth and development. Methane as a greenhouse gas. Prediction on global warming, GCA models, effects on climate and biota. High temperature and CO2 interaction on plant growth and productivity, ionising radiation UV-B chlorofluoro carbon (CFC)– their impact on ozone layer-ozone hole and alteration in UV-B radiation. Effects of UV-B radiation on plant ecosystem, repair and acclimation to UV-B damage. Carotenoids and their role in membrane stabilization. Air pollution, SO2, NO, methane, ozone, peroxy acetyl nitrate and their effect on ecosystem. Industrial and domestic effluent-their effect, on aquatic ecosystem, plant growth and development.

Unit 8: Seed Physiology

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

Unit 9: Physiology of Flowering and Reproduction

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

Unit 10: Physiology of Horticultural and Plantation Crop Species

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

Unit 11: Post-Harvest Physiology

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

Unit 12: Morphogenesis, Tissue Culture and Plant Transformation

Morphogenesis; the cellular basis of growth and morphogenesis; polarity in tip growing cells and

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

Unit 13: Phenomics

Phenotyping methods, phenotyping under different abiotic stress like drought, High temp., salinity etc. Image based phenotyping traits, Use of UAV in phenotyping and trait dissection under field conditions

10 AGRICULTURAL BIOTECHNOLOGY/BIOTECHNOLOGY/MOLECULAR BIOLOGY & BIOTECHNOLOGY

Unit 1: Cell Structure and Function

Prokaryotic and eukaryotic cell architecture, Cell wall, plasma membrane, Structure and function of cell organelles: Nucleus, vacuoles, mitochondria, plastids, Golgi apparatus, ER, lysosomes, peroxisomes, glyoxisomes. Cell cycle-Regulation of cell cycle. Cell division, growth and differentiation. Protein secretion and targeting. Transport across cell membrane, Cell signaling, Developmental biology of plants, programmed cell death (apoptosis), Cell renewal and cancer, stem cell applications.

Unit 2: Biomolecules and Metabolism

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

Unit 3: Enzymology

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

Unit 4: Molecular Genetics

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

Unit 5: Gene Expression

Expression of genetic information, operon concept, Transcription – mechanism of transcription in prokaryotes and eukaryotes, transcription unit, regulatory sequences and enhancers, activators, repressors, co-activators, Co-repressors in prokaryotes and eukaryotes, inducible genes and promoters, Transcription factors post transcriptional modification and protein transport, DNA-protein interaction, Genetic code. Mechanism of translation and its control, post translational modifications. Epigenetic control of gene expression; Regulatory RNA in gene regulation - Small RNAs, RNA interference and its applications.

Unit 6: Molecular Biology Techniques

Isolation and purification of nucleic acids. Nucleic acids hybridization: Southern, northern and western blotting hybridization. Immune response monoclonal and polyclonal antibodies and ELISA, DNA sequencing. Construction and screening of genomic and C-DNA libraries. Gel electrophoretic techniques. Spectroscopy,Polymerase chain reaction, real time PCR, RT-PCR, ultracentrifugation, chromatography, FISH, RIA, etc. Next generation genome sequencing techniques, basic bioinformatics, microarray, etc. Proteomics, 2D and protein sequencing, metabolomics.

Unit 7: Gene Cloning

DNA manipulative and modifying enzymes-restriction enzymes and their uses. Salient features and uses of most commonly used vectors i.e. plasmids, bacteriophages, phagemids, cosmids, BACs, PACs and YACs, binary vectors, expression vectors. Gateway cloning vectors. Gene cloning and sub-cloning strategies, chromosome walking, genetic transformation, Basis of animal cloning. Gene pyramiding and gene fusion, ribozyme technology. Biological risk assessment and IPR.

Unit 8: Molecular Biology

Genome complexity-C value and C-value paradox; DNA re-association kinetics. Analysis of repetitive sequences. Molecular events in DNA replication, transcription and translation. RNA processing and Post transcriptional modifications. Ribosome structure and function. Protein biosynthesis in prokaryotes and eukaryotes. Post-translational modification. Gene regulation, DNA damage-types and repair mechanisms. Bioprospecting. Non coding RNA.

Unit 9: Plant Molecular Biology

Photoregulation and phytochrome regulation of nuclear and chloroplastic gene expression. Molecular mechanism of nitrogen fixation. Advances in conversion of C3 to C4 pathway. 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, Hormone regulatory pathways, mitochondrial control of fertility, structure, organization and regulation of nuclear gene concerning storage proteins and starch synthesis. Crop genome sequencing projects.

Unit 10: Tissue Culture

Basic techniques in cell culture and somatic cell genetics. Clonal propagation. Concept of cellular totipotency. Androgenesis and gynogenesis, somaclonal and gametoclonal variations. Hybrid embryo culture and embryo rescue, somatic hybridization and cybridization. Application of tissue culture in crop improvement. Secondary metabolite production. In vitro mutagenesis, cryopreservation and plant tissue culture repository. Synthetic seeds, Virus indexing.

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. RNAi technology. Cisgenesis. Molecular pharming, bioremediation. GM detection methods. Resistance management strategies for target traits. 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, biofortification, Genetic engineering for pollination control, Induction of male sterility in plants. Current status of transgenics, biosafety norms and controlled field trials and release of transgenics (GMOs). IPR, genome editing technique.

Unit 12: Molecular Markers and Genomics

DNA molecular markers: Principles, type and applications; restriction fragment length polymorphism (RFLP), randomly amplified polymorphic DNA sequences (RAPD), amplified fragment length polymorphism (AFLP), Simple sequence repeats (SSR), Single nucleotide polymorphism (SNP), DaRT, SRAP, TRAP markers. Structural and functional genomics, gene mapping, genome mapping-GWAS and Genomic selection, gene tagging and comparative genomics and application of genomics. TILLING and ECOTILLING applications. Development of mapping population and types of mapping populations-RILs, NILs, F2, BILs, DH, MAGIC, Mutant populations. Linkage mapping. Association mapping, Molecular mapping of complex traits and Marker Assisted Selection and other applications of markers: MABC, MARS and Genomic Selection. DNA fingerprinting and barcoding. Phylogeography, conservation genetics. DNA chips and their use in transcriptome analysis; Mutants and RNAi in functional genomics; Proteomics, Metabolomics and ionomics.

11 AGRICULTURAL MICROBIOLOGY/MICROBIOLOGY

Unit 1: History of Microbial World

Microbial world, History of microbiology and types of micro-organisms, Prokaryotic and eukaryotic cell, Classification and major characteristics of different microbial groups.
Morphological characteristics, Internal structures and their functions in bacteria, archaea, algae, cyanophages, viroids, prions, fungi, actinobacteria, mycoplasma, rickettsias, chlamydia, viruses, bacteriophages.
Basics of microbial growth and reproduction, Bacterial communication, Environmental and nutritional requirements for microbial growth, Pure cultures, Control of microorganisms: Principles, methods including radiation, Chemicals, Antibiotics etc.
Classification of fungi. Life cycles of important phytopathogenic fungi. Economic mycology, edible fungi and entomogenous fungi. Mycorrhizal associations. Cell organelles, their morphology, functions and chemical composition.

Unit 2: Basic Microbiological Techniques

An introduction to laboratory instruments, Safety rules in laboratory, Handling of different glassware. Methods of sterilization and disinfection. Handling of autoclave, Hot air oven, BOD incubator, Laminar flow, Colony counter, pH meter, Biological filters; Spectrophotometer.
Isolation and preservation of different types of microorganisms; Microscopy: Light, Compound, Dark field, Phase Contrast, Fluorescent, EM, TEM, SEM ; Wet mount, Hanging drop technique, Stains and staining techniques.
Types of culture and culture media, Inoculation techniques, Isolation of pure culture, Proof of purity of cultures, Maintenance and preservation of pure cultures, Culture collections.
Identification of bacteria using biochemical tests, Introduction and importance of Bergey's Manual, Bioassay techniques, Antibiotic sensitivity of bacteria.
Isolation of Genomic DNA and PCR amplification in bacteria and cyanobacteria, RAPD and RFLP, Isolation of plasmids, Protein profiling by SDS-PAGE.

Unit 3: Microbial Physiology

Microbial growth, Requirements for growth; Bacterial division, growth kinetics, Energetics of growth; Types/modes of growth - Batch culture, Synchronous growth, Continuous growth, Chemostat and Turbidostat, Growth characteristics, Measurement of microbial growth: Plate counts, Filtration, The Most Probable Number (MPN) method, Direct microscopic count, Indirect methods ; Growth yield and its significance. Energy yielding pathways in microorganisms, Catabolic and anabolic reactions – Aerobic respiration: Glycolysis, Substrate level phosphorylation, Electron transport chain and oxidative phosphorylation , Hexose mono-phosphate pathway (HMP), Entner – Doudoroff Pathway (ED pathway), Tricarboxylic acid cycle (TCA cycle) and other mechanisms, Chemiosmotic mechanism of ATP generation, Obligate anaerobes, Aerotolerant anaerobes, Catabolism of other kind of organic substrates, Anaerobic

respiration, Dissimilatory and assimilatory reductions, Types of fermentation, Fermentation balances.

Microbial photosynthesis, Diversity, Chlorophylls and bacterio- chlorophylls, Accessory pigments, Light-dependent reactions and light independent reactions, Carbon dioxide assimilation in prokaryotes, Bacteriorhodopsin and Halorhodopsin and their significance, Classification and taxonomy of photosynthetic organisms: Microalgae (cyanobacteria, green algae) and bacteria, Major characteristics of different groups, Photosynthetic eubacteria: Introduction, Characteristics of important genera of photosynthetic eubacteria. Physiology of chemooligotrophs.

Enzymes and chemical reactions, Enzyme specificity and efficiency, Classification, Enzyme components, Mechanism and Factors influencing enzymatic activity: Temperature, pH, substrate concentration, Inhibitors, Feedback inhibition, Ribozymes, Coenzymes.

Cell wall and its biosynthesis; Polysachharide biosynthesis, Lipid biosynthesis, Biosynthesis of nitrogenous compounds- Amino acid and proteins, Purine and pyrimidines, Nucleic acids. Proteins break down by microorganisms, Deamination, Transamination, Assimilation of complex carbohydrates- Cellulose, Hemicellulose, Starch, Pectin and Chitin, Nitrogen fixing micro-organisms, Requirements of nitrogen fixation, Mechanism of nitrogen fixation, Nitrogenase enzyme, Biochemistry of hydrogenase enzyme and hydrogen assimilation. Secondary metabolism, Primary and secondary metabolites and their significance, Physiological response of microorganisms to salinity, alkalinity, UV, drought and heavy metals, adaptive mechanisms employed to cope with stress.

Unit 4: Microbial Genetics

Principles of microbial genetics; Gene organization in bacteria, Archeae, Eukaryotes and viruses; Gene regulation and expression in these organisms; Plasmids and their inheritance; Transposons and insertion sequences; DNA replication; Mutations and DNA repair mechanisms; Gene and genetic code; Nucleic acid synthesis and Protein synthesis: Transcription, Translation and Post Translational modifications; Genetic recombination in bacteria: Transformation, Conjugation, Transduction; Restriction enzymes; vectors; Virus multiplications and Genetics analysis of bacteriophages and cyanophages.; Genome and gene editing. Introduction to gene cloning.

Unit 5: Soil Microbiology

Role of microorganisms in soils, Major microbial indicators of soil health and their significance, Direct and indirect methods of studying soil microorganisms and their activities. Soil microbial interactions: Types and significance. Carbon cycle: Biodegradation of starch, Cellulose, Hemicellulose, Pectin and lignin in soil, Decomposition of organic matter, Humus and fulvic acid, Quantity and distribution of organic matter in soil, role of microorganisms in decomposition of soil organic matter, Dynamics of microorganisms during different stages of OM decomposition, Humus and its fractions, contribution of humus to soil quality. Nitrogen cycle: Ammonification, Nitrification, Denitrification, Non-symbiotic and symbiotic nitrogen fixation through bacteria and nitrogen assimilation. Environmental influences on microorganisms, Effect of temperature,

aeration, moisture, osmotic pressure, pH. Recent development on the role of microbial communities and role in nutrient cycling. Transformation of phosphorus, Sulphur, Iron, Manganese, Magnesium, Copper, Mercury and Arsenic.
Soil microbial biomass, microbial interactions, unculturable soil biota. Microbiology and biochemistry of root-soil interface. Phyllosphere. Soil enzymes, origin, activities and importance. Biofertilizers – definition, classification, specifications, and role in crop production.

Unit 6: Microbial diversity and Ecology

Molecular approaches for measuring the microbial diversity: RISA,TGGE, DGGE, T-RFLP, BIOLOG, FAME analysis. Plant-microbe interactions, Endophytic and pathogenic interactions, Rhizosphere, Rhizoplane, Spermosphere and phyllosphere, Root exudates, Quorum-sensing in bacteria, Flow of signals in response to carbon substrates. Legume –*Rhizobium* symbiosis, Frankia- Actinorhizal symbioses, Classification of nodulating bacteria, Formation of nodules in leguminous plants, Types of nodules, Genetics of nodulation and nitrogen fixation, *sym* genes, *nod* genes, *nif* genes and *fix* genes, NOD factors, Hydrogenases. Mycorrhizae: Types of mycorrhizae, Mycorrhizal links with plants and their functioning. Biochemical/ Molecular aspects. Type three secretion systems, Plant growth promoting rhizobacteria (PGPR) and their direct and indirect mechanisms of action, Biocontrol agents and their mechanisms.

Unit 7: Microbiology of food and water

Food and their composition, Food as substrate for micro-organisms, Important bacteria in food microbiology, Microflora of meat, fish, eggs, fruits, vegetables, juices, flour, canned foods. Food spoilages, Fermented foods (Sauerkraut, Pickle, Soy Sauce, Tempeh, Miso), Bacterial toxins in food, Food-borne diseases and intoxications, Action of microbes on different components of food, Methods of food preservation. Mycotoxins, Microbiological quality assurance, Hazard analysis and critical control point (HACCP) concept, Methods for examination of micro-organisms in food. Composition of milk and factors affecting the composition, Microbiology of milk, Fermented milk products, Cheese, Pasteurisation, Spoilage of milk and its products, Microbiological methods for examination of milk and its products, Probiotics -concept, microorganisms and proteins used in probiotics; Bacteriological standards for milk and milk products.
Microbiology of water, Sources and types of water, Procedures for water purification, Water pollution and its sources, Nuisance bacteria in water, Water-borne diseases and their spread and prevention. Modern tools in food and aquatic microbiology- PCR based techniques, microarrays, sensors.

Unit 8: Industrial Microbiology

Theory and principles of industrial fermentation, Fermentor design, Different types of fermentors used in industrial fermentation, Microbial culture selection, Strain development, The formation and extraction of fermentation product, C&N sources used for industrial fermentation.
New approaches and advances in downstream processing, Primary and secondary metabolites,

Ethanol, Second generation biofuels, Beer, Wine and Cider fermentation.
Enzyme production : Rennet, Cellulase, Amylase *etc*., Microbial enzymes, Immobilisation of enzymes, Organic acid, Vinegar production, Amino acid production : Glycine and Glutamic acid, Biomass production, Microbial insecticides. Single cell protein production for use as food and feed, Vitamin and related compounds (Carotenoid, Vitamin B12, Riboflavin), Antibiotic production, Biotransformation, Bioplastics, Bioprocess cost evaluation. High and low volume/value products, Bioprocess cost evaluation, Product finishing, formulation, encapsulation, immobilization, preservation, quality. Current advances in production of antibiotics, vaccines, Biotransformation, Bioplastics, Production of recombinant DNA products; production of vitamins and fine chemicals, source of single cell protein (SCP). Yeast technology, Genetics and strain improvement for brewing, baking and distilleries.

Unit 9: Applications of microorganisms in agriculture

Role of microbes in bioindustries, Value addition, Production of recombinant vaccines and hormones, Biosensors, Bioflavours, Biowarfare, Bioremediation Bioprocess engineering; Process design for various classes of products. Microorganisms in aquatic environment, pollution control, Bioindicators of pollution, Metal detoxification, Controlled photosynthesis and its application, Bioremediation, carbon sequestration, mitigation of global warming and environmental sustainability. Pesticides: Types, Resistance to microbes and metabolism; Residual effects of pesticides. Extremophiles as source of novel bioproducts, Microbial biofilms and their applications, Anaerobes in industry and environment, Serology and Immunodiagnostics in agriculture, Transplantation immunology. Microbial ore leaching (biomining), Microbial enzymes in clinical diagnostics, Metabolic pathway engineering, Principles of crop inoculation with microbial agents, Overview of microbial inoculants and their production, Carriers for inoculants- types and their characteristics, Strain selection for biofertilizer production and quality control, Mass multiplication – methodology and constraints/benefits, Bulk production (small scale and commercial scale), Setting up of pilot scale inoculant production plants. *Rhizobium*-evaluation as biofertilizer, *Azotobacter*-evaluation as biofertilizer, Phosphate solubilizing microorganisms: Methods for their identification, AM fungi, Ecology of inoculants/ microorganisms in soil, Biocontrol agents. Biogas production technology, Methanogens, Methanotrophs and their applications. Retting and Silage production, Techniques of composting and vermi-compost and their evaluation. Microbial inoculants: Formulation and application methods; Quality standards of inoculants.
Role of microorganisms in sewage treatment, Phyto and microbial remediation approaches; Biological oxygen demand, Effluent management, Integrated systems for pollution abatement and clean water. Microbial strategies for mitigation of stress. Patents and IPR issues in microbiology.

Unit 10: Microbial omics

Microbial Genomics, metagenomics, metatranscriptomics, Proteomics, Microbial functional genomics; Principles, methods and recent advances in DNA sequencing; RNA and protein

sequencing; Microbial Gene Manipulation-Gene fusions and reporter genes; Microbial genes for improving resistance to biotic stresses and tolerance to abiotic stresses in crop plants; Microbial genes for quality improvement in agricultural products and value addition; Concept of Microbiome: Soil and Plant Microbiome. Isolation of metagenome from environmental sources, Development of environmental libraries, DGEE, 16S rDNA community analysis, Functional and sequence based analysis of clones, Bioremediation of recalcitrant compounds. Bioinformatics, Bioprospecting, Microbial diversity and global environment issue, IPR and biosafety.

Unit 11: 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 (X_2), F test, Probit analysis.
Experimental designs - basic principles, completely randomized, randomized block, Latin square and split plot designs.

12 VEGETABLE SCIENCE / OLERICULTURE

Unit 1: Production Technology of Cool Season Vegetable Crops

Introduction, climatic and soil requirement, 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 of potato, chow chow, cole crops: cabbage, cauliflower, knolkhol, sprouting broccoli, Brussels sprout, root crops: carrot, radish, turnip, and beetroot, bulb crops: onion and garlic, Peas and beans, leafy vegetables:palak

Unit 2: Production Technology of Warm Season Vegetable Crops

Introduction, 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 of: Tomato, eggplant, hot and sweet pepper, Okra, vegetable cowpea, Dolichos lablab and cluster bean, Cucurbitaceous crops, and sweet potato, cassava,yams, coclocasia, moringa and amaranths.

Unit 3: Breeding of Vegetable Crops

Cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, biotechnology and their use in breeding in vegetable crops - molecular marker, genomics, marker assisted selection and QTLs. Potato and tomato, Eggplant, hot pepper, sweet pepper and okra, Peas and beans, lettuce, gourds, melons, pumpkins and squashes, cabbage, cauliflower, carrot ,beetroot, radish, moringa, amaranthus, cassava, sweetpotato, lab lab, onion and garlic

Unit 4: Growth and Development

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

Unit 5: Seed Production

Introduction, importance and present status of vegetable industry.; modes of propagation in vegetables; Seed morphology and development in vegetable seeds; Floral biology of these plant species; classification of vegetable crops based on seed dormancypollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops; methods of seed production; comparison between different methods e.g. pollination mechanisms; sex types, ratios and expression and modification of flowering pattern in cucurbits; nursery raising and transplanting stage; Seed production technology of vegetables viz. solanaceous, cucurbitaceous, leguminous, malvaceae, cole crops, leafy vegetables, root, tuber and bulb crops; harvesting/picking stage and seed extraction in fruit vegetables, grading, storage,seed quality testing and seed certification standards; clonal propagation and multiplication in tuber crops e.g. Potato and sweet potato, seed-plot technique in potato, TPS (True Potato Seed); hybrid seed production technology of vegetable crops;maintenance of parental lines; use of male sterility and self-incompatibility in hybrid seed production.

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, taxonomy, botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables; Floral biology, 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 :Potato and tomato, Eggplant, hot pepper, sweet pepper and okra, Peas and beans, lettuce, gourds, melons, pumpkins and squashes, cabbage, cauliflower, carrot ,beetroot, radish, moringa, amaranthus, cassava, sweetpotato, lab lab, onion and garlic

Unit 7: Production Technology of Underexploited Vegetable Crops

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, planting time and method, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting of: Asparagus and leek; Chinese cabbage, Chinese potato, and kale; Amaranth, , parsnip, rhubarb, basella and bathu (chenopods); lima bean, winged bean, vegetable pigeon pea and sword bean; Sweet gourd, spine gourd, pointed gourd, Ivy gourd

Unit 8: Post-Harvest Technology 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, regulation methods; Harvesting tools, harvesting practices for specific market requirements; grading,post-harvest physiological and biochemical changes, disorders-chilling injury in vegetables, influence of pre-harvest practices and other factors affecting post-harvest losses, packaging house operations, commodity pre-treatments- chemicals, wax coating, pre-packaging 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, precooling and cold storage, zero energy cool chamber; HACCP, Codex ,FSSAI.

Unit 9: Organic Vegetable Production Technology

Importance, principles, prospective, concept and component of organic production of vegetable crops, managing soil fertility, pest, disease and weed problem in organic farming system, crop rotation in organic vegetable production. Method of enhancing soil fertility, mulching, raising green manure crops, indigenous methods of compost, panchgavya, biodynamics preparation, ITKs organic farming. Role of botanicals and bio-control agents. GAP and GMP, organic certification standards, opportunity and challenges in organic production of vegetables.

Unit 10: Hi-tech Production Technology of VegetableCrops

Importance and scope of protected cultivation of vegetable crops, principles used in protected cultivation and greenhouse technology, effect of temperature, carbon dioxide, humidity; energy management, low cost structures, training methods, engineering aspects,classification of protected structures including low cost poly-house/green houses and other structures in vegetable production, types of cladding material,types of media, Mulching, solarisation,fumigation, Drip and sprinkler irrigation, fertigation, ,special horticultural practices, hydroponics, vertical farming andsoilless culture for enhancing productivity and off-season of high value vegetable crops like tomato, capsicum and cucumber.

13 FRUIT SCIENCE/POMOLOGY

Unit 1: Tropical and Dry Land Fruit Production

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, scion-stock relationship, planting systems, cropping systems, canopy management, nutrient management, water management, fertigation, role of bio-regulators, abiotic factors limiting fruit production, physiology of flowering, pollination, fruit set and development, honeybees in cross pollination, physiological disorders–causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones (AEZ) and industrial supports. Crops: Mango, Banana, Citrus, Papaya, Guava, Sapota, Annonas, Aonla, Bael, Wood apple, Jamun, Pomegranate**,** Ber and minor fruits of tropics.

Unit 2: Subtropical and Temperate Fruit Production

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, scion-stock relationship, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bio - regulators, abiotic factors limiting fruit production, physiology of flowering, pollination, fruit set and development, honeybees in cross pollination, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones (AEZ) and industrial supports. Crops: Avocado, Pineapple, Jackfruit, Mangosteen, Carambola, Fig and Rambutan, Litchi, Loquat, Apple, Pear, Quince, Grapes, Plums, Peach, Apricot, Cherries, Persimmon, Kiwifruit, Strawberry, Walnut, Almond, Pistachio, Hazelnut.

Unit 3: Biodiversity and Conservation

Biodiversity and conservation; issues and goals, centres of origin of cultivated fruits; primary and secondary centres of genetic diversity; present status of gene centres; exploration and collection of germplasm; Role of NAGS ; Conservation of genetic resources–conservation *insitu* and *exsitu.* Germplasm conservation – problem of recal citrancy-cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine; intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group; GIS and documentation of local biodiversity, geographical indication. Crops: Mango, Sapota, Citrus, Guava, Banana, Papaya, Grapes, Jackfruit, Custard apple, Ber, Aonla, Malus &*Prunus* sp., Litchi andNuts.

Unit 4: Canopy Management in Fruit Crops

Canopy management - importance and advantages; factors affecting canopy development;

Canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies; Spacing and utilization of land area - canopy classification; Canopy management through rootstock and scion; Canopy management through plant growth retardants, training and pruning and management practices; Canopy development and management in relation to growth, flowering, fruiting and fruit quality in temperate fruits, Grapes, Mango,Sapota,Guava,Citrus and Ber.

Unit 5: Breeding of Fruit Crops

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, breeding constraints ideo types, approaches for crop improvement – introduction, selection, hybridization, mutation breeding, polyploidy breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops. Crops: Mango, Banana, Pineapple, Citrus, Grapes, Guava, Sapota, Jackfruit, Papaya, Custard apple, Aonla, Avocado, Ber, Litchi, Jamun, Phalsa, Mulberry, Raspberry, Apple, Pear, Plums, Peach, Apricot, Cherries and Strawberry.

Unit 6: Post-Harvest Technology

Maturity indices, harvesting practices and grading for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration; Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling; Treatment prior to shipment, *viz.*, chlorination, waxing, chemicals, bio-control agents and natural plant products, fungicides, hot water, vapour heat treatment, sulphur fumigation and irradiation. Methods of storage-ventilated, refrigerated, MAS, CA storage, physical injuries and disorders; Packing methods and transport, quality evaluation, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jelly, candy; Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management and food safety standards; Role of HACCP.

Unit 7: 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, brassinosteroids, growth inhibitors, morphactins, role of plant growth promoters and inhibitors, developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase,

flowering, pollination, fertilization and 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.

Unit 8: Biotechnology of Fruit Crops

Harnessing bio-technology for improvement of horticultural crops, 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, *ex vitro*, establishment of tissue culture plants; Physiology of hardening - hardening and field transfer, organ culture-meristem, embryo, anther, ovule culture, embryo rescue, soma clonal variation, protoplast culture and fusion; Construction and identification of somatic hybrids and cybrids, wide hybridization, *in vitro* pollination and fertilization, haploids, *in vitro* mutation, artificial seeds, cryopreservation, rapid clonal propagation, genetic engineering and transformation in horticulture crops, use of molecular markers. *In vitro* selection for biotic and abiotic stress, achievements of biotechnology in horticultural crops and application of gene editing tools in horticultural crops.

Unit 9: Protected Fruit Culture

Greenhouse – world scenario, Indian situation; present and future, different agro-climatic zones in India, environmental factors and their effects on plant growth; Basics of green house design, different types of structures-glasshouse, shade net, poly tunnels-Design and development of low cost green house structures; Interaction of light, temperature, humidity, CO2, water on crop regulation - Greenhouse heating, cooling, ventilation and shading; Types of ventilation-Forced cooling techniques-Glazing materials-Micro irrigation and Fertigation; Automated green houses, microcontrollers, waste water recycling, management of pest and diseases-IPDM.

Unit 10: Principles and Practices of Plant Propagation

Introduction, life cycle in plants, cellular basis for propagation. Sexual propagation – apomixis, polyembryony, chimeras. Factors influencing seed germination, hormonal regulation of germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing. Rooting of cuttings under mist and hot beds. Physiological, anatomical and biochemical aspects of root induction in cuttings. Selection of elite mother plants. Establishment of bud wood bank. Stock, scion and inter stock relationship and incompatibility. Physiology of dwarfing rootstocks. Rejuvenation of senile and seedling orchards progeny orchard and scion bank. Micropropagation *In vitro* clonal propagation, director ganogenesis, embryogenesis, micro grafting and meristem culture. Hardening, packing and transport of micro-propagules.

14 FLORICULTURE & LANDSCAPING / FLORICULTURE & LANDSCAPE ARCHITECTURE

Unit 1: **Breeding**

Principles – Evolution of varieties, origin, distribution, genetic resources, genetic divergence. Patents and Plant Variety Protection in India; Genetic inheritance of flower colour, doubleness, flower size, fragrance, post-harvest life; Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants – introduction, selection, domestication, polyploidy and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops; Breeding constrains and achievements made in commercial flowers – rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster, heliconia, liliums, Breeding constrains and achievements made in ornamental plants – petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snap dragon, pansy) and ornamental foliages – Introduction and selection of plants for waterscaping and xeriscaping.

Unit 2: **Production Technology of Cut Flowers**

Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India – Patent rights, nursery management, media for nursery, special nursery practices; Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO_2 on growth and flowering; Flower production – water and nutrient management, rationing, fertigation, weed management, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes; Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation; Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Pre-cooling, pulsing, packing, Storage and transportation, marketing, export potential, institutional support, Agrl. Export Zones; Crops: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, lilies, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliage.

Unit 3: **Production Technology for Loose Flowers**

Scope of loose flower trade, Significance in the domestic /export markets, Varietal wealth and diversity, propagation, sexual and asexual propagation methods, propagation in mist chambers, nursery management, pro-tray nursery under shadenets, transplanting techniques; Soil and climate requirements, field preparation, systems of planting, precision farming techniques; Water and nutrient management, weed management, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and

remedies, IPM and IDM; Flower forcing and year round flowering production for special occasions through physiological interventions, chemical regulation; Harvest indices, harvesting techniques, post-harvest handling and grading, packing and storage, value addition, concrete and essential oil extraction, transportation and marketing, export potential, institutional support, Agrl. Export Zones; Crops – Jasmine, scented rose, chrysanthemum, marigold, tuberose, crossandra, nerium, hibiscus, celosia, gomphrena, non-traditional flowers (barleria, Nyctanthes, Tabernaemontana, ixora, lotus, pandanus, etc.).

Unit 4: **Landscaping**

Landscape designs, Styles of garden, formal, informal and free style gardens, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, Vanas, Buddha garden; Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporates; Garden plant components, arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Production technology for selected ornamental plants; Lawns, Establishment and maintenance, special types of gardens, vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, colour wheels, temple garden, sacred groves; Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

Unit 5: **Protected Floriculture**

Prospects of protected floriculture in India; Types of protected structures – Greenhouses, polyhouses, shade houses, rain shelters etc., Designing and erection of protected structures; Low cost/Medium cost/High cost structures – economics of cultivation; Location specific designs; Structural components; Suitable flower crops for protected cultivation; Environment control – 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; Containers and substrates, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, IPM and IDM; Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.), Staking and netting, Photoperiod regulation; Harvest indices, harvesting techniques, post-harvest handling techniques, Pre-cooling, sorting, grading, packing, storage, quality standards.

Unit 6: **Value Addition**

Prospects of value addition, National and global scenario, production and exports, Women empowerment through value added products making, supply chain management; Types of value added products, value addition in loose flowers, garlands, veni, floats, floral decorations, value addition in cut flowers, flower arrangement styles, ikebana, moribana, 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; Techniques in dry flower making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage; Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Plant pigments: Significance of natural pigments, Applications; Selection of species and varieties, Types of pigments - carotenoids, anthocyanin, chlorophyll, betalains; Extraction methods; Packing and storage, .

Unit 7: **Turfing and Turf Management**

Prospects of landscape industry, History of landscape gardening, site selection, basic requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment; Turf grasses – Types, species, varieties, hybrids; Selection of 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, astro-turfing; Turf management – Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing – mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs; Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, etc.

Unit 8: **Computer Aided Designing (CAD) for Outdoor and Indoorscaping**

Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHICAD, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing; 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LOT 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 sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, 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 ARCHICAD; ARCHICAD organization tools, Dimensioning and detailing of designs, Attribute settings of components, Visualization tools for landscape preview, data management, plotting and accessories for designing, inserting picture using Photoshop, Making sample drawing for outdoor and indoor gardens.

15 SPICES, PLANTATION, MEDICINAL & AROMATIC PLANTS

Unit 1: Production technology of Plantation Crops

Role of plantation crops in national economy, export potential, IPR issues, clean development mechanism, classification and varietal wealth. Plant multiplication including invitro multiplication, systems of cultivation, multitier cropping, 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, training and pruning, crop regulation, maturity indices, harvesting. Postharvest processing practices. GAP and GMP in plantation crop production and processing. Cost benefit analysis, organic farming, management of drought, precision farming. Crops: Coffee, tea, cashew cocoa, rubber, palmyrah, oilpalm, coconut, arecanut, wattle and betel vine. Role of commodity boards and developmental institutions in plantation crops.

Unit 2: Production Technology of Spice Crops

Introduction, importance of spice crops-historical accent, present status - national and international, future prospects, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, site selection, seed / planting material production including rapid multiplication and micropropagation, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management and processing practices, plant protection measures precision farming, quality control of : Black pepper, cardamom, clove, cinnamon, nutmeg, allspice, turmeric, ginger, garlic, coriander, fenugreek, cumin, fennel, ajwain, dill, celery, tamarind, garcinia, curryleaf, saffron, and vanilla. Role of commodity boards in spices development.

Unit 3: Production Technology of Medicinal and Aromatic Crops

Herbal industry, WTO scenario, Export and import status, Indian system of medicine, Indigenous Traditional Knowledge, IPR issues, Classification of medicinal crops, Systems of cultivation, Organic production, Role of institutions and NGO's in production, GAP in medicinal crop production. Production technology, Post-harvest handling – Drying, Processing, Grading, Packing and Storage, processing and value addition; GMP and Quality standards in herbal products. Influence of biotic and abiotic factors on the production of secondary metabolites, Regulations for herbal raw materials, Phytochemical extraction techniques. Aromatic industry, WTO scenario, Export and import status, Indian perfumery industry, History, Advancements in perfume industry. Production technology, Post-harvest handling, Distillation methods, advanced methods, Solvent extraction process, TLC, HPLC, GC, steam distillation, Perfumes from non-traditional plants, Quality analysis, Value addition, Aroma chemicals, quality standards and regulations. Institutional support and international promotion of essential oil and perfumery products. Medicinal crops: Senna, periwinkle, coleus, aswagandha, glory lily, sarpagandha,

dioscorea sp., Aloe vera, Phyllanthus amarus, Medicinal solanum Isabgol, PoppyStevia rebaudiana, Mucuna pruriens, Satavari, Long pepper, sweat flag, Belladona and Cinchona

Aromatic Crops: Palmarosa, lemongrass, citronella, vettiver, geranium, artemisia, Mentha, Ocimum, eucalyptus, rosemary, thyme, patchouli, lavender, marjoram, and oreganum.

Unit 4: **Breeding of Plantation, Spice, Medicinal and Aromatic Crops**

Species and cultivars, cytogenetics, survey, collection, conservation and evaluation, blossom biology, breeding objectives, approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, molecular aided breeding and biotechnological approaches, marker-assisted selection, bioinformatics, IPR issues, achievements and future thrusts. Crops: Coffee, tea, cashew, cocoa, rubber, palmyrah, oilpalm, coconut, arecanut, black pepper, cardamom, ginger, turmeric, fenugreek, coriander, fennel, celery, ajwain, nutmeg, cinnamon, clove and allspice. Medicinal crops, *viz*. Cassia angustifolia, Catharanthus roseus, Gloriosa superba, Coleus forskohlii, Stevia, Withania somnifera, Papaver somniferum, Plantago ovata, Dioscorea sp, Chlorophytum sp, Rauvolfia serpentina, Aloe vera, Phyllanthus amarus, Medicinal Solanum

Aromatic crops: Geranium, vettiver, Lemon grass, Palmarosa, citronella, rosemary, Patchouli, Eucalyptus, Artemisia, Ocimum sp, and Mint.

Unit 5: **Processing of Plantation Crops, Spices, Medicinal and Aromatic Plants**

Commercial uses of spices and plantation crops. Processing of major spices - cardamom, black pepper, ginger, turmeric, chilli and paprika, vanilla, cinnamon, clove, nutmeg, allspice, coriander, fenugreek, curry leaf. Extraction of oleoresin and essential oils; Processing of produce from plantation crops, viz. coconut, arecanut, cashewnut, oil palm, palmyrah, date palm, cocoa, tea, coffee, rubber etc; Processing of medicinal plants– dioscorea, gloriosa, stevia, coleus, ashwagandha, tulsi, isabgol, safed musli, senna, aloe, catharanthus, etc. Different methods of drying and storage. Microbial contamination of stored product. Influence of temperature and time combination on activeprinciples; Extraction and analysis of active principles using TLC/HPLC/GC. Distillation, solvent extraction from aromatic plants– davana, mint, rosemary, citronella, lavender, etc. Study of aroma compounds and value addition

Unit 6: **Organic Spice and Plantation Crop Production Technology**

Importance, principles, perspective, concept and component of organic production of spice and plantation crops; viz. Pepper, cardamom, turmeric, ginger, cumin, vanilla, coconut, coffee, cocoa, tea, arecanut; managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods; methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of composting, preparation of panchagavya, biodynamics, etc.; pest and disease management in organic farming; ITK's in organic farming. Role of botanicals and bio-control

agents; GAP and GMP- certification of organic products; organic production and export-opportunity and challenges.

16 POST HARVEST TECHNOLOGY

Unit 1: **Post-Harvest Technology of Vegetable Crops**

Scope and importance of post-harvest management of vegetables;Nature and causes of post-harvest losses; Maturity indices and standards for different vegetables; methods of assessment of maturity, physiological and biochemical changes during maturity and ripening, enzymatic and textural changes, ethylene evolution and ethylene management, respiration, transpiration, regulation methods; Influence of pre-harvest practices and other factors affecting shelf life and post-harvest quality;Harvesting methods, tools, harvesting practices for specific market requirements; pre cooling methods; grading, washing,pack house operations, pre treatments-chemicals, wax coating, edible coating, pre packaging and irradiation; packaging of vegetables, packaging materials; Storage methods - ventilated, refrigerated, MA, CA storage, hypobaric storage, cold storage, zero energy cool chamber; Storage disorders -chilling injury in vegetables, post-harvest diseases and pests - prevention from infestation; principles of transport; food safety standards and export standards.

Unit 2: **Post-Harvest Technology of Fruit Crops**

Scope and importance of post-harvest management of fruits; Factors leading to post-harvest losses; Maturity indices, methods of assessment of maturity, harvesting practices and grading for specific market requirements; Physiological and biochemical changes during maturity and ripening, ethylene evolution and ethylene management; enzymatic and textural changes, respiration, transpiration; Influence of pre-harvest practices and other factors affecting shelf life and post-harvest quality;Harvesting methods, tools, harvesting practices for specific market requirements; Pre cooling methods; grading, washing, pack house operations, pre treatments treatment prior to shipment, viz., chlorination, waxing, chemicals, bio-control agents and natural plant products, fungicides, hot water, vapour heat treatment, sulphur fumigation and irradiation; Pre packaging and irradiation, packaging of fruits, packaging materials; Storage methods - ventilated, refrigerated, MAS, CA storage ; Physical injuries and disorders; Transportation and marketing standards for international markets, quality evaluation,principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies; Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards and export standards.

Unit 3: **Value Addition of flowers**

Prospects of value addition; National and global scenario, production and export; Women empowerment through value added products making, supply chain management; Types of value added products, value addition in loose flowers, garlands, veni, floats, floral decorations; Value addition in cut flowers, flower arrangement, styles, ikebana, morebana, free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, floral craftsetc.;Selection of containers and accessories for floral products and decorations; Aromatherapy, pigment and

natural dye extraction techniques;Dry flowers – Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage; Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packaging and storage, Selection of species and varieties, Types of pigments, carotenoids, anthocyanin, chlorophyll, betalains; Significance of natural pigments, Extraction methods; Applications ; Export standards.

Unit 4: **Processing of Plantation Crops, Spices, Medicinal and Aromatic Plants**

Prospects of processing and value addition, National and global scenario, production and exports; Commercial uses of spices and plantation crops. Processing of major spices - cardamom, black pepper, ginger, turmeric, chilli and paprika, vanilla, cinnamon, clove, nutmeg, allspice, coriander, fenugreek, curry leaf. Extraction of oleoresin and essential oils; Processing of produce from plantation crops, viz. coconut, arecanut, cashewnut, oil palm, palmyrah, date palm, cocoa, tea, coffee, rubber etc; Processing of medicinal plants– dioscorea, gloriosa, stevia, coleus, ashwagandha, tulsi, isabgol, safedmusli, senna, aloe, catharanthus, etc. Different methods of drying and storage. Microbial contamination of stored product. Influence of temperature and time combination on active principles; Extraction and analysis of active principles using TLC/HPLC/GC. Distillation, solvent extraction from aromatic plants– davana, mint, rosemary, rose, citronella, lavender, jasmine, etc. Extraction of aroma compounds and aromatherapy; Extraction of pharmaceutical and neutracutical compound from medicinal and aromatic crops; Application of nano technology in medicinal and aromatic plants. Applications; Export standards.

17 ANIMAL GENETICS & BREEDING

Unit 1: Overview of Genetics

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

Unit 2 : Advanced Genetics

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

Unit 3 : Overview of Breeding

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

Unit 4 : Genetic Properties of Population

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

Unit 5 : Population Genetics

Gene and genotypic frequencies and factors affecting them. Hardy Weinberg Law and consequences of it. Prediction of selection response by different methods. Selection for threshold characters. Indirect selection and 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.

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. Biotechnology and its role in improving animals and poultry production. Role of artificial insemination / frozen semen / embryo transfer / ONBS / MOET 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 current recommendations of cross breeding programmes of cattle, sheep and goat in India.

Unit 7 : Selection & Selection Experiments

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

Unit 8 : Genetic Laboratory Techniques

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

Unit 9 : Research Techniques for Quantitative Animal Genetics

Use of computers in handling animal breeding data. Estimation of variances and covariances. Development of statistical models for analyses of breed data and to quantify environmental variance. Estimation of inbreeding and relationship. Estimation of inbreeding rate in a closed

herd / flock. Estimation and interpretation of genetic and phenotypic parameters. Development of efficient selection programmes and procedures. Estimation of genetic gains. Designing and evaluation of breeding strategies like reciprocal recurrent selection, diallele and polyallele crossing. Designing field based progeny testing programmes. Development of efficient methods and traits for genetic evaluation of males under indigenous conditions. Data bank concept.

Unit 10 : Laboratory Animal Breeding

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

18 ANIMAL NUTRITION

Unit 1: Energy and Proteins

Nutritional significance of carbohydrates, lipids and proteins. Cell-wall fractionation. Available energy from organic nutrients. Partitioning of dietary energy. Basal metabolic rate. Energy retention. Efficiency of energy utilization. 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. Essential, critical amino and limiting acids. Protein evaluation. Metabolizable protein concept. Protein energy inter-relationship. Energetic of protein utilization for maintenance and different productive functions.

Unit 2: Minerals, Vitamins and Feed Additives

Minerals: Classification of minerals, ultra trace elements, newer elements, occasionally possible elements, Physiological functions, Deficiency symptoms and toxicity - Inter-relationships - Synergism and antagonism - Requirements - Different sources and bio-availability - Role of chelated, nano and hydrated minerals. Vitamins: Physiological functions and co-enzyme role - Deficiency symptoms, hyper-vitaminosis. Requirements, Sources and vitamin analogues - Antivitamins –Relationship between mineral and vitamin functioning. Feed Additives: Feed additive regulations. Nutritional role. Prebiotics, Probiotics, synbiotics and eubiotics, phytochemicals other metabolic modifiers. Role of phyto-chemicals as growth promoters.

Unit 3: Rumen Eco-system and Functions

Rumen and its environment. Development of functional rumen. Digestion kinetics in reticulo-rumen. Role of rumen microbes, Classification 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. Recycling of urea in ruminant, Ammonia toxicity - Role of slow release urea compounds. Manipulation of rumen fermentation. Bio-hydrogenation and utilization of dietary lipids. Methanogenesis their mechanism of production, essentiality and methane inhibitors. Carbon trading.

Unit 4: Non-ruminant Nutrition

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

Unit 5: Nutrient Requirements

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

Unit 6: Forage Conservation and Evaluation

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

Unit 7: Global feed industry and production scenario

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

Unit 8: Anti-metabolites and Toxic Principles

Naturally occurring anti-nutritionalfactors 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 – Invitro, gas production and nylon bag techniques, Rumen simulation techniques -Rusitec Tracer techniques in nutrition research - Role of NIR Spectroscopy - Feed microscopy in quality evaluation of feedstuffs.

Unit 10: Clinical Nutrition

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

19 LIVESTOCK PRODUCTION MANAGEMENT

Unit 1: General

Present status and future prospects of livestock and poultry development in India. Animal production systems in different agro-climatic zones of the country. Sustainability issue in relation to environment. Livestock farming systems. Effect of mechanization of agriculture on livestock sector. Breeds of cattle, buffalo, sheep, goat, pigs, equine, camels, rabbits and poultry. Various livestock and poultry development programmes & their impact on productivity & health. Livestock behaviour vis-à-vis adaptation and production. Behaviour & welfare. Systems of behaviour. Sexual behaviour in various species of livestock and poultry. Social order in farm animals. Behavioural aberrations – causes and control. Adaptation of livestock and poultry in tropics, deserts cold and high altitudes. Biosecurity and environmental considerations. Emerging challenges for livestock production in relation to the climate change scenario. Biotechnology in animal improvement.

Unit 2: Breeding Management

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

Unit 3: Feeding Management

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

Unit 4: Reproduction Management

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

Unit 5: Shelter Management

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

Automation in livestock farming. Types & designs of Milking parlours suitable for different scales of production. Disposal of animal wastes under urban and rural conditions. Disposal of carcasses.

Unit 6: Health Management

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

Unit 7: Production and Management of Cattle and Buffalo

Cattle and buffalo production trends and factors affecting them. Prenatal and postnatal care and management of cattle and buffalo. Care of neonates and young calves. Management strategies for reducing mortality in calves, age at first calving, and calving intervals. Management to improve reproductive efficiency in cattle and buffalo. Management strategies against summer & winter stress. Feed conversion efficiency for growth and milk production. Application of body condition scoring & other scoring techniques to improve productivity & efficiency of dairy animals. Milking management: hand vs machine milking practices. Standard milking protocols for clean milk production. Management practices for high yielding cows & buffaloes. Standard norms for manpower deployment for dairy farms & measures for improving labour efficiency. Dairy farm management efficiency measures. Mechanization & automation of various dairy farm operations (milking, feeding, waste disposal, heat detection, identification & health monitoring).

Unit 8: Production and Management of Other Animals

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

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

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

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

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

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

Unit 9: Wildlife Management

Status of wildlife in India and its conservation. Biological and ecological basis of management of wildlife. Breeding and feeding of wildlife in captivity. Principles & practices health management of wild animals.

Unit 10: Forage Production and Conservation

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

Unit 11: Economics and Marketing of Livestock and Poultry and their Products

Economic principles as applied to livestock production. Production functions. Farm size, resources and product combinations. Cost concepts. Criteria for 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. Estimation of cost of different livestock products (milk, meat, egg & wool). Determination of prices of livestock products.

20 LIVESTOCK PRODUCTS TECHNOLOGY

Unit 1: Basic and General Aspects of Livestock Products

Composition and physico-chemical properties of cow and buffalo milk. Milk proteins, lipids, carbohydrates, minerals, vitamins and other minor constituents of milk. Nutritive value of milk. Reception of milk - platform tests, filtration and clarification, Membrane processing and related techniques, chilling, separation, standardization, pasteurization and homogenization. Cleaning and sanitation of dairy equipments. Present status and future prospects of meat and poultry industry. Structure, composition, physical biochemical and nutritive aspects, and functional properties of different kinds of meat, fish, poultry and eggs. Sensory evaluation and organoleptic properties of livestock products. Post-mortem aspects of muscle as meat. Ageing of meat and chemical changes. Meat in human health. Bacteria, yeasts, molds, parasites important in food microbiology. General principles of spoilage. Chemical and deteriorative changes caused by micro-organisms. Contamination and spoilage of meat, fish, poultry and eggs. Food poisoning and food-borne infections. Assessment of microbial condition and wholesomeness of different livestock products. National and International microbial standards.

Unit 2: Abattoir and Poultry Processing Plants

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

Unit 3: PFA and FSSAI standards of different dairy products

Processing and Preservation Principles of processing of dairy products. Special milk: sterilized milk, flavoured milk, homogenized milk, soft curd milk, Vitaminized/irradiated milk, fermented milk, standardized milk, reconstituted/rehydrated milk, recombined milk, toned, double toned milk, skimmed milk, Humanized milk. Processing of dairy products: - butter, butter oil, ice-cream, fresh and ripened cheeses, cream, condensed milk, dried milk, dried milk products etc. Indigenous dairy products: ghee, khoa, dahi, misti dahi, makkhan, chhana, paneer, Khurchan, Lassi, kunda, milk cake, Organic milk. Principles of preservation of livestock products. Equipment and technology of processing and preservation. Industrial food preservation, chilling, freezing, freeze drying, dehydration, bio preservation, canning irradiation, pasteurization, curing,

smoking, use of chemical additives and antibiotics. Recent advances in preservation of livestock products. Cooking methods including micro-wave cooking. Tenderisation and use of enzymes for processed foods. Production of value added products, process methods, process optimization and quality control. Development and preservation self-stable (canned and dehydrated) intermediate moisture, textured, cured, fermented fabricated meat and poultry products. Sanitation, regulation and inspection of processed meat foods. Development of emulsified, communited, restructured and other processed meat products. Desugarization, freezing, pasteurization and dehydration of eggs. Principles involved in preparation of egg powder and other egg products. Effect of processing on nutritional, chemical, microbiological and organoleptic qualities of livestock products. Economics of pre-costing and product development. Application of biotechnology in processing and preservation of meat, poultry and fish products. Genetically modified foods. Bioactive products and biogenic amines.

Unit 4: Wool, Mohair and Fur

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

Unit 5: Packaging

Principles of packaging. Types of packaging materials. Characterization, methods and systems of packaging. Gas packing, Vacuum packing, modified atmosphere packing, controlled atmospheric packaging, shrink and stretch packing, industrial packaging. Aseptic and retort pouches. Standardization and quality control of packaging material. Product attributes and packaging requirements for different livestock products. Latest trends in packaging of meat, poultry, eggs, wool and fish products: Active and smart packaging, antimicrobial packaging, edible films and coatings, nanocomposite materials for food packaging. Use of biosensors in livestock products packaging.

Unit 6: Quality Control

Grades and grading of livestock products. Stress factors effecting meat quality – PSE, DFD, 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. Detection of antibiotics, chemical residues, heavy metals and toxins in meat. Techniques for detection of adulteration of meat. Different techniques for meat speciation. HACCP concept of quality control of meat, fish, poultry and eggs.

Unit 7: Marketing

Livestock production and supply characteristics. Meat consumption and related demands. Present status, constraints and future aspect of livestock production and marketing. 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.

21 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 improvementnatural, 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 nonadditive gene effects. Selection for specific characters. Recurrent and reciprocal recurrent selection. Part record versus complete record selection. Genotype and environment interaction. Relative merits and demerits of different methods of selection. Different mating systems-Diallel mating, pair mating, pen mating and block mating. 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 and layers. Selection for disease resistance. Immunogenetics. Blood group systems. Biochemical polymorphism and usefulness in poultry breeding. Development of transgenic chicken. Different molecular techniques for estimation of genetic diversity and similarity among breeds and lines of poultry. Scope of 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. Essential fatty acids. Essential vitamins and minerals and their functions. Nutrients deficiency, toxicity, synergism and antagonism. 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,

prebiotics, synbiotics, organic acids, enzymes, antimicrobials, anticoccidials, performance-promoters, antioxidants, flavouring agents, colouring agents and other non-nutrient feed additives.

Unit 3: Avian Physiology

Homeostasis and its regulation; Characteristics features of endocrine glands; Regulation of feed and 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; Photoperiodism and its role in optimization of reproductive functions; physiology of avian testes, spermatogenesis, semen ejaculation and its characteristics. Fate of sperm in oviduct and fertilization; Respiratory system – mechanisms of gaseous exchange; Thermoregulatory and stress mechanisms; Physiobiochemical stress responses and remedial approaches; Factors influencing reproductive functioning.

Unit 4: Poultry Products Technology

Structure, chemical composition and nutritive value of egg. 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. Further processing and fast food preparation. Physical, chemicals, 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. Lay out of a modern hatchery. Equipments required in a modern hatchery. Single and multi-stage incubators. Hatchery business. Sexing, handling, packaging and transportation of chicks. Principles and methods of brooding. Space required for brooding, rearing, feeding and watering. Preparation of brooder house to receive young chicks. Forced feeding of turkey poults. Brooding of quails, ducklings and turkey poults. Managements during growing period. Overcrowding, culling. Management of replacement pullets for egg production and breeding stocks. Management of layers and breeders. Light

management. Debeaking, dubbing and other farm routines. Littre management. Broodiness and forced moulting in layers. Management of turkey, ducks, quails and Guinea fowl. Summer and winter management. Farm location and site selection. Ideal layout of poultry houses for different systems of rearing. Design of poultry houses like brooder, grower, broiler, layer and cage house, poultry processing unit, feed mill, etc. Environmentally controlled and open poultry houses. Types of construction materials used. Cross-ventilation and ridge ventilation. Effect of pollution on production performance of birds. Ammonia control in poultry houses. Type of brooders, feeders, waters, laying nests, cages, etc. Automation in poultry production.

Unit 6: Economics and Marketing

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

Unit 7: Poultry Health Management

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

22 VETERINARY PARASITOLOGY

Unit 1: Veterinary Helminthology

Introduction to veterinary helminthology, general account of morphology, classification, life-cycle patterns, epizootiology, pathogenesis, symptoms, diagnosis; treatment and control of parasites belonging to the various families, Identification of various snail species, laboratory rearing, dissection and general control measures against snail borne helminthosis. Vaccines and recent advances in diagnostic techniques for helminth diseases.

Unit 2: Veterinary Entomology

Introduction to veterinary entomology, classification, distributions, morphology, life-cycle, seasonal patterns and economic significance of insects and acarines belonging to the various families. Treatment, control and integrated arthropod pest management. Current advances in immunological interventions/ Control of arthropods, Vaccines and recent advances in diagnostic techniques for arthropods

Unit 3: Veterinary Protozoology

Introduction to veterinary protozoology, classification, morphology, life-cycle, clinical symptoms, pathogenesis, diagnosis, chemotherapy, prophylaxis and control of parasites belonging to the various families, Vaccines and recent advances in diagnostic techniques for protozoan diseases.

Unit 4: Clinical Parasitology

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

Unit 5: Parasitic Zoonoses

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

Unit 6: Management of Livestock Parasitism

Factors affecting epidemiology, host environment, development and survival of infective stages, microhabitat, seasonal development (hypobiosis/diapause), dietary and host factors altering susceptibility, concurrent infections. Influence of genetic factors, general approaches to control of parasitic diseases – stock management practises, stock rates, rotational grazing, clean grazing.

Parasite worm burden (EPG). Strategic and tactical control strategies involved in chemical control of helminth, protozoan and arthropod infestations. Broad and narrowspectrum anthelmintics, antiprotozoal drugs, insecticides and acaricides. Newer drug delivery systems-slow and pulse release methods. Anthelmintic failure – drug resistance monitoring and management. Prospects of alternative methods of control, breeding for host resistance against parasites. Control of vectors and intermediate hosts and sustainable management. Estimation of economical losses due to parasitic diseases.

Unit 7: Immunoparasitology

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

Unit 8: Diagnostic Parasitology

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

23 VETERINARY PUBLIC HEALTH/VETERINARY PUBLIC HEALTH & EPIDEMIOLOGY

Unit 1: Veterinary Public Health

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

Unit 2: Milk Hygiene

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

Unit 3: Meat Hygiene

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

Unit 4: Food-borne Infections and Intoxications

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

Unit 5: Zoonoses

Definitions, Concept and classification of Zoonoses, Ecological aspects of Zoonoses, Wild animals-, cold blooded animals - domestic animals -, and aquatic life, -associated Zoonoses, Vectors-, milk-, meat-, egg-, fish- and waterspread Zoonoses, Occupational zoonoses, Nosocomial zoonoses, xenozoonoses, Nationally and internationally emerging and re-emerging Zoonoses, Epidemiology of bacterial, rickettsial, viral, parasitic and mycotic Zoonoses, Principles of Zoonoses management: methods of prevention, control and eradication of Zoonoses.

Unit 6: Environmental Hygiene

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

Unit 7: Epidemiology

Definitions, Epidemiology, Epizootiology, Causal association, concept of infection, Theory of natural nidality, Ecological basis of diseases, Disease transmission, Epidemic process, Distribution of diseases in space and time, Epidemiological hypothesis, Types of epidemiological studies, Epidemiological survey, surveillance, monitoring of diseases, experimental epidemiology, epidemiological measurements, Predictive epidemiology, Epidemiological models, Sero-epidemiology. Use of information technology and computer applications in disease monitoring, Epidemiological investigation and evaluation of intervention measures. Scope of Epidemiology: Definitions, uses, components, subdisciplines and types of epidemiology, Concept of causality and epidemiological hypothesis, Measures of describing disease occurrence and frequency in animal populations, epidemiological rates and ratios, Determinants of disease, epidemiological triad, Transmission and maintenance of infection, ecology of disease and landscape epidemiology, Patterns of disease, Survey of animal disease , surveillance and monitoring, Data collection, management ,storage, retrieval and presentation, Epidemiological studies: observational and experimental, Serological epidemiology, Economics of animal disease, Control and eradication of disease, Use of information technology and computer applications in disease monitoring, Epidemiological investigation and evaluation of intervention measures.

Unit 8: Experimental Animal Medicine

Occupational health and safety in the care and use of research animals. Breeding, care and management of experimental animals, Production of gnotobiotic, germfree, specific pathogen

free, transgenic, syngenic animals and tailor-made animals in relation to public health, provisions of Animal welfare and Society for Prevention of Cruelty to Animals Act.

Unit 9: Health Education

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

Unit 10: Standard Guidelines and Legislation

Definitions, standards/guidelines of products and product ingredients. Hazards Analysis Critical Control Points (HACCP), Good Manufacturing Practices (GMP), Good Laboratory Practices (GLP), Milk and Milk Product Order (MMPO), Meat Food Products Order (MFPO), Total Quality Management (TQM), Quality assurance and food safety management systems, Bureau of Indian Standards, International Organization for Standards, Codex Alimentarius, World Trade Order, 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 11: Microbiology in Public Health

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

24 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 enzymes. Respiration in bacteria. Carbohydrate protein, fat and nucleic acid metabolism in bacteria. Reproduction and growth phase of bacteria. Effects of chemical and physical agents and antibiotics. Bacterial variations including transduction, transformation and conjugation. Bacterial vaccines and toxins. The role of microbial toxins in the pathogenesis of diseases; Biochemical and biological characteristics of toxins produced by various bacteria. Toxin producing Gram-positive and Gram-negative bacteria. Properties and clinical conditions produced by different bacterial toxins.

Unit 2: Systematic Bacteriology

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

Unit 3: General Virology

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

Unit 4: Systematic Virology

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

Orthomyxoviruses, Rhabdoviruses. Picornaviruses. Bunyaviruses. Arenaviruses. Arterioviruses. Caliciviruses. Filoviruses, DNA viruses: Poxviruses. Hepadnaviruses. Iridoviruses, Adenoviruses, Papovaviruses. Parvoviruses. Circoviruses. Unclassified viruses. Slow viruses - Scrapie, Flavi virus, Borna virus, Herpes virus, Asfar virus.

Unit 5: Mycology

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

Unit 6: Immunology

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

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

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

25 VETERINARY PATHOLOGY

Unit 1: Introduction, History and Etiology

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

Unit 2: Haemodynamics Derangements, Degeneration and Necrosis

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

Unit 3: Inflammation and Healing

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

Unit 4: Immunopathology

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

Unit 5: Genetically Determined Diseases

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

Unit 6: Disturbances in Cell Growth and Oncology

Disturbance in cell growth – aplasia, hypoplasia, hyperplasia, atrophy, metaplasia, dysplasia. Neoplasms-growth, etiology, classification, morphology, and behaviour of the neoplasms,

structure and biology of the tumor cell, tumor immunology, tissue response to tumors, spread of tumors, pathological features of various neoplasms.

Unit 7: Post-mortem Diagnosis and Histopathological Techniques

Post-mortem examination as a diagnostic tool. Post-mortem techniques for different species including poultry, post-mortem changes, lesions in various organs in different diseases, identification and interpretation of lesions, preparation of necropsy reports. Handling of necropsy in vetero-legal cases, collection, preservation and dispatch of materials for diagnosis. Fixation and processing of tissues for histopathology and histochemistry. Different staining techniques. Histochemistry and histoenzymology as diagnostic tools. Principles of electron microscopy, 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 counts, serum enzymology, bone marrow examination, erythrocytes, leucocytes and platelet disorders and their interpretations. Electrolyte and acid base analysis, altered electrolyte concentrations and their interpretations, fluid accumulation disorders, examination of effusions (chemistry and exfoliative cytology). Complete examination of urine, skin scrapings stools, CSF and milk for pathological constituents and interpretation of results.

Unit 9: Systemic Pathology

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

Unit 10: Pathology of Infectious Diseases

Pathology of bacterial, mycotic, viral, mycoplasmal, rickettsial, chlamydial and parasitic diseases. Diseases caused by prions.

Unit 11: Avian Pathology

Farm placements and building in relation to disease, management and nutrition in relation to disease. Biosecurity in the control of diseases. Stress and its effects. Omphalitis and yolk sac infection, Newcastle disease, infectious bronchitis, infectious laryngotracheitis, 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, chlamydiosis, colibacillosis, spirochaetosis, aspergillosis, thrush, mycotoxicosis, parasitic diseases – nematodes, cestodes and protozoa, nepherosis/nephritis syndrome, multi-etiology syndromes. Immunosuppression and conditions/diseases associated with it. Vaccinations against various diseases, their failures and remedies.

Unit 12: Nutritional and Production Pathology

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

Unit 13: Pathology of Toxicosis

Clinico-pathological features of toxicosis due to heavy meals, mycotoxins, insecticides, pesticides, toxic plants, chemicals and drugs.

Unit 14: Pathology of Diseases of Laboratory and Wild Animals

Etiopathology of common diseases of laboratory and wild animals.

26 VETERINARY MEDICINE

Unit 1: General Medicine

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

Unit 2: Diagnosis of Animal Diseases

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

Unit 3: Gastroenterology

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

Unit 4: Diseases of Cardiovascular and Pulmonary System

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

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

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

Unit 6 : Production and Deficiency Diseases

Metabolic profile test, milk fever, Downer’s cow syndrome, ketosis, hypomagnesaemia, diabetic ketoacidosis, hypomagnesaemia, post-parturient haemoglobinuria, azoturia. Fat cow syndrome, rickets, osteomalacia, osteodystrophiafibrosa. Trace mineral and vitamin deficiency.

Unit 7 : Common toxicities

Sources, pathogenesis, clinical manifestations, post-mortem findings, diagnosis and treatment of conditions occurring in the following classes of poisonings: Metal Corrosives/irritants. Plant

poisonings. Water-borne toxicities. Pesticide poisonings. Insect bites and stings. Snake bite. Environmental pollution hazards. Radiation hazards and injuries.

Unit 8 : Infectious Diseases (Bacterial and Mycoplasmal)

Etiology, epidemiology, pathogenesis, clinical manifestations, post-mortem findings, diagnosis, treatment and control of the following diseases of livestock : Mastitis, Strangles. Caseous lymphadenitis in sheep and goats.Clostridial diseases.Ulcerative lymphangitis in horses & cattle.Listeriosis, Leptospirosis, Erysipelas, Collibacillosis, Salmonellosis, Pasteurellosis, Brucellosis, TB, JD, Actinomycosis, Actinobacillosis, Glanders and Mycoplasmal diseases.

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

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

Unit 10: Parasitic Diseases

Etiology, epidemiology, pathogenesis, clinical manifestations, post-mortem findings, diagnosis, treatment and control of the following diseases of livestock: Major conditions produced by nematode, cestode and trematode infestations. Major conditions produced by arthropod parasites.

Unit 11: Poultry Disease

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

Unit 12: Veterinary Jurisprudence and Ethics

Judicial procedure. Duties of veterinarian particularly as an expert evidence. Vetero-legal aspects of wounds.Vetero-legal aspect of death in general, due to diseases, drowning, near drowning, electrocution, lightening, etc. Post-mortem examination of a vetero-legal, cases. Collection and dispatch of materials for forensic science examination.Common offense against animals.Common frauds in dealing with livestock and livestock products.Animal Insurance.Identification of animal species for vetero-legal purposes.Determination of time since

death. Examination of blood and semen stains. Blood grouping in animals and its vetero-legal significance. Veterinary ethics: Code of conduct, professional ethics and etiquette for veterinarian. Laws: Role of veterinarian. Legal enactment in IPC related to animals and veterinarians. Prevention of Cruelty to Animal Act, Indian Veterinary Council Act.Wild life (protection) Act.Glanders and Farcy Act, Livestock Importation Act.Dangerous Drug Act and Prisoning Act. Legal provisions related to animals, animal diseases and drugs.

Unit 13: Special Therapeutic Approaches

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

Unit 14: Prevention and Control of Diseases

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

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

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

27 VETERINARY PHARMACOLOGY& TOXICOLOGY

Unit 1: General Pharmacology

Development and Scope, branches of pharmacology,Terminology, Sources and nature of drugs. Pharmacopoeia and drug compendia.Drug Schedules.Factor modifying drug activity. Concepts of pharmacogenetics, pharmacogenomics Gene based therapy, overview of indigenous medicinal plants its active principles in therapeutic use. Pharmacodynamics: Drug structure activity relationship. Drug receptor interaction.Role of secondary messengers.Drug modulation via different types of channels.Characterisation of agonist, antagonists.Pharamacokinetics:Principles, Drug absorption, distribution, metabolism and excretion. Factors modifying drug kinetics.Kinetic constants. Different models, determination of kinetic parameters and application in rational dosage regimen. Pharmacometrics:Drug discovery and development process. Multidimensional screening methods, bioassays.Determination of median doses – LD50, ED50, therapeutic indices.Types of dose response relationship.

Unit 2: Drugs Acting on Central Nervous System

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

Unit 3: Drugs Acting on Humoral and Autonomic Nervous Systems

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

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

Drugs acting on heart and blood vessles. Antihypotensive and anti-arrhythmic agents.Blood coagulants and anticoagulants. Heamatinics. Haemorrhagic shock and its treatment. Expectorants, antitussives. Cough sedatives. Bronchodilators. Mucolytic agents. Analeptics.

Unit 5: Drugs Acting on Digestive System

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

Unit 6: Drug acting on Urogenital System

General principles of electrolyte therapy. Drugs altering fluid balance. Diuretics and antidiuretics.Drugs acting on uterus (oxytocics and tocolytics).Therapy of infertility and improving conception and synchronization of oestrus.

Unit 7: Endocrine Pharmacology

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

Unit 8: Autacoids

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

Unit 9: Chemotherapy

General principles. Classification of antibiotics based on chemistry, mechanism of action, etc., Drug allergy, hypersensitivity, mechanism of resistance development. Veterinary drug residues and its impacts.Extra label usage of antibiotics.Withdrawal period for antibiotics.Antiseptics and Disinfectants. Antibiotics: beta lactams (Penicillin, cephalosporins, etc.) protein synthesis inhibitors (aminoglycosides, tetracyclines, chloramphenicol and macrolide/lincosamides, Quinolones, nitrofurans, polypeptide and other miscellaneous and emerging antibiotics. Sulphonamides, thrimethoprim and derivatives.Antifungal, antitubercular, antiviral and antineoplastic drugs.Anthelminitic: Antinematodal, anticestodal, antitrematodal drugs. Antiprotozoans, Anticoccidials. Drugs used for ectoparasite control.

Unit 10: Toxicology

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

Unit 11: Ecotoxicology

Toxicity 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. Recent advances in evaluation of cytotoxicity, immunotoxicity, teratogenicity, mutagenicity, embroyotoxicity.

Unit 12: Miscellaneous Topics

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

28. VETY. GYNAECOLOGY & OBSTETRICS/ANIMAL REPRODUCTION, GYNAECOLOGY & OBSTETRICS

Unit 1: Veterinary Gynaecology

Biology of sex. Development of female genitalia.Functional anatomy of female reproductive system of farm animals.Growth, puberty and sexual maturity.Reproductive cycles (oestrous cycle) in female farm animals.Oogenesis and folliculogenesis.Follicular dynamics and ovulation.Transport and survival of gametes, fertilization, cleavage, implantation and maternal recognition of pregnancy.Sex determination and differentiation, Development of foetus and foetal membranes.Period of embryo and period of fetus, Teratology of fetus, Placentaclassification and functions.Gestation and pregnancy diagnosis in farm animals.

Unit 2 : Reproductive Endocrinology

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

Unit 3 : Accidents during Gestation

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

Unit 4 :Veterinary Obstetrics

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

Unit 5 :Andrology

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

sperm metabolism, sperm abnormalities and its classification, sperm separation and spermatozoa karyotyping. Breeding soundness evaluation of bulls, testicular cytogram, routine semen analysis, advances in semen analysis techniques including fluorescent dyes.

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. Libido problem and its management, fertility markers.Evaluation of male for breeding soundness, reproductive health status.Effect of parental drugs and vaccines on semen quality.

Unit 7 : Frozen Semen Technology and Artificial Insemination

History and development of artificial insemination. Advantages and disadvantages of AI and frozen semen, selection of bulls for AI purpose.Management of breeding bulls, methods of semen collection in different domestic animals, semen evaluation including latest techniques for evaluation of motility and fertilization.Ideal extenders, extenders for liquid semen.Preservation of semen at various temperatures.Processing and preservation of liquid semen.Extenders for frozen semen, principles and techniques of semen freezing. Cold shock and ultra-low temperature shock. Cryoprotectants.Semen additives.Evaluation of frozen semen.Transport and storage semen.Handling of frozen semen, Liquid nitrogen and its containers.Insemination techniques.Estrus and estrus detection tools, Planning and organization of semen bank.

Unit 8 : Reproductive Technology

Synchronization of oestrous cycle in domestic animals, control of ovulation. Embryo transfer technology – History, advantages and disadvantages, superovulation, collection, evaluation, preservation and transfer of oocytes / embryos.History of in vitro maturation and fertilization.Recovery of oocytes in vitro and in vivo, maturation, fertilization, culture, evaluation, preservation and transfer of oocytes / embryos.Micromanipulation of embryos.Embryo splitting and cloning. Stem cells and production of transgenic animals. Sex determination and gene insertion.Establishment of laboratory for ETT, IVM, IVF and IVC.Use of Ultrasonography, laparoscopy and ovum-pick technology in farm animals.

Unit 9 : Infertility in Cows and Buffaloes

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

Unit 10 : Reproduction and Infertility in Ovine/Caprine

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

Unit 11 : Reproduction and Infertility in Swine

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

Unit 12 : Equine Reproduction

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

Unit 13 : Canine and Feline Reproduction

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

29 VETERINARY SURGERY & RADIOLOGY/VETERINARY SURGERY

Unit 1: General Surgery

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

Unit 2 :Anaesthesia

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

Unit 3 : Radiology

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

Unit 4 :Orthopaedics and Lameness

Physiological and biochemical considerations of bone. Osteogenesis and mineralization of bone. Bone research techniques.Circulation of long bones.Biomechanics of fractures. Etiology, classification and healing of fracture; factors affecting fracture healing. Complications of fractures and their management.Methods of internal and external fixations of fracture and factors

governing selection of fixation methods.Effect of various internal fixation methods on physiology and blood circulation of bone. Bone grafts. Metallic and non-metallic materials in bone surgery and their biological behaviour.Surgical affection of vertebral column.Etiology, pathophysiology, diagnosis and treatment of affections of bones and joints.Technique of arthroscopy.Lameness and allied surgical conditions of fore and hind limbs. Various foot diseases. Affections of tendons, ligaments and their management.Relationship between conformation of the limbs, foot and its axis to soundness. Soundness and examination of horse for soundness

Unit 5 : Surgery of Head and Neck Region

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

Unit 6 : Thoracic Surgery

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

Unit 7 : Abdominal and Pelvic Surgery

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

30 VETERINARY ANATOMY/VETERINARY ANATOMY & HISTOLOGY

Unit 1: Comparative Osteology and Arthrology

Structure, chemical composition and classification of bones, Bones of appendicular and axial skeleton of ox as a type and their comparison with those of horse, dog, pig and poultry, classification and detailed study of different joints of the body. Study of various indices for estimating race, sex and age of different animals.Basics of biomechanics of the locomotor system, Radiography of normal and developing bones.

Unit 2: Comparative Splanchnology

Descriptive anatomy of various organs of digestive system and associated glands, respiratory system and associated glands and urinary system and associated glands of ox and their comparison with those of horse, dog, pig and poultry. Study of boundaries of thoracic, abdominal and pelvic cavities, pleura and peritoneum and their reflection. Complete study of various organs and associated glands of male and female genital systems, surgical sites for various operations and clinically significant areas for performing auscultation, percussion and for carrying out surgical procedures such as laryngotomy, oesophagotomy, gastrotomy, rumenotomy, cystotomy, urethrotomy, caesarian section, exploratory laparotomy, mammectomy, thoracotomy, thoracocentesis, etc.

Unit 3: Myology, Angiology, Neurology and Aesthesiology of Ox

Classification of muscle fibres, origin, insertion and relations of muscles of different body parts. Topographic anatomy of the vascular system comprising of heart, arteries, veins and lymphatics.Study of various components of central nervous system, peripheral nervous system and autonomic nervous system. Complete study of the gross anatomy of various sense organs. Study of different nerve blocks, injections in different species of domestic animals, sites and enucleation of eyeball.

Unit 4: Histological and Histochemical Techniques

Preparation of tissues for light microscopy using different fixatives, different staining methods for routine light microscopy, frozen sectioning techniques and staining methods for enzymes, carbohydrates, lipids, proteins, pigments etc. Silver staining techniques for nervous tissue.

Unit 5: General and Systemic Histology and Ultrastructure

General: Light and ultra-structural details of animal cell, epithelial tissue, muscular tissue, connective tissue and nervous tissue. Systemic: Light and ultrastructure of different organs of digestive system, respiratory, lymphoid organs, endocrine organs, cardiovascular system, urogenital system, different sense organs, integumentary system and nervous system of ruminants with differential features among domestic animals.

Unit 6: Developmental Anatomy

Gametogenesis, fertilization, cleavage and gastrulation, development of foetal membranes and placenta in domestic animals, histogenesis of nervous system, sense organs, endocrine organs and cardiovascular system, embryonic development of digestive, respiratory, urogenital and musculoskeletal system.

Unit 7: Principles and Applications of Biomechanics

Biomechanics, its definition and scope with reference to anatomy and physiology of domestic animals and musculo-skeletal dynamics. Locomotion and clinical applications, biomechanics of cortical and trabecular bones, biomechanics of fracture fixation, instrumentation and techniques in locomotion and their application in lameness.

Unit 8: Avian Anatomy

Gross and microscopic features of different body systems of domestic fowl.

Unit 9: Neuroanatomy

Gross and microscopic anatomy of the brain and spinal cord, various cranial and spinal nerves along with their associated nuclei and ganglia, motor and sensory pathways, different ascending and descending tracts of brain and spinal cord and autonomic nervous system.

Unit 10: Endocrine Anatomy

Advanced gross and microscopic anatomy of the hypothalamus and pituitary gland, thyroid, parathyroid, thymus, adrenal glands, islets of Langerhans, pineal body and other tissues associated with endocrine secretions.

Unit 11: Theory and Applications of Electron Microscope

Introduction and principles of electron microscopy, methods for transmission electron microscopy and scanning electron microscopy.

Unit 12: Histoenzymology and Immunocytochemistry

Classification of enzymes – principles of enzymes, histochemistry methods; Substrates – combination–coupling azo-dye methods –capture reagents, localization of enzymes and controls in enzyme histochemistry. Fluorescence microscopy in enzyme histochemistry, immunohistochemistry- principles and techniques.

Unit 13: Applied Embryology and Teratology

Principles of experimental embryology and teratology, factors affecting the developmental mechanisms of embryo. Use of organizer implants, chemical and hormonal preparations in the developmental models and available literature on teratogenic experimentation.

Unit 14: Functional Veterinary Anatomy

The relationship of structure to form and function, the relationship of structure for adaptation and behaviour and in relation to clinical conditions/ applications.

Unit 15: Gross Anatomy of Laboratory Animals

Study of different organs of digestive system of different laboratory animals, detailed study of urinary, male and female reproductive systems of different laboratory animals, complete study of respiratory system of different laboratory animals, study of organs of circulation and nervous system of different laboratory animals. Descriptive anatomy of endocrine glands of different laboratory animals.

31 VETERINARY PHYSIOLOGY/ANIMAL PHYSIOLOGY

Unit 1: Cellular Basis of Animal Physiology

Animal cell ultra-structure, composition and functions. Physio-chemical laws and membrane phenomena. Body fluid and its dynamics. Transport through biological membranes.

Unit 2: Blood and Circulation

Composition of blood, structure & functioning of its constituents. Hematopoiesis. Blood coagulation and anticoagulants. Hemoglobin and its polymorphism. Anaemias. Reticulo-endothelial System. Body defense mechanism and immunogenesis. Electrophysiology of heart. Electro-cardiography – Principles and interpretation. Hemodynamics and concerned biophysical principles. Capillary fluid exchange, microcirculation 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.

Unit 3: Respiration

Mechanics of respiration. Neural and chemical control of respiration. Lung capacity and volumes. Gaseous transport and exchange. Hypoxia. Physiology of hypo-barrism and high altitude. Work and exercise physiology.

Unit 4: Excretion

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

Unit 5: Digestion

Control of motility and secretion of alimentary canal. Gastric hormones and reflexes in the control of digestive functions. Control of rumen motility. Digestion in ruminant and monogastric animals. GI motility and absorption from rumen and the digestive tract. Manipulation of rumen microflora to enhance fibre digestion and microbial protein synthesis. Nitrogen recycling and rumen bypass mechanisms. Post-ruminal digestion. Physiology of rumen disorders.

Unit 6: Muscle Physiology

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

Unit 7: Nervous System

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

Unit 8: Endocrinology

Hormones. Hormone receptors. Mechanism of hormone action at cellular and subcellular levels. Feedback control of hormone secretion. Hypothalamic – hypophyseal axis. It should include (i) Hypothalamic – hypophyseal axis controlling secretions from thyroid, parathyroid, adrenal and gonads, (ii) Endocrine control of general metabolism. Hypothalamic releasing and inhibiting factors. Pineal gland and its hormones. Hormones of hypophysis and all other endocrine glands. Mechanisms of different hormone actions. GI hormones. Endocrine disorders.

Unit 9: Reproduction and lactation

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

Unit 10: Physiology of Growth

Concept and definition. Growth regulation and factors affecting prenatal and post-natal growth. Role of growth in production. Growth curve and growth measurement, body conformation.

Unit 11: Climate Physiology

Physiology of climatic stress. Adaptation and acclimatization. Effects of stress on production and reproduction. Neuro-hormonal regulation of body temperature in homeotherms. Mechanism of adaptation. Photoperiodicity and biological rhythms. Design of shelters / animal houses for different class of livestock for different climate conditions. Heat stress alleviation tools, physiological and biochemical markers of thermal stress

32 VETERINARY BIOCHEMISTRY/ANIMAL BIOCHEMISTRY

Unit 1

Scope of Biochemistry and molecular biology in animal sciences. Structural and functional organization of prokaryotic and eukaryotic cells, viruses and bacteriophages. Compartmentalization of metabolic processes within the cell and fractionation of subcellular components. Structure and functions of biomembranes with special reference to active transport of ions and metabolites. Chromatin structure. Molecular aspects of cell division and cell cycle. Cellular regulation, development and differentiation. pH, water, Henderson-Hasselbalch equation, buffers, Extra and intracellular communication.

Unit 2

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

Unit 3

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

Unit 4

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, biological oxidation, respiratory chain and oxidative phosphorylation. Citric acid cycle and ATP generation. Glycolysis, Kreb’s cycle,pentose phosphate pathway and gluconeogenesis, cori cycle, glycogenolysis 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 determination, 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

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

Fundamental principles of nutrition, nutritional requirements, balanced diet, nutritive value of foods, importance of dietary fiber, assessment of protein quality, deficiency diseases and metabolic disorders; diabetes, food toxins; 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. Feedback mechanisms. Metabolic function of different hormones and associated disorders due to hypo or hyper secretions of major endocrine glands viz. pituitary, thyroid, adrenal, pancreas and gonads. Growth factors and their role.

Unit 8

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

Unit 9

Basic principles and use of latest photometric, chromatographic, electrophoretic and radioisotopic methods of biochemical analysis. Chromatography: partition, ion-exchanges, adsorption and affinity, TLC, HPTLC, HPLC, Gel Filtration and GLC. Electrophoresis: PAGE, SDG PAGE, agarose gel electrophoresis and isoelectrofocusing; Blotting techniques; Electroblotting, Northern, Southern and Western blotting; Radiotracer techniques: beta and gamma emitters and their detection, solid and liquid counting, autoradiography and phosphor image analysis, isotope dilution technique; Binding assays: RIA and ELISA; Spectroscopy: UV-visible, fluorescence, ORD, CD, NMR, ESR and Mass; PCR & RT-PCR. 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, hormones, vitamins and other biochemical constituents with special reference to disease diagnosis in domestic animals.

Unit 10

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

Unit 11

Overview of the immune system, cells and organs of immune system, Innate and adaptive immune system Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cell epitopes, structure and function of antibody molecule, .generation of antibody diversity, monoclonal antibodies, antibody engineering, antigen-antibody interactions, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and Tcellreceptors, humoral and cell-mediated immune responses, primary and secondary immune modulation,the complement system, Toll-like receptors, cell-mediated effector functions, cytokines, Hypersenstive reaction, autoimmunity and vaccines.

33 ANIMAL BIOTECHNOLOGY

Unit 1: Biomolecules and their Interaction Relevant to Biology

Structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). Basics of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes. Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds). Types of nucleic acids (helix A, B, Z DNA), (types of coding and noncoding RNA). Stability of proteins and nucleic acids. Metabolism of carbohydrates, lipids, amino acids and nucleotides.

Unit 2: Cell Biology

Membrane structure and function (Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes). Structural organization and function of intracellular organelles (Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility). Organization of genes and chromosomes in Bacteria and eukaryotes (Operon concept in bacteria, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, mobile genetic elements). Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle). Specialised cell and tissue culture in animal science: Sperm cell Oocyte. In-vitro fertilization. Transgenesis. Stem cell: Embryonic and somatic stem cell. Microbial Physiology (Growth yield and characteristics, strategies of cell division, stress response)

Unit 3: Fundamental Cellular Processes

DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific and cre lox recombination). RNA synthesis and processing (transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport). Protein synthesis and processing (Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post- translational modification of proteins). Control of gene expression at transcription and translation level (regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing). Epigenetic regulation of gene expression.

Unit 4: Cell Communication and Cell Signalling

Cell signaling Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant twocomponent systems, light signaling in plants, bacterial chemotaxis and quorum sensing. Cellular communication Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. Cancer Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth. Cellular and viral oncogenes. Innate and adaptive immune system Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cell epitopes, structure and function of antibody molecules. generation of antibody diversity, monoclonal antibodies, antibody engineering, antigen-antibody interactions, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, humoral and cell-mediated immune responses, primary and secondary immune modulation, the complement system, Toll-like receptors, cell-mediated effector functions, inflammation.

Unit 5: Molecular Biology and Recombinant DNA methods

Basics of DNA, RNA and Proteins: Isolation and purification of RNA , DNA (genomic and plasmid) and proteins, different separation methods. Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels. Gene manipulation: Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. Expression of recombinant proteins using bacterial, animal and plant vectors. Isolation of specific nucleic acid sequences. Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms. Sequencing: Protein sequencing methods, detection of post translation modification of proteins. DNA sequencing methods, strategies for genome sequencing and Next Generation DNA sequencing principles. Gene expression: Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques. DNA fingerprinting, RFLP, RAPD and AFLP techniques. Recombinant vaccine and vaccine based on pathogen genome.

Unit 6: Animal Tissue Culture and Hybridoma Technology

Development of cell (tissue) and organ culture techniques. Nutrient requirements of mammalian cells. Media for culturing cells. Growth supplements. Primary cultures. Established cell lines. Stationary, Roller and Suspension culture techniques. Large-scale production of cells using bioreactors, microcarriers and perfusion techniques. Characterisation and maintenance of cells, karyotyping, cryopreservation and revival. Detection of contaminants in cell cultures. Isolation and culture of lymphocytes. Application of cell and organ cultures. Micromanipulation of cells. Cell cloning. Cell fusion and Somatic cell hybrids. Principles and methods of hybridoma technology. Production and characterization of monoclonal antibodies.

Unit 7: Embryo Transfer and Related Techniques

Induction of superovulation. Embryo collection and evaluation. Embryo splitting. Embryo sexing. Embryo transfer. Advantages of embryo transfer in farm animals. In vitro fertilization. Embryo cloning. Nuclear transplantation. Production of transgenic animals and gene farming. Identification and transfer of gene influencing production and disease resistance.

34 DAIRY CHEMISTRY

Unit 1

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

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

Unit 2

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

Unit 3

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

Unit 4

Milk adulteration and detection methods; Estimation methods for antibiotics, pesticides, heavy metals, lactose, lactate, protein, total solid, fat, salt, vitamin C, calcium, phosphorous, iron, citric

acid in milk and milk products. Estimation of vitamin A, total phospholipids and free fatty acids in ghee.Estimation of starch in food.Measurement of BOD and COD in dairy waste.

Unit 5

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

Unit 6

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

Unit 7

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

Unit 8

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

Unit 9

Definition of quality, quality control and assurance. Standards, statutory and voluntary organization.Role of international organisations such as ISO, IDF, CAC, AOAC, WTO and national organisations like BIS, FSSAI, AgMark and APEDA in dairy industry, Quality Council of India (QCI), Export Inspection Council (EIC); guidelines for setting up quality control laboratory and chemical safety aspects; sampling of milk and milk product; food labeling

guidelines. FSSAI, AGMARK and BIS standard for milk and milk products Agro-chemicals/veterinary drug residues; occurrence of pesticide residues, antibiotic residues, heavy metals etc in dairy products, Laboratory auditing, Food traceability systems, Food recall and withdrawal.

Unit 10

Spectroscopy – UV – Vis spectrophotometry, IR. Separation techniques : TLC, GLC, HPLC, Ion exchange, size exclusion, affinity chromatography, ultracentrifugation. Ultrafiltration. Precipitation by salting out agents. Electrophoresis – PAGE, SDS-PAGE, Immuno based analytical techniques such as ELISA & Lateral flow assay. Flame photometry, AAS and potentiometry (principle, various electrodes, electrometric measurements of pH, buffers)

35 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. Role of Food additives and processing aids.

Unit 2: Technology of Foods of Plant Origin

Fruits and Vegetable Processing: Post harvest handling and storage of fresh fruitsand vegetables. Preparation of fruits and vegetables for processing.Minimally processed products.Cold chain logistics. ZECC (Zero Energy Cool Chambers), 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. Role of membrane technology in juice processing.Chemistry and manufacture of pectin, role of pectin in gel formation and products like jellies, jams and marmalades.
Technology of Preserves, Pickles, Chutneys and Sauces. Nature and control of spoilage in these products, Re-structured fruits and vegetables, Byproducts utilization infruits 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. Spent coffee ground. Medicinal and aromatic plants: their therapeutic values. Spice processing viz. cleaning, grading, drying, grinding, packaging and storage. Oleoresins and essential oils.

Food grain Processing: 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 β-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 their importance in Indian diet. Milling and processing of pulses viz. germination, cooking, roasting, frying, canning and fermentation. Use in traditional products, protein concentrates and isolates. Modified starches and proteins. Oilseeds: edible oilseeds, composition and importance in India. Oilseed processing.Oil extraction and its processing, byproducts of oil refining. Production, packaging and storage of hydrogenated vegetable fat (Vanaspati), peanut butter, protein concentrates, isolates and their use in high protein foods. Soybean protein concentrates and isolates.Soy lecithin extraction.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

Technology of Milk and Milk Products: Milk and Milk production in India.Importance of milk processing plants in the country.Handling and maintenance of dairy plant equipment.Dairy plant operations viz. receiving, separation, clarification, pasteurization, standardization, homogenization, sterilization, storage, transport and distribution of milk. Problems of milk supply in India. UHT, toned, humanized, fortified, reconstituted, recombined and flavoured milks.Technology of fermented milks. Milk products processing viz. cream, butter, *ghee*, Cheddar and mozzarella cheeses, condensed milk, evaporated milk, whole and skimmed milk powder, malted food, ice-cream, butter oil, *khoa*, *channa*, *paneer*and similar products. Concept of composite dairy foods.Judging and grading of milk products. Cheese and dairy-based fat spreads. EMC (Enzyme modified cheese), Enzymes in dairy processing. Sanitization *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. FSSAI specifications and standardsof milk and milk products.Dairy plant sanitation and waste disposal.

Technology of Meat / Fish / Poultry Products: Scope of meat, fish and poultryprocessing 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 affecting quality.Quality

measurement.Preservation of eggs using oil coating, refrigeration, thermo stabilization and antibiotics.Packing, storage and transportation of eggs.Technology of egg products viz. egg powder, albumen, flakes and calcium tablets. Industrial and food uses.Physiologicalconditions 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 including food recall regulations. US-FDA, EFSA, ISO-9000 and FSSAI.Food adulteration.Sensory evaluation, panel screening, selection methods.Sensory and instrumental analysis quality control.Quality control of food at all stages and ofpackaging materials.Non-destructive food quality evaluation methods.Biosensors and their use in quality evaluation of food products.Aspects of food safety.

Unit 5: Food Engineering/Packaging and Labeling

Unit operations of food processing viz. grading, sorting, peeling and size reduction machineries for various unit operations, energy balance in food processing.Functions and levels of food packaging.Packaging materials: properties and testing procedures.Metal cans: types, mechanism of corrosion and protective coatings. Packaging requirements and practicesof fresh and processed foods. Shelf life studies. Recent trends in packaging, aseptic, modified atmosphere, vacuum and gas packaging, active and intelligent/smart packaging, antimicrobial packaging, edible films and coatings, biodegradable and nanocomposite materials for food packaging. Food packagingand labeling requirements as per FSSAI regulations.Principles of package design.

Unit 6: Food Microbiology & Biotechnology

Fermentation technology, fermented food products (animal and plant based including cereal), microbial spoilage of foods, bacterial growth curve, hurdle technology.Role of biotechnology in productivity of plants, livestock and microbes of 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, Single cell oils, Food contaminants viz. aflatoxins.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.

Unit 8: Consumer Sciences/Food Product Development/Health Foods

Socio-cultural, psychological and economical consideration for food appearance, domestic and export marketing.Consumer trends and their impact on new product development.Product development viz. to conceive ideas, evaluation of ideas, developing ideas into products, test marketing and commercialization.Role of food in human nutrition. Nutritional disorders, natural contaminants and health hazards associated with foods. Diet therapy.Therapeutic / Engineered / Fabricated and Organic foods/ Nutraceutical and functional foods.FSSAIregulations related to food fortification,nutraceuticals and organic food.

36 DAIRY MICROBIOLOGY

Unit 1: Scope and History of Microbiology

Scope and history of Microbiology; Diversity and taxonomy of microorganisms; Cell wall, structure, synthesis and inhibition, cell membrane, ribosomes, capsule, flagella, pili; Principles and functions of light, phase, fluorescent and electron microscopes; Fungi, viruses, viriods, prions; Bacterial growth: phases and kinetics, factors affecting bacterial growth, growth measurement; Bacterial nutrition and growth factors; Active and passive transport, Electron transport chain; Metabolism and bioenergetics, respiration and fermentation, bacterial photosynthesis.

Unit 2: Microbial Genetics

DNA and RNA, DNA structure and replication; Gene Expression and its regulation in Prokaryotes – Transcription, Genetic Code, Translation; Negative and positive regulation of gene expression; Operon Models; Mutations, physical and chemical mutagens, Damage and Repair; Plasmids, transposable elements, Insertion sequences; Bacterial Recombination; Recombinant DNA technology - Restriction enzymes, Plasmid Vectors, PCR and Real Time PCR, Application of genetic engineering in dairying.

Unit 3: Microbiological Quality of milk

Microbes in milk, sources of contamination, microbiological changes in milk during production and processing, mastitis; Antimicrobial systems in milk, Role of psychrotrophic, mesophillic, thermophilic and thermodurics in spoilage of milk; Microbiological defects and their control; Food poisoning, infections, toxi-infections and pathogens associated with milk and milk products and their prevention; Biofilms, their role in transmission of pathogens and preventive strategies, Microbiological standards and quality of dairy products (cream, butter, dried and evaporated milk, sweetened condensed milk, frozen dairy products, and indigenous dairy products).

Unit 4: Microbiology of Processed Foods

Microbiology of processed foods; Thermal processes for shelf stable-products, low temperature food preservation, concepts in irradiation technology; Biopreservation, Bacteriocins, antimicrobial and antifungal substances; Intermediate moisture foods and hurdle concept, stress induced injury, drug resistance in pathogens, industrial strategies for safe foods; Methods for controlling spoilage of foods; New emerging methods of preservation; Active/intelligent and antimicrobial packaging, modified atmosphere packaging; Milk derived bioactive proteins and peptides; Microencapsulation, GM foods, Functional foods and nutraceuticals.

Unit 5: Starter Cultures and Probiotics

Lactic Acid Bacteria, characteristics of dairy starter organisms : *Lactococcus*,*Leuconostoc*, *Streptococcus, Pediococcus, Lactobacillus, Bifidobacterium, Enterococcus, Propionibacterium*; lactose, galactose and glucose metabolism, homo- and hetero-lactic fermentation, citrate

metabolism and formation of flavouring compounds, proteolytic systems and protein metabolism, Phenotypic and genotypic characterization of LAB; Adjunct starter organisms; Genetics of starter cultures: plasmids; genetic modification of starter cultures; single, mixed, multiple strain, mesophilic, thermophilic starters, propagation and preservation, concentrated and super-concentrated starters, bulk culture systems; Inhibition of LAB by antibiotics, bacteriocins; immunoglobulins and bacteriophage; starter cultures of fermented milks: lactic, yeast-lactic, mould-lactic fermented milk products - dahi, lassi, yoghurt, acidophilus milk, cultured buttermilk, koumiss, kefir, starter cultures of cheeses, microbiology of fresh and ripened cheeses, accelerated cheese ripening, microbiological spoilage and safety of fermented dairy products, Nutraceutcials, probiotics and functional fermented foods (dairy and non-dairy), Mechanism of action of probiotics and their health benefits, and regulations

Unit 6: **Quality Assurance**

Microbiological criteria; Sampling methods; Establishment of microbiological standards, guidelines and specifications for milk and milk products; Indicator Organisms; Selection criteria -for -their -use as quality and safety indicators; Conventional and rapid detection methods including commercial kits for indicator and pathogenic bacteria; Characteristics, classification and components of microbial bio-sensors; detector system; Application of microbial bio-sensors in monitoring pathogens, antibiotic and pesticide residues and aflatoxin Ml; Quality assurance in dairying; Bio-safety levels; Standard microbiological practices.

Unit 7: **Fermentation Technology**

Fermenter/ Bioreactor design, Types of fermentation, submerged/solid state, Batch/ continuous fermentation, Fermentation kinetics, Product recovery, Immobilization, Downstream processing, Industrial production of Lactic acid, Industrial production of Penicillin, Industrial production of enzymes, Beta- galactosidase, amino acids, vitamins, ethanol and SCP.

37 FOOD SAFETY & QUALITY ASSURANCE

Unit 1: **Basic Concepts of Food Safety and Quality Assurance**

Definition and Terminology; Current changes in global food safety standards and their harmonization; HACCP concept, principle and application in food industry; General Principles, Fundamentals and Standards requirements of QMS (ISO: 9000:2000); TQM tools and techniques; Biosafety concept, principles and safety levels; EMS/Laboratory Management System-ISO: 17025; NABL Accreditation of Food Laboratory; Statistical Quality Control.

Unit 2: **Concept of Risk Analysis**

Microbiological risk profile of pathogen/toxins, ICMSF Risk Ranking of Dairy Products; Risk Management Issues and Control Strategies for dairy products; Food infection, intoxication and toxi-infection; Growth /survival of pathogens, their pathology of illness, mode of transmission, virulence and infectivity.

Unit 3: **General Principles of Food Law**

Integrated Food Law and its harmonization; Standards, Specifications and guidelines; 2 and 3 class sampling plan; FSSAI Microbiological criteria for different foods including dairy products; Conventional / rapid detection methods/commercial kits for hygiene and safety indicators; Bio-sensors and their current application in food safety evaluation.

Unit 4: **Food Microbiology**

Classification of food related microorganisms, Sources of contamination, Types of food spoilages of raw and processed fruits, vegetables, meat and fish and milk products, preservative principle, microbial defects and their control measures, Role of different Bacteria in food fermentation; Clean milk production and antimicrobial systems in raw milk; Microbiological aspects of bactofugation, thermization, pasteurization, sterilization, boiling, UHT, non-thermal processes and membrane filtration techniques; Microbiological quality of cream and butter, ice cream, evaporated and condensed milk, dried milks, infant dairy foods, heat desiccated, acid coagulated, fermented and frozen products.

Unit 5: **Chemistry of Milk and Milk Products**

Definition, composition and level of various constituents of milk; Physical properties of milk; Chemistry of major milk constituents- carbohydrates; proteins, enzymes, lipids, vitamins and salts; Effect of various processing variables on the constituents of milk; Chemistry of milk products; Composition and legal standards of milk and milk products; Reaction kinetics; Role of enzymes as a biological catalysts; Water activity and its role on shelf-life of milk products; Chemistry of oxygen in relation to auto-oxidation of milk fat, thermal oxidation; Emulsions,

foams, gels-their formation, structure and stability; Functional properties of major food ingredients- starch, proteins and lipids; Hydrocolloids and interactions with proteins; legal requirements for food colorants.

Unit 6: **Research Techniques**

Principles, theory and applications of spectroscopy - visible, infrared and ultraviolet; Chromatography - thin layer, gas liquid, high pressure liquid chromatography (HPLC), gel filtration, ion exchange and affinity; Electrophoresis (PAGE, SDS-PAGE); iso-electric focusing, ultra-centrifugation, potentiometry - pH meter and ion selective electrodes

38 DAIRY TECHNOLOGY

Unit 1: Technology of Milk and Milk Products

Status of dairy industry in India. Clean milk production, Milk procurement processes, Raw milk quality assessment and preservation, Physical properties and chemical composition of milk of cow, buffalo and other species of milch animals; their importance in milk processing. Principles, processes and advances of unit operations in milk and milk products processing, Special milks; Principles and processes of manufacture of fat rich dairy products, cheese and fermented dairy products, ice cream and frozen desserts, traditional Indian dairy products, concentrated and dried milks and dairy products, infant foods, dairy byproducts; Cleaning and sanitizationof dairy equipments.

Unit 2: Advances in Dairy Food Packaging

Status of current packaging; types of packaging materials; criteria for selection of proper packaging; testing of packaging materials; Adhesives; graphics; coding, and labeling used in food packaging; Protective packaging of foods; packaging of food products sensitive to oxygen, light, moisture; Active packaging; special problems in canned foods; Packaging of dairy products; packaging of convenience foods; Packaging of fats and oils; Modified atmosphere packaging, Controlled atmosphere packaging, Shrink and stretch packaging; Retort pouch technology, microwavable, biodegradable, and edible packages; Industrial packaging: unitizing, palletizing, containerising, distribution systems for packaged foods including prevention of shock damage to articles during transportation; Safety aspects of packaging materials; sources of toxic materials and migration of toxins into food materials.

Unit 3: Advances in Dairy Processing

Concentration processes and their impact on quality of finished products; Dehydration: advances in drying of milk and milk products; Freeze dehydration: physico-chemical changes and industrial developments; Glass Transition Temperature and its relevance to dried milks; Water activity; sorption behaviour of foods, energy of binding water, control of water activity of different milk products in relation to their chemical; microbiological and textural properties; hurdle technology and its application in development of shelf-stable and intermediate-moisture foods, Use of carbonation in extending the shelf life of dairy products. Alternate processes for dairy processing: Radiation preservation, microwave heating, ohmic heating, high pressure processing, pulse electric field, infra red heating, ultrasonic heating etc.; Current trends in cleaning and sanitization of dairy equipment; Automation, Ultrasonic techniques in cleaning; Bio-films; Bio-detergents, innovations in sanitizers - chemical, radiation; Mechanism of fouling and soil removal; Assessing the effectiveness of cleaning and sanitization of dairy equipment, Water conservation methods.

Unit 4: **Membrane Processing**

Classification of membrane processes, membrane hardware, design of membrane plants, modeling of ultrafiltration (UF) processes, mass transfer model, resistance model; membrane flouling-problem and treatment, cleaning and sanitization of different types of membranes. Factors affecting permeate flux during UF and reverse osmosis; energy requirements for processing of milk and whey. Preparation of special foods like lactose, low lactose powder and dairy whiteners, whey protein concentrates, casein and coprecipitates. Demineralisation: Importance, principles and processes; Functional properties of whey proteins (WPC & WPI), casein, co-precipitates and UF milk retentate and their modifications; Evaluation of functional properties of proteins.

Unit 5: **Rheology of Dairy Foods**

Principles of rheology; Rheological classification of Fluid Foods; Instruments for measuring rheological properties; Rheology of semi-solid and solid food; Rheological characterization of foods in terms of stress-strain relationship; Viscoelasticity; Transient tests - Creep Compliance and Stress Relaxation; mechanical models for viscoelastic foods: Maxwell, Kelvin, Burgers and generalized models and their application; Dynamic measurement of viscoelasticity. Large Deformations and failure in foods: Definitions of fracture, rupture and other related phenomena; Texture Profile Analysis; Instrumental measurements – Empirical and Fundamental methods; Rheometers and Texture Analyzers; Measurement of Extensional viscosity; Acoustic measurements on crunchy foods. Rheological and textural properties of selected dairy products: Measurement modes and techniques; Effect of processing and additives (stabilizers and emulsifiers) on food product rheology; Relationship between instrumental and sensory data.

Unit 6: **Functional Foods and New Product Development**

Definition, classes of functional foods; Dietary and therapeutic significance of dairy nutrients, bioactive components in dairy products; Food fortification, techniques for fortifying dairy foods with minerals and vitamins, High protein foods prospective nutraceuticals for fortification of dairy foods, Nutritional significance of dietary fibers, classes of dietary fibers, fortification techniques for fibers in dairy foods; Designing foods for different populations: Infant, geriatric, sports nutrition, foods for specific diseases; Principles and processes for reduced calorie and reduced sodium foods; Bio-flavours and flavour enhancers; Nutritional and therapeutic potential of herbs, phytochemicals, pre- and probiotics and technological interventions for their incorporation in dairy foods

Unit 7: **Biotechnology for Dairy Applications**

Development and impact of biotechnology on dairy and food industry; Principles of recombinant DNA technique; Microbial rennet and recombinant chymosin - characteristics and applications in cheese making; exogenous free and microencapsulated enzymes; Immobilized enzymes - their application in continuous coagulation of milk in cheese making; Enzyme modified cheeses (EMC) - their utilization in various food formulations; technological requirements of modified

micro-organisms for applications in cheese, Physiologically active bio-peptides/ nutraceuticals; protein hydrolysates - production, physico-chemical, therapeutic properties and application in food formulations; Enzymatic hydrolysis of lactose- batch and continuous; Microbial polysaccharides - their properties and applications in dairy foods; Production of alcoholic dairy beverages; Bio-sweeteners - Types, properties and their applications in dairy and food industry. Bio-preservatives - characteristics and their applications in enhancing the shelf life of dairy and food products.

Unit 8: **Technology of Food Emulsions, Foams and Gels**

Food dispersions; Food emulsions; Emulsifiers and their functions in foods; HLB concept for food emulsifiers; Emulsion formation and stability; Surfactants; Dairy based foams and their applications, structure of foams; Foam formation and stability; Theory of gel formation; carbohydrate and protein based gels; Gelled milk products. Structure of dairy based emulsions, foams and gels; Techniques for evaluating the structure of food emulsions, foams and gels; Advances in food gels (organogel, hydrogel and nanogel); Effect of stabilizers and/or emulsifiers on functional properties of dairy foods; Aerosols and propelling agents in foamed dairy products.

Unit 9: Legal and Quality Aspects for Milk and Milk Products

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

39 DAIRY ENGINEERING

Unit 1: Dairy and Food Engineering-I

Basics of fluid mechanics, pumps, Concept of rheology: ideal elastic, plastic and viscous behaviour, viscoelasticity, rheological properties, Food texture, Freezing, freezing curves, freezing time, freezing equipment, freeze drying, freeze concentration.

Unit 2: Evaporation and Drying

Evaporation techniques and evaporators, drying fundamentals and type of dryers, spray dryer, equipments for separation and product recovery.

Unit 3: Dairy and Food Engineering-II

Water activity and its measurement methods, water sorption isotherms, sorption hysteresis, IMF and their application; Permeability and shelf-life, permeability to gases and vapours, measurement methods, permeability of multilayer materials, Membrane types, properties and selection of membrane; microwave heating processes and parameters.

Unit 4: Thermal Engineering

Basics of thermodynamics and heat transfer,vapour and gas power cycles, fins, fin efficiency, effectiveness. Heat Exchangers: classification, LMTD, effectiveness-NTU approach, Fick's law of diffusion, equimodal diffusion, mass transfer coefficients. Dimensionless numbers used in heat and mass transfer.

Unit 5: Process Equipment Design

Dairy processing equipments, equipment for aseptic processing and packaging, Pressure vessels: codes and regulations, design for pressure and temperature, allowable stress, corrosion control, cylindrical and spherical shells, formed heads, reinforcement openings, tests and non-destructive examination, design and stress evaluation; milk storage tank: horizontal silos, vertical silos, insulated and un-insulated, nozzles and mountings; constructional features and material for high pressure vessels; multi shell construction; solid walled vessel; bracket support; leg support, skirt support, saddle support; construction codes and design considerations for heat exchangers.

Unit 6: Refrigeration Engineering

Vapour compression refrigeration system: major components and their different types; theoretical and actual vapour compression cycle; Effect of operating parameters on COP; multi-pressure commercial refrigeration systems; Vapour absorption refrigeration system. Heat Pumps: Design and construction of cold storage and air-conditioning systems: cooling loads and

calculation, Psychometry. Equipment selection, insulating materials, vapour barriers, Ice bank tank.

Unit 7 Instrumentation and Process Control

Elements of generalized measurement system, static and dynamic characteristics of instruments. Transducers for measurement of process variables like temperature, pressure, flow, level, consistency, pH and humidity. Indicating and Recording Devices: Digital indicators, strip and circular chart recorders. Principles of Automatic Process Control: Process characteristics, control system parameters, discontinuous, continuous and composite control modes, PLC.

40 FARM MACHINERY AND POWER ENGINEERING

Unit 1: Design of Tillage and Planting Machinery

Modern trends, principles, procedures, fundamentals and economicconsiderations for design and development of farm machinery. Design considerations, procedure and their applications in tillage andplanting machinery. Design of coulters, shares, mould boards, landside, frog, jointer.Forces acting on plough bottom and their effect. Draft on ploughs.Design of disk ploughs, concave disk working tools and forces acting on discploughs.Machines and implements for surface and inter row tillage, peg toothed harrow, disk harrows, graders, rollers, cultivators, design of V shaped sweeps -rigidity of working tools. Rotary machines, trajectory of motion of rotary tillertynes, forces acting and power requirement. Machines with working tools executingan oscillatory motion.Methods of sowing and planting. Grain hoppers, seed metering mechanism, furrow openers and seed tubes. Planting and transplanting, paddy transplanters and potato planters.

Unit 2: Design of Plant Protection and Harvesting Equipments

Modern trends, principles, procedures, fundamentals and economicconsiderations for design and development of plant protection and harvestingmachinery. Machines for fertilizer application and discs type broadcasters. Organic fertilizer application, Properties of organic manure and spreading machines. Liquid fertilizer distributors. Function of sprayer, atomization principles, hydraulic sprayers. Air blast spinning disc and electrostalic sprayers. Design of sprayercomponents, pumps, pressure vessel, nozzle, materials of construction. Spraydroplets and distribution pattern. Spray application to orchards. Physico-mechanical properties of grass and cereal stalks, resistance to cutting, speed of cutting of stalks, cutting angle of the knife segment. Kinematics of thedrive mechanisms of cutting equipments. Mowers, Design and construction, mowers with rotary cutting units, mower pick up chopper and loader.Grain harvesting, combines and its features. Threshing unit, types and separation process. Straw walker, separation of straw in oscillating straw walker.Grain cleaning and grading and principal parameters.Root crop harvesting, potato other root crop.

Unit 3: Testing and Evaluation of Agricultural Machinery

Types of tests; test procedure, need for testing & evaluation of farm equipments and standardization of testing machinery, available national and international codes. Need of test codes and advantages of certification. Measurement & calculation of operating speed, wheel slip, draft of manual, trailed & mounted implements, fuel consumption, field capacity, Soil moisture, bulk density, soil inversion, soil pulverization, size & shape of furrow, field efficiency, calibration of test equipment and its usage limitations.Prototype feasibility testing and field evaluation. Laboratory and field testing ofprimary & secondary tillage equipment. Test code for performance testing for tractors & power tillers - evaluation and interpretation of results. Dynamometers. Review and interpretation of test reports for selected farm machinery.

Unit 4: Tractor Design Principles

Functional Requirement and Limitations, Systems and power outlets, Technical specifications of tractors available in India and modern trends in tractordesign and development. Special design features of tractors in relation to Indianagriculture.Parameters affecting design of tractor engine and their selection. Design of fuelefficient engine components and tractor systems like transmission, steering, front suspension, hydraulic system. Studying tractor performance. Tractor mechanics, Ideal Analysis with and without losses, Engine Performance, Tractor Drawbar performance. Tractor Performance on a Firm Surface and soft soil. Rolling resistance. Tire selection. Hitching and mechanics of the tractor chassis, Weight transfer. Computer aided design and its application in agricultural tractors. Tractorimplements matching and operation.

Unit 5: Ergonomics and Safety in Farm operations

Ergonomics, scope, concepts and areas of application. System concept to humanfactors. Human factor in system development, basic processes in systemdevelopment. Human Skeletal system, muscle, structure and function. Muscle metabolism. Direct and indirect calorimetry Physiological stress and measurement of human energy expenditure during rest and physical activities. Work physiology invarious agricultural tasks. Mechanical efficiency of work, fatigue and shift work. Anthropometric data and measurement techniques, joint movement and method of measurement, analysis and application of anthropometric data in design of foot and hand controls andoperator' seat for tractors and agricultural equipment. Measurement of physical and mental capacities. Effect of illumination, noise, vibration and dust on work performance and health of workers. Thermal and cold stress and its effect on human performance. Field of vision and colour discrimination. Work psychology, basic concepts, Subjective rating scales and quantification techniques. Safety standards at work place. Accidents and prevention. Occupational health hazards of agricultural workers.

Unit 6: Soil Dynamics in Tillage and Traction

Dynamic properties of soil, stress strain relations and distribution, soil strength. Yield in soil, shear, compression, tension and plastic flow. Rigid body soil movement, momentum, friction, adhesion and absorption. Dynamic versus static properties. Dynamic parameters, measuring in dependent parameters and composite parameters. Measuring gross dynamic behavior and rupture. Mechanics of tillage tools: The reaction of soil to tillage tools, mechanics of simple reactions, soil behavior in simplified systems, geometry of soil toolsystems, mechanics of complex reactions. Dimensional analysis of different variables related to soil-tyre system; soil vehicle models; mechanics of steering of farm tractor; special problems of wet land traction and floatation. Introduction of traction devices, tyres-types, function & size, their selection; mechanics of traction devices. Deflection between traction devices and soil, slippage and sinkage of wheels, evaluation and prediction of traction performance. Design of traction and transport devices - Soil compaction by agricultural vehiclesand machines.

Unit 7: Manufacturing Technology

Specification of materials, surface roughness, production drawing, computer aided drawing heat treatment, 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, welding processes, testing of joints and metallurgy.

Unit 8: Instrumentation and Measurement Techniques

Mechanical measurements, sensors and transducers, application of electrical strain gauges, signal transmission and processing, dynamic measurements; measurement of temperature, pressure, strain, force, torque, power vibrations etc.; determination of calorific value, fluid flow rates etc., signal conditioning and monitoring, data acquisition and storage.

Unit 9: Energy in Agriculture

Conventional and renewable energy sources in agriculture; solar radiation and its measurement; characteristics of solar spectrum; solar energy collection, storage and applications; 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, solvents of amino 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.

41 SOIL AND WATER CONSERVATION ENGINEERING/SOIL AND WATER ENGINEERING

Unit 1: Groundwater Development, Wells and Pumps

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

Unit 2: Open Channel Hydraulics

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

Unit 3: Soil, Plant, Water and Atmosphere Relationship

Soil physical characteristics influencing irrigation. Soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water. Soil irrigability classifications, factors affecting water storage profile. Determination of soil water content, computation of soil water depletion, soil water potential and its components, hydraulic head. Field water budget: water gains and water losses from soil, deep percolation beyond root zone, capillary rise. Evapotranspiration (ET) and irrigation requirement, critical stages of crop growth in relation to irrigation. Irrigation scheduling. Plant water relations, concept of plant water potential. Water movement through soil plant atmosphere system. Uptake and transport of water by roots. Management strategies to improve crop productivity under limited water supplies. Contingent crop plans and other strategies for aberrant weather conditions. Cropping patterns, alternate land use and crop diversification in rainfed regions.

Unit 4: Watershed Hydrology

Hydrologic cycle, precipitation, infiltration and surface runoff. Measurement and analysis of hydrologic data. Intensity duration frequency analysis**.** Hortonian and saturation overland flow theories, partial source area concept of surface runoff generation. Rainfall and run off relationships, stream gauging and runoff measurement. Different methods of surface runoff

estimation, hydrographs, S-hydrograph, IUH, Synthetic hydrograph, unit hydrograph theory and its application. Concept of hydrologic flood routing:channel and reservoir routing.

Unit 5: Soil and Water Conservation

Soil erosion and types of erosion. Quantitative soil loss estimation, universal soil loss equation and its subsequent modifications. In-situ measurement of soil loss. Field practices in controlling erosion by water and wind. Soil and Water conservation structures and their design. Gully control: vegetative measures, temporary, semi-permanent and permanent structures for gully control and reclamation and their design. Design and construction of farm pond and reservoir. Seepage theory. Design of earthen dams and retaining walls, stability analysis on slopes. Application of RS and GIS in soil and water conservation.

Unit 6: Watershed Management

Watershed concept, Identification and characterization of watersheds. Surveying: topographic, reconnaissance. Soil types and depth properties. Soil maps and their scales. Meteorological observations, monitoring, reclamation and conservation of agricultural and forest watersheds, hill slopes and ravines. Hydrological and geomorphological characteristics of watersheds. Land capability and irrigability classification and soil maps. Principles of watershed management. Development of watershed management plans, its feasibility and economic evaluation. Land levelling and grading, Criteria for land levelling, design methods. Machineries and equipments for land levelling.

Unit 7: Irrigation Water Management

History of irrigation in India. Management of irrigation water. Major irrigation projects in India. Crop water requirements. Soil water depletion, plant indices and climatic parameters. Methods of irrigation, surface methods, overhead methods, Pressurized irrigation system such as drip and sprinkler irrigation. Merits and demerits of various methods. Hydraulics of furrow, check basin and border irrigation, Hydraulics and design of pressurized irrigation systems. Irrigation efficiency and economics of different irrigation systems. Agronomic considerations in the design and operation of irrigation projects, characteristics of irrigation and farming systems affecting irrigation management. 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.

Unit 8: Management of Degraded, Waterlogged and Other Problematic Soils and Water

Problem soils and their distribution in India. Excess salt and salt tolerant crops. Hydrological imbalances and their corrective measures. Concept of critical water table depths for crop growth. Contribution of shallow water table to crop water requirements. Management strategies for flood

prone areas and crop calendar for flood affected areas. Crop production and alternate use of problematic soils. Agricultural field drainage, drainage techniques and theory of flow in saturated soil. Flow net theory and its application. Drainage investigations. Drainage characteristics of various type of soils. Water table contour maps and isobaths maps. Drainage coefficient. Steady state flow into drains. Hooghoudt Equation.Design and installation of surface and subsurface drainage system. Interceptor and relief drains and their design. Drain pipe and accessories. Drainage requirements of crops. Drainage in relation to salinity and water table control. Biodrainage.

Reclamation of ravine, waterlogged, swampy areas and polders. Salt-affected soils and their reclamation. Command area development organizational structures and activities. Irrigation water users association concept and responsibilities. Environmental considerations in land and water resources management.

Unit 9: Protected Cultivation

Production technology for vegetables under Protected conditions in soil and soilless media - hydroponics and aeroponics. Types of Green house - orientation and layout. Construction of Green house. Solar radiation – Diffused radiation – Inside and Outside green house radiation. Naturally ventilated and forced ventilated system. Automation for climate control in protected structures. Thermal Modeling of greenhouse Environment for protected cultivation.

42 AGRICULTURAL PROCESSING AND FOOD ENGINEERING

Unit 1: Engineering Properties and Quality of Biomaterials

Engineering Properties and Quality of Biomaterials Uniqueness of bio-materials, Importance of engineering properties of biological materials, Physical characteristics viz. shape, size, volume, density, porosity, surface areas, Frictional characteristics viz., rolling resistance, angle of repose. Properties of bulk particulate solids viz. specific surface area, mean diameter, flow rate, Aerodynamics characteristics viz. drag coefficient and terminal velocity. Pressure drop through packed beds, Thermal properties viz. specific heat, thermal conductivity, thermal diffusivity, Dielectric properties viz. dielectric and microwave radiation, dielectric constant, energy absorption, heating, Optical properties and transmittance and reflectance, Rheological properties and stress-strain-time relationship, rheological models, visco-elasticity, Hertz's theory of contact stresses, Food Quality and BIS specifications for quality of food materials, milling quality analysis, cooking and baking qualities, Organoleptic and sensory evaluation of product quality. Determination of protein, oil content, carbohydrates, colour, hardness, texture, nutritive value, bio- availability and microbial loads, Maturity, ripening stages and indices of fruits and vegetables.

Unit 2: Heat and Mass Transfer

Basic laws of thermodynamics, thermodynamic properties and processes, energy equations, heat, work, heat engine, heat pump, refrigeration and steam tables. EMC, sorption and desorption isotherms, water activity and psychrometry. 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.

Unit 3: Post Harvest Unit Operations

Grading, cleaning, washing, sorting, shelling, dehusking, decortication, milling, polishing, pearling, drying (evaporative, osmotic and freeze drying), pasteurization and sterilization of liquid foods, kinetics of microbial death, size reduction, cryogenic grinding, granulation, crystallization, membrane separation processes *viz.* micro filtration, ultra-filtration, nano-filtration, reverse osmosis; Evaporation, Distillation, Mixing, coagulation, mechanical separation processes, *viz.* sedimentation, clarification filtration, pressing, expelling, leaching, extraction, pelleting, extrusion and industrial fermentation and processing.

Unit 4: Process Technology and Machinery

Pre-milling/conditioning treatments. Process technology and machinery for cereals, pulses, oil seeds, fruits, vegetables, flowers, spices, condiments, plantation crops, animal products, sea-foods, fiber crops, animal feed, natural resins and gums. Bioprocess engineering, enzyme reaction kinetics, Industrial fermentation and processing, down-stream processing, bio-

separation. Minimal processing of fruits 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 by-products/residue utilization, Waste disposal of food processing plants, different methods and equipment.

Unit 5: Design of Processing Machinery

Design of grain cleaners, graders, dryers, parboiling plants, size reduction machines, bioreactors, fermenters, centrifuges, cyclone separator, 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 *viz.* pulley, chains, sprockets, bearings, belts, fasteners, hydraulic components, pipes, hoses.

Unit 6: Material Handling, Packaging and Transport

Bulk conveying equipments, *viz*. belt conveyors, screw/auger conveyors, bucket elevators and drag/chain conveyors. Estimation of energy requirement and capacity, 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. Transportation of agro-produce by bullock-carts, trailers, trucks, rail wagons and containers. Cold chain design and operation. Safety standards in handling, packaging and transport of agricultural produce.

Unit 7: Storage Engineering

Storage environment and its interaction with stored product, factors/parameters influencing the shelf life of the stored product and deterioration index. Prediction of storage life, quality deterioration mechanisms and 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, smart storage system. Quality analysis of stored produce.

Unit 8: Process Plant Design

Plant design concepts and general design considerations, plant location, product and process design, process flow charts, equipment selection, plant layout. Design and selection of machinery for handling utilities like water, steam, fuel etc. and disposal of effluents and residues.

Unit 9: Instrumentation and Process Control

Static and dynamic characteristics of instruments, Transducers 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, Programmable logic controller, Data loggers, Data Acquisition Systems (DAS). Introduction to Direct Digital Control (DDC), Supervisory Control and Data Acquisition Systems (SCADA), and Virtual Instrumentation.

Unit 10 : 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, transport model, 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 standards/ guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed.

43 RENEWABLE ENERGY ENGINEERING

Unit 1: Biochemical Conversion Technology

Anaerobic digestion – biogas plants – design - operation – utilization – high rate biomethanation process – anaerobic contact process – anaerobic filter – UASB –expanded bed reactor – fluidized bed reactor – sequential bed reactor – landfills. Bioethanol – feedstock – process – utilization - composting - methods – machinery.

Unit 2: Thermo chemical conversion Technology

Thermochemical degradation – Arrhenius Law. Stoichiometric air requirement - Combustion process – design of combustion system – chemistry of combustion - construction - operation - combustion zones - flame structure - stability – emissions. Cofiring of biomass – biorefinery. Incinerators - layout. Biomass gasification – chemistry of gasification – gasifiers design - gas turbine systems - applications - shaft power generation - Gas cleaning & conditioning - thermal application - performance evaluation - economics. Pyrolysis – product recovery – types - biochar – biooil – operation – recovery.

Unit 3: Liquid Biofuels

Global and India scenario in biofuel - potential – options for transport fuel – impacts studies. Biofuel – biofuel crops – production – processes – properties and characteristics. Biodiesel – chemistry –raw materials – availability – preparation - production – trans esterification methods – storage methods – blending options - by-product utilization. Bioethanol production from different biomass substrates – pre-treatment techniques –product recovery systems – blending characteristics. Biofuel versus fossil fuels - Energy balance on liquid biofuels.

Unit 4: Solar Energy Engineering

Solar radiation availability - radiation measurement – transmittance-absorptance - flat plate collectors and concentrating collectors - collector efficiency - heat balance – absorber plate – types - selective surfaces. Design and types of solar driers – heat and mass transfer – performance. - solar thermal power stations – principle and applications. Solar stills and ponds - types - design and performance. Photovoltaics - types – characteristics – load estimation - batteries – invertors –operation - system controls. PV system installations – standalone systems – PV powered water pumping - hybrid system – lifecycle costing - solar technologies in green buildings

Unit 5: Wind Energy Engineering

Nature of wind – wind structure and measurement - wind power laws - velocity and power duration curves - aero foil - tip speed ratio - dimensionless coefficients -torque and power characteristics - power coefficients - Betz coefficient. Wind tunnel testing - axial momentum theory - momentum theory – blade element theory - strip theory - tip loss factor of HAWT rotors - taxonomy. Wind mill – types – design – materials – loads – subsystems – power curve. Upwind

and downwind systems. Stand-alone system - grid system – batteries. Wind energy storage - wind farms - wheeling and banking - testing and certification procedures.

Unit 6: Biochemical and Process Engineering

Hierarchy of cellular organisation - role of microbes and enzymes. Kinetics of enzyme – catalysed reactions - enzyme substrate complex - enzyme action - Simple enzyme kinetics - Michealis - Menten equation. Growth kinetics in growth culture. Kinetics of reversible reactions. Kinetics on substrate utilization - Monod model. Immobilized enzymes – effect of immobilization. Transport phenomena in bioprocess system - gas liquid mass transfer in cellular systems - Oxygen transfer rates - mass transfer. Heat transfer in bioreactors – methods of sterilization of gases and liquids. Ideal bio reactors - multi phase bio reactors - batch, CSTR and plug flow reactors. Stoichiometry and mass balance in bioreactors. Fermentation technology – design and development of fermenters for bioconversion - pilot scale and scale up operations. Product formation and downstream processing. Economics of bioconversion - impact on environment.

Unit 7: Power Generation and Energy Storage

Power generation basis – potential – types – comparison. Diesel and Gas turbine power plant - basic engine components – types – cooling system – lubricating system –combined cycle. Nuclear Power Plant - nuclear waste & its disposal. hydro power plant – classification & selection of turbines – governing mechanisms of turbine – draft tubes – micro hydro power plants. Geothermal power plants – Tidal power plants – wind power plant – solar power plant – direct energy conversion. Energy storage systems – mechanical energy storage – electrical storage – chemical storage – electromagnetic energy storage – thermal energy storage – biological storage.

Unit 8: Energy Auditing and Management

Energy conservation and its importance – energy strategy for the future – energy conservation act and its features. Energy management – principles – energy audit strategy - types – detailed energy audit – steps. Energy performance – bench marking – fuel substitutions – energy audit instruments – material and energy balance. Energy efficiency in thermal utilities – methodology - performance evaluation. Energy audit in electrical utilities methodology – energy conservation opportunities in motors – efficiency – energy efficient motors - energy efficiency in compressed air system. HVAC and refrigeration system – fans and blowers – fan performance – pumps - lighting system - energy auditing and reporting in industries

Unit 9: Modeling and Project Management in Energy

Model – basics - - types of models. Physical -analogy models and applications. Mathematical models – concepts - types. Methodologies in model development – variables and factors – effect and significance of variables - softwares in model formulation – testing of models. Model studies in renewable energy gadgets and heat transfer applications – moving boundary models. Economics of energy sources – Investment and Cost management in various energy

technologies. Energy action planning – project planning - project development in energy technologies – cost economics – financial analysis – sensitivity and risk analysis.

44 IRRIGATION WATER MANAGEMENT ENGINEERING / IRRIGATION & DRAINAGE ENGINEERING

Unit 1: Soil-Water-Plant Relationships

Evaporation – free water surface and soil. Evapotranspiration – Different methods of Estimation – Separation of Evaporation and Transpiration components. Irrigation requirement, critical stages of crop growth in relation to irrigation. Irrigation scheduling. Plant water relations, concept of plant water potential. Soil physical characteristics influencing irrigation. Soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water. Soil irrigability classifications, factors affecting water storage profile. Determination of soil water content, computation of soil water depletion, soil water potential and its components.Flow of water in saturated and partially saturated soils- Richards Equation-Infiltration rate - unsaturated hydraulic conductivity models.Field water budget: water gains and water losses from soil, deep percolation beyond root zone, capillary rise. Uptake and transport of water by roots. Management strategies to improve crop productivity under limited water supplies. Contingent crop plans and other strategies for aberrant weather conditions. Cropping patterns, alternate land use and crop diversification.

Unit 2: Fluid Mechanics and Open Channel Hydraulics

Fundamental Concepts of Fluid Flow: Fundamental definitions, Flow characteristics, Classification of fluids, Fluid properties, Foundations of flow analysis.Fluid Statics: Fluid pressure, Forces on solid surfaces, Buoyant forces. Kinematics of Fluid Flow: Equations for acceleration, Continuity equation, Irrotational and rotational flow, Potential and stream functions Dynamics of Fluid Flow: Finite control volume analysis, Euler and Bernoulli's theorems, Impulse momentum theory, Vortex, Applications of energy and momentum equations, Water Hammer.Laminar and Turbulent Flows: Types of flow, Reynolds experiment, Laminar flow between parallel plates, Laminar flow in pipes, Turbulent flow in pipes. Pipe Flow Systems: Darcy-Weisbach equation, Moody diagram, Energy losses in pipelines, Minor losses, Multiple pipe systems. Dimensional Analysis: Model similitude, Model scales, Theory and applications.Hydraulics of open channel flow, energy and momentum principles, specific energy, Hydraulic jump, classification and its use as energy dissipater. Design of different types of irrigation channels. Irrigation water measurement: using velocity area method, water meters, weirs, notches, flumes, orifices etc. Water conveyance and control. Conveyance losses and lining of irrigation channels. Irrigation water delivery and distribution.

Unit 3: Groundwater Development, Wells and Pumps

Water resources of India. Present status of development and utilization of water resources of India and scope for additional use. Irrigation potential and contribution of groundwater, scope of groundwater development. Application of groundwater models for groundwater development and management. Aquifer types and parameters. Principles of groundwater flow, interaction between surface and groundwater, natural and artificial groundwater recharge. Salt water intrusion in inland and coastal aquifers. Groundwater exploration techniques. Hydraulics of fully

and partially penetrating wells. Design, construction and development of irrigation wells. Water lifts, pumps and prime movers, well and pumps characteristics, performance evaluation and selection of pumps. Energy requirement in groundwater pumping. Design of centrifugal pumps. Groundwater pollution. Conjunctive use of surface and groundwater.

Unit 4: Irrigation Systems

History of irrigation in India. Management of irrigation water. Major irrigation projects in India. Methods of irrigation, surface methods, overhead methods, Merits and demerits of various methods. Hydraulics of furrow, check basin and border irrigation. Quality of irrigation water and irrigation with poor quality water. On farm water management, socio-economic aspects of on farm water management.Command area development organizational structures and activities. Irrigation water users association concept and responsibilities. Environmental considerations in land and water resources management.Lift Irrigation systems and Underground Pipe systems-Structures-Valves- Design- Optimal Pipe selection methods.Drip and Sprinkler Irrigation system- Types- Design-Installation-Evaluation- Fertigation-Operation & Maintenance-economics. Automation of Irrigation systems-Principles and Components.

Unit 5: Protected Cultivation & Landscaping

Types of Protected Cultivation Net house and Green house - orientation and layout. Energy Balance.Structural design & Construction of green houses –Design of Cooling and heating Systems in Green houses –Natural ventilation, Foggers, Fan-pad and heaters Soil less culture, Hydroponics and Aeroponics, Design of Irrigation systems in Green houses,Automation of climate control in protected structures. Landscape surveying with Theodolite and Total station, Landscape creation, Landscape irrigation- surface drip –subsurface drip – pop up sprinklers – spacing methods, design, Installation and automation

Unit 6: Drainage Systems

Problem soils and their distribution in India. Excess salt and salt tolerant crops. Hydrological imbalances and their corrective measures. Concept of critical water table depths for crop growth. Contribution of shallow water table to crop water requirements. Management strategies for flood prone areas and crop calendar for flood affected areas. Crop production and alternate use of problematic soils. Theories and applications of surface and sub-surface drainage, steady state, unsteady state drainage equations for layered and non-layered soils. Principle and applications of Hooghoudt, Ernst, Glover Dumm, Kraijenhoff-van-deleur equations.Design of surface and subsurface drainage systems, vertical drainage, Disposal of drainage effluents, Management of drainage projects of waterlogged and saline soils.

Unit 7: Hydrology of Agricultural Lands, Farm ponds and Percolation ponds

Hydrologic cycle, precipitation, infiltration and surface runoff. Measurement and analysis of hydrologic data.Intensity duration frequency analysis**.** Hortonian and saturation overland flow theories, partial source areaconcept of surface runoff generation. Rainfall and run off relationships, stream gauging and runoff measurement.Different methods of surface runoff

estimation, hydrographs, S-hydrograph, IUH, Synthetic hydrograph, unithydrograph theory and its application. Hydrologic flood routing**:** channel and reservoir routing.

Design, construction and Management of Farm Ponds and Percolation ponds

Unit 8: Precision Agriculture

Precision agriculture: concepts and techniques; their issues and concerns for Indian agriculture; Geo-informatics- definition, concepts, tool and techniques; their use in Precision Agriculture. Crop discrimination and Yield monitoring, soil mapping; fertilizer recommendation using geospatial technologies; Spatial data and their management in GIS; Geodesy and its basic principles; Remote sensing concepts and application in agriculture; Image processing and interpretation; Global positioning system (GPS), components and its functions; System Simulation- Concepts and principles, Introduction to crop Simulation Models and their uses for optimization of Agricultural Inputs.

45 FAMILY RESOURCE MANAGEMENT

Unit 1: Family Resource Management

Interdisciplinary nature of management and systems approach to family management. Philosophy and concepts & principles of management, goal types and goal setting and value types. Sources of learning values and their importance to family Standards – type and relationship with values and goals. Process of management: planning, controlling, evaluating, organizing and their application to resources use and resource classification. Decision making in use and development of resources. Decision making types. Application of management process for work simplification. Application of Mundel's classes of change in household work and agricultural task, communication as a resource.

Unit 2: Art Principles and Interior Enrichment

Importance of interior enrichment. Elements and principles of art and their application to interior decoration. Selection and making of accessories for homes, Flower arrangement. Importance of colour in home, colour theories and schemes. Importance of natural and artificial light in house. Floor coverings, wall and window treatments. Floor and floor covering.

Unit 3: Housing and Space Designing

Identifying family housing needs. Selection of site. principles of house planning: orientation, space requirements for various activities and room layout. Building materials, their characteristics, Selection and suitability for low cost rural and urban housing, estimating costs of building a house. Advantages of owning and renting. green building design evaluation system – GRIHA and LEED. Energy Conservation Building Codes (ECBC) launched by BEE. Housing standards & bye laws, housing finance, economy in housing ergonomic principles.

Unit 4: Household Energy and Equipments

Household energy forms : sources, fuels, and their classification. Energy crisis, its causes and implications for energy management in homes. National efforts for energy and environment conservation Equipments, tools and accessories for rural and urban houses, their selection, maintenance and care. Base materials, finishes, insulation materials and methods of forming utensils. Modular kitchen. Low cost simple equipments – hay box, water filter, solar cookers etc.

Unit 5: Family Finance and Consumer Education

Family income types, sources and contributors Financial planning guidelines for budgeting. Engel's law, expenditure, account keeping, investment; and savings. Credit sources, advantages, disadvantages, selection and repayments. Consumer problems –buying problems, adulteration and substandard goods, public distribution system, Consumer rights and responsibilities and consumer protection measures, Consumer organization and their roles. Standards, standardization & legislative measures for regulating quality.

Unit 6: Entrepreneurship Management

Scope of enterprise. Role of government and private organizations in financing. Environmental Scanning and opportunity identification, project planning and formation. Personnel management, financial management, marketing management, planning identification and opportunity of business.

Unit 7: Markets and Marketing

Types of markets and their functions. Marketing information systems, Sales management and product promotion. Marketing management, financial management and accounting and crisis management.

Unit 8: Ergonomics

Significance and scope of ergonomics. Man, Machine and Environment, System and interactions. Body mechanics at work & drudgery.

Environmental ergonomics - lighting, noise and interiors. Universal design - principles of designing work stations / product designing.

46 TEXTILES AND APPAREL DESIGNING

Unit 1 : Clothing Construction and Pattern Making

Elements and principles of apparel design. Methods of developing patterns – flat pattern making, draping and drafting. Standards of good fit, fitting problems and their remedies. Application of special sewing techniques in dress designing. Commercial processes in apparel industry. Factors influencing fashion movement. Fashion forecasting. Understanding consumer demands. Consumer decision processes. Socio-psychological aspects of clothing. Traditional costumes, textiles and embroideries of India and their influence on modern trends. Costumes of world. Computer Aided Fashion and Apparel Designing. Textile and apparel softwares for designing.

Unit 2 : Fibre Science

Textile chemistry – polymerization, bonding, reactive groups. Manufacture/ processing, structure and physical, chemical and biological properties of cotton, silk, wool and linen, rayon and synthetics. Bleaches –types and their commercial application. Special finishes applied to different textile such as wash-n-wear, water-proof, water repellent, shrink proof, durable press and carbonizing. Anti microbial finishes - for textiles for p/c blends. Quantitative estimation of blends and mixtures.Water, detergents – types and their influence on fabric performance. Textile auxiliaries.

Unit 3 : Dyeing and Printing

Study of dyes and pigments – composition, properties. Styles of printing. Dyeing and printing auxiliaries. Advanced dyeing and printing methods. Textile dyeing effluent and its impact - BOD and COD.

Unit 4: Textile and Apparel Quality Analysis

Importance and scope of quality testing in textiles and apparel. Textile testing standards and methods. Fibre, yarn and fabric testing equipment and methods. Quality standards, specifications and acceptable quality levels for apparel production.

Unit 5: Woven and Knitted Structures

Analysis of textile designs. Application of art elements and principles in textile designing. Classification and characteristics of yarns. Methods of fabric construction. Woven – variation of twills, leno, double cloth, dobby, jacquard, warp and weft figuring, terry pile weaving. Warp and circular knitting. Fabric defects and faults. Textile designing centres and their functions. Computer aided textile designing.

Unit 6: Textile and Apparel Industry

Role of textile industry in Indian economy. Status of textile industry in the last decade with reference to cotton, rayon, jute, silk, wool, garments and hosiery. Domestic and international consumption. Export and import policies of textiles and garments. Five Year Plans and their influence on textile and clothing related policies. Associations and research organizations related to textiles, garments, hosiery and consumer. Retailing and merchandizing of textiles and garments. Sales promotion techniques for textiles and garments e-retailing. Consumer education and protection.

47 HUMAN DEVELOPMENT AND FAMILY STUDIES/HUMAN DEVELOPMENT

Unit 1: Lifespan Development

Major factors influencing human growth and development. Principles of human growth and development. Analysis of significant areas of development. Prenatal development.Factors influencing pre natal development Physical psychological,social, intellectual, emotional, moral and language development during early childhood, late childhood, adolescence, adulthood and old age and their characteristics. rehabilitation of the aged. National and community service for the aged. Death and bereavement.

Unit 2: Theories of Human Development

Meaning and significance of child development theories. Psychoanalytic theories of Freud, Alder, Jung and the Neo Freudians-Karen Horney, Sullivan, and Erech Fromm Erikson's stages of psycho-social development. Pieget's theory of cognitive development. Language development theory of Chomsky and learning theories of Paviov Skinner, Thorndike, Watson and Gestalt psychology. Theories of Heinz Werner and Kohlberg Personality theories of Allport, Murray and Lewin's Field theory.

Unit 3: Early Childhood Education

History of early childhood education. Modern education, Historical review of major philosophies of early thinkers like Locke, Owan, Rousseau, Pestallozzi, Froebel and Montessori, Gandhi's basic education and contributions of Giju Bhai and Tarabai Modak. importance of pre-school education. Administration of pre-schools. Planning infrastructure and programmes for pre-schools education. Maintenance, budget and keeping of records. Principles of curriculum planning, and indoor and outdoor activities of preschool. Models of types of pre-school in India.

Unit 4: Children with Developmental Challenges

Definition and needs of children with developmental challenges. Classification of children with developmental challenges, visual impairment, deaf and hard of hearing speech and language defect, crippled child, socially and emotionally maladjusted and juvenile delinquents. Gifted and mentally retarded children. Psychological problems; necrosis, psychoneurosis, psychoses and schizophrenia. Remedial measures and rehabilitation. Policies and legislations.

Unit 5: Assessment, Guidance and Counselling

Concept, need and principles of guidance. Aims and objectives of individual and group guidance. Sources of information and methods of group guidance. Use of psychological tests and criteria for testing and measurements. Guidance services: meaning, scope, principles counseling services, methods and techniques in counseling service of children, parents and youth.

Unit 6: Family Ecology

Family Ecology: Family in social context. Approaches to study of family: developmental, social, psychological and educational. Modern trends in Indian, urban and rural families. Changing roles and relationships, influence of socio-economic status, culture, religion and the role of family in maintaining mental health. Problems of the family related to sexual misbehavior, aggression and hostility, drug addiction, AIDS etc. Services for family and children, crèches. Impact of consumerism, migration and multiculturism. Marriage and family therapy.

Unit 7: Parenting and Community Education

Meaning and need for community education. Child rearing practices of community, Objectives and principles of parent education. The disadvantaged family. Problems and needs of the disadvantaged family and child. Subject matter or areas of knowledge for parent education. Role of parents and teachers in children. Methods and procedures of parent and community education. Parental education to support the child. Engaging parents as a resource. Role of community and supporting children's transition.

48 FOOD SCIENCE AND NUTRITION/HUMAN NUTRITION

Unit 1: Food and Food Groups

Food production and consumption trends in India and their consequences on nutrition situation. Cereals, millets, pulses, oilseeds, vegetables, fruits, milk, eggs, meat and other animal foods. Nutritional value of these food groups and their contribution towards nutrients in Indian diets.

Unit 2: Food Preservation and Packaging

Principles and methods of food preservation and storage. Preservation of fruits, vegetables, meat, milk and milk products. Food packaging, packaging material, labelling, food laws and regulation. International food standards and codex alimentarius, FSSAI, 2011

Unit 3: Cooking methods and Food Processing

Food processing-physical and chemical changes in foods during processing including cooking and preservation with special reference to sensory characteristics and nutritional value. Traditional methods of processing such as parboiling, germination, malting and fermentation and their nutritional advantages. Food colours, flavours and enzymes, and their importance. Food additives: need for food additives and types of additives.

Unit 4: Food Safety

Food safety-natural toxicants, pesticide residues, common adulterants and mycotoxins, their harmful effects on health, and methods of eliminating their harmful effects. Food borne diseases and their prevention. Food spoilage: perishable, semi-perishable and non-perishable.

Unit 5: Macro and Micro Nutrients in Human Nutrition

Macro and micro-nutrients in human nutrition. Carbohydrates, lipids, proteins, vitamins, minerals and trace elements. Requirements, sources, functions and effects of deficiency. Energy-methods of assessing energy requirement and factors influencing requirement. Qualitative differences in food proteins and methods of assessing protein quality. Factors influencing availability of minerals. Nutrients inter-relationships. Importance of fibre in human nutrition. Water and electrolyte balance. Metabolism of carbohydrates, proteins and lipids. Roles of vitamins and hormones in metabolism.

Unit 6: Community Nutrition

Major nutrition problems in India – causes, magnitude and distribution. Nutritional problems of vulnerable segments – pregnant and lactating women, and pre-school children. Food nutrition programmes to combat malnutrition-strategies, targets and progress. Assessment of community nutritional status-anthropometry, diet survey, biochemical and clinical methods. Indicators/parameters and standards used for assessment by different methods. Growth norms for pre-school children and importance of growth monitoring.

Unit 7: Nutrition during Life Cycle

Nutritional requirements of pregnant and lactating women and pre-school children. Consequences of chronic nutritional deficiencies in these groups. Infant and child feeding practices in India and importance of promoting good feeding practices. Nutrition for elderly.

Unit 8: Clinical Therapeutic Nutrition

Relationships between clinical biochemical results and nutritional status. Drug nutrient interaction. Nutrition in disease, therapeutic modifications of normal diets, and their use in treatment of diabetes, cancer, obesity, burns, fever and infections and diseases of gastro-intestinal tract, cardio-vascular, renal, hepatic. Metabolic and febrile disorders.

Unit 9: Institutional Food service management

Menu planning for industrial canteen, hospital canteen, snack bar, residential hostel, fast food outlets and cafeteria. Food safety, safety hazards and risks, food related hazards, microbiological considerations in food safety, effect of processing and storage on microbial safety, microbiological methodology, HACCP as method to prevent food borne illness, chemical hazards associated with foods.

Unit 10: Food Analysis

Principles and methods of proximate analysis- moisture, ash, crude fiber, crude fat, crude protein and carbohydrates by difference, Basic Principles of HPLC, GLC, spectrophotometry, electrophoresis, refractometery, densitometry, minerals and vitamins estimations. Methods for determining physical and rheological properties of foods.

49 EXTENSION EDUCATION AND COMMUNITY MANAGEMENT

Unit 1: 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. Institution and its importance, types, etc. Relationship between family and community development. Gender sensitivity in extension education programmes. Leadership-concept, types, identification, leadership styles, 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. Modularized communication- concept, approach, need , process of designing instruction for transfer of communication. Concept, functions, key elements, theories and models of communication. Barriers to communication. Revolution in communication strategies. Advanced techniques in mass communication and software production, importance of media in TOT, importance of ICT in TOT. Participatory communication – theories and models, designing and developing participatory massage. Concept, need and constraint of community based learning. Concept, steps, principles and theories of programme planning. Application of programme planning for Home Science Extension through PERT and CPM. Evaluation – concept, significance, methods and tools for monitoring and evaluation. Motivation and its importance. 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), Krishi Vigyan Kendras (KVKs). Role of Non-governmental Organizations (NGOs) in extension, SWOT analysis of development programmes. Programmes and agencies promoting women as entrepreneurs. Types and techniques of training for developing entrepreneurial activities in Home Science areas. Self Help Groups- concept, organization, mobilization and functioning of SHGs for sustainability. Human Resource Development- concept, need and strategies.

- NITI Aayog
- Diffusion and Adoption of Technologies: Concept and element of diffusion process, adoption: meaning, process, factors & constraints, adaptor categories.
- Journalism: meaning, type, fundamentals of good writing editing & proof reading for print media.
- Video production: terminology related to video production, steps involved in video production.
- Information and communication Technology (ICT): meaning, types, use of ICT in extension.

50 FISHERIES RESOURCE MANAGEMENT

Unit 1: Fisheries Resources

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

Unit 2: Fish Biology and Stock Assessment

Biosystematics and Life history of economically important fish species; Food and feeding habits, methods of studying food and feeding habits, trophodynamics, feeding indices; Reproductive biology, maturity stages, fecundity, ova diameter studies and breeding cycles,developmental biology;Length weight relationship; Condition factor, gonado somatic index; Age and growth studies- method for determination of age, study of growth rates, direct and indirect methods; Fish migration, structures and design of fish passes; Taxonomy of major fish groups; Modern tools in ichthyotaxonomy;Concept of Stock and its characterization; Recruitment, growth and mortality of fish in natural water bodies.Different analytical and Holistic models for fish stock assessment, their advantages and disadvantages; Catch per unit effort; Concept of Maximum Sustainable Yield and Maximum Economic Yield; Applications of Remote Sensing(RS) and GIS in fisheries, resource mapping and forecasting;Mechanisms, methods and status of fish yield data acquisition; Ecosystem-based fisheries management tools:Productivity models, ECOPATH with ECOSIM; Monitoring, control and surveillance (MCS) systems for major fisheries; Computer softwares in stock assessment; Use of Virtual Population Analysis and Predictive models.

Unit 3: Fisheries Management and Responsible Fisheries

Concepts and principles of fisheries management; Fisheries Acts and Legislations, revisions and amendments; Fisheries policies, instruments and mechanisms for inland, coastal and open ocean fisheries management; Management of riverine, reservoir and lacustrine fisheries; Management of marine fisheries; Modes of fisheries management: Open access, regulated, advisory, participatory, user rights; International fishery regulations, treaties and instruments; Input control measures such as access control, size, type, number and power of boats, duration of fishing; Output control measures such as total allowable catch, catch quotas, licensing, technical control measures such as size limitations, closed fishing areas, closed seasons, size of nets and mesh size regulations, limited entry; Impediments to fisheries governance; UNCLOS, FAO Code of Conduct for Responsible Fisheries; Illegal unregulated and unreported fishing methods (IUU); Destructive and prohibited fishing systems and practices; Eco friendly fishing methods and fishing gears; Effect of fishing on nontargetspecies; Effect of bottom trawl on benthic fauna and habitats; Conservation methods issues and implications for biodiversity.

Unit 4: Fisheries Livelihood

Relevance of capture fisheries in food, nutrition, employment, income and livelihood securities of fishers; Vulnerability and marginalization of fishers, small scale processors and traders to changes in resource availability, diversification, exploitation and utilization patterns; Impact of dams, river linking and fisheries regulations on the fisher communities; Land and water body use issues in fisheries; Role of extension in fisheries, mechanisms and modes of extension and their impact on capture fisheries and fishers' livelihood, alternative livelihood options; Management of conflicts within sub-sectors in fisheries; Women in fisheries, status, role, impact, future; Vulnerability of fishers to natural disasters and coping mechanisms in disaster management; Block chain Technology; Fisheries co-operatives; Institutional support for fisheries development.

51 FISH PROCESSING TECHNOLOGY/FISH POST-HARVEST TECHNOLOGY

Unit 1: Fish Biochemistry

Proteins: Classification, pigments, heme-proteins, hemocyanins, antifreeze proteins; Functional properties of seafood proteins and their significance to processing and quality; Lipids: Composition and nutritive value, lipid types and their variations, fatty acid composition of fish liver and body oils; Triglycerides and phospholipids; Polyunsaturated fatty acids and their beneficial effects on human health;Autooxidation of fatty acids, pro- and anti-oxidants, oxidation indices, lipid protein interactions, rancidity, lipases and phospholipases; Carbohydrates: Classification and biological significance of carbohydrates, structure and properties of monosaccharides, disaccharides and polysaccharides; Uses of modified starch and other carbohydrates as food additives (as thickening and binding agents); Changes in carbohydrates during processing and relationship of carbohydrates to food stability, gelatinization; Non-protein nitrogenous compounds: free amino acids, peptides, nucleotides, guanidines, urea, quaternary ammonium compounds; Enzymes in fish: Their classification and mechanism of action; Vitamins in fish: vitamin deficiency diseases; Minerals and trace elements in fish; Toxins and toxic substances in fish, their bioaccumulation and bio magnification; Biogenic amines; Seafood flavours and pigments, chemical basis of flavor perception, influence of processing on flavours; Fundamental techniques in food analysis; Principles and applications of spectrophotometry, chromatography including GC-MS.

Unit 2: Low and High Temperature Preservation

Postmortem changes, factors affecting quality of fresh fish(intrinsic and extrinsic factors);Depuration of bivalves; Chilled storage of fish, different types of ice, changes during chill storage, melanosis and its prevention; Freezing of fish and shellfish: structure of water and ice, phase equlibria and freezing curves for fish, crystallization, nucleation- homogeneous and heterogeneous nucleation; Super cooling, crystal growth, eutectic point, location of ice crystals in tissue, changes during freezing; Technological aspects of freezing, packing of fresh and frozen fish for consumers, modified atmosphere packaging, controlled packaging; Frozen storage: Physical, chemical, bacterial, sensory changes; Prevention of quality loss during frozen storage, theories of cryoprotection, glazing (importance and methods); Heat load calculation;Canning: Principles of thermal processing; mechanism of heat transfer, heat resistance of bacteria and spores, decimal reduction time, thermal death time, "Z" and "F" values, heat penetration, cold point, heat processing and heating equipment, process value calculation;Classification of foods, pasteurization and sterilization, unit operation in canning process; Spoilage of canned food;Flexible packing, retort pouch processing of fish and fishery products principles and techniques.

Unit 3: Fish Curing, Value Addition and by Products

Principles of fish preservation; Factors affecting spoilage of fish; Preservation of fish by curing (drying, salting,fermentation and smoking)**;** Water content, psychometrics, water activity and sorption behaviour of foods; Sous-vide, freeze drying and accelerated freeze drying (AFD);

Modified atmosphere packaging (MAP) of fish and fish products; Irradiation:Radiation sources, units, dose levels, radappertization, radicidation, radurization; Surimi and fish-mince: Preparation and uses; Quality evaluation of surimi, Kamaboko and analogue products;Battered and breaded products; By products: Fish meal, fish silage, fish oil, chitin, chitosan, glucosamine hydrochloride, carotenoids from shellfish wastes and its applications, fish protein hydrolysate; Shark liver oil, squalene, shark cartilage, ambergris, collagen, gelatin; Mechanism of extrusion, mechanical and chemical changes during extrusion, parameters affecting quality of extruded products; Cook-chill products; Edible seaweeds: nutritive value of seaweeds, products from seaweeds; Fish processing wastes; Liquid and solid wastes in fish processing and their disposal; Fish wastes utilization: Recovery of proteins, enzymes and pigments;Packaging and transportation: Aim and objectives of packaging and transportation of preserved and processed fish, temperature modeling and relationships in fish transportation, transportation containers; Safety, quality and spoilage of fish during transportation; Labeling requirements, intelligent packaging, edible packaging; disposal and recycling of packaging materials; Additives: Classes of additives, preservatives, antimicrobial additives; Emerging technologies in Fish Processing.Fishery products and byproducts exported from India;

Unit 4: Microbiological and Quality Aspects of Fish and Fishery Products

Microbial changes during icing, freezing and curing, chemical control of microbial spoilage, effect of preservatives on microflora; Fermentation: Batch wise and continuous; Important fermented products, microbial injury, inactive physiological states;Microorganisms of public health significance- Sources of pathogens in seafood, infection and intoxication; Microbial food poisoning, bacteria of public health significance in fish& fishery products;Epidemiology; Botulism and staphylococcal food poisoning, food infections by Salmonella, *Clostridium perfringens, Vibrio parahaemoliticus, V. vulnificus,* pathogenic *E. coli, Listeria monocytogenes*, Campylobacter, Arcobacter(Virulence mechanisms, sources, incidences, foods involved and prevention measures); Histamine poisoning, aflatoxins, patulin, ochratoxin and other fungal toxins found in food, virus and parasites found in foods. Fish quality evaluation and different indices of quality; Sanitary and phytosanitary requirements for maintenance of quality; Hazards in sea foods; Risk assessment; National and international standards;HACCP and ISO 9000 series of quality assurance system, ISO22000:2006, Codex alimentarius, ICMSF; Food Safety and Standards Act of India 2006; Role of BIS and EIA; Role of MPEDA in export trade; Export documentation and certification: Certificate for export (CFE), health certificate and other certifications; Traceability issues for farm reared and wild aquatic products in international trade; Dealing with returned consignments; Foreign trade policy of Fish and Fishery Products in Indian and World contexts; Foreign trade regulations in India.

52 FISHERIES ENGINEERING & TECHNOLOGY

Unit 1: Fishing Technology

Different types of craft and gear, their operation and their maintenance; Construction of fishing vessels; Deck layout and deck equipment of fishing vessels based on the fishing methodprincipal dimensions of a boat; Engine: characteristics, handling and maintenance; Power requirement, auxiliary machinery systems, diving underwater vehicles;Importance of shape of underwater hull, classification and description of hull forms based on shape and speed-length ratio; Theory of waves: Rolling, pitching and heaving; Wall sides formula; Resistance and motion: Wave and eddy creating resistance, fluid resistance; Powering of fishing vessels; Safety and stability aspects of fishing vessels;Design of different types of fishing gears;Conventional and current practice for the representation of fishing gear by scale drawing;Selectivity of fishing gears; Fish Aggregation devices (FADs): Objectives and types of FADs; Definition of bycatch, types of bycatch reduction devices and the principles of operation; Design and construction of FADs; Types of TEDs: soft and hard types, materials used for their construction and maintenance; Use of modern techniques and equipment for fish finding and capturing; Factors affecting fishing gear design, types, general structure of gear, characteristics of fishing vessel and accessories of trawl (bottom and mid water), purse seine, gill net, bag nets, lines and traps;Fishing gear testing: Full scale and model testing in flume tanks, methods of testing a fishing gear; The influence of design features on the overall economic performance of fishing gears; Basic principles of acoustic fish detection; Acoustic surveys, acoustic equipment used in fishing;Components of GPS, working, functions, important applications of GPS in fisheries; Identification of Potential Fishing Zones (PFZ); Participatory GIS in fishing systems, theme Maps; Navigation and seamanship; Introduction to sea safety: Safe navigation procedures for fishing vessels, distress signals; Weather warning signals and weather reporting system for fishing vessels; International conventions related to sea safety.

Unit 2: Fishing Harbour and Fleet Management

FAO classification of fishing vessels; Indigenous fishing boats of India: Fishing boats of maritime states of India, fishing boats used in the inlandand brackish waters, account of mechanized boats introduced in India; Personnel management, planning of fishing cruises; Fishing fleet capacity, fleet registration, fleet insurance, seaworthiness assessment, tonnage measurements; Statutory rules and regulations under MSA, classified societies, manning regulations and requirements; Regulations to prevent collisions at sea; Classification and functions of fishing harbour; Facilities – waterside and landside facilities, services and utilities provided, layout of a modern fishing harbour, stages in the planning of fishing harbours; Dredging; Economic evaluation on fishing harbour project; Dry docks and slipway; Fishing harbour management and maintenance.

Unit 3: Aquaculture engineering

Site selection for aquaculture;Surveying and leveling,earthwork calculations; Design of dykes, sluice, channels; Tide fed farms; Studies on water supply; Aquaculture in open systems:Design

of cages, rafts, pens, rakes, ropes etc.; Fluid mechanics, pumps, flow estimation and measurement; Aquaculture in ponds, raceways and tanks; Recirculating aquaculture system; Aeration, sterilization and disinfection of ponds, tanks and other impounding structures; Filtration; Aeration: efficiency of Aerators; Recirculation and reuse systems;. Designs of re-use systems; Engineering aspects of fish and shrimp hatchery;Farm machinery operation and maintenance;Pond sealing techniques; Automatic feeding system, feed dispensers and demand feeders;Design and construction of aquaculture system pond construction, water transportation system, pump houses,inlet and outlet structures,water treatment plants.

Unit 4: Refrigeration, Electrical & Equipment Engineering

Principles of refrigeration: Application of refrigeration in fisheries, refrigeration in sea food processing plant, refrigeration in factory trawlers,heat load calculations; Handling and operation of refrigeration equipment; General structure of electrical power systems; Principles and working, electronic components, principle and application of DC and AC networks, single phase AC circuits, three phase AC circuits, magnetic, transformers, induction motor, DC motors etc.; Principles of working of radio, radio telephone, radio direction finder, echo-sounder, sonar, radar, GPS etc.; Processing equipmenton board the fishing vessels; Fish meal plant equipment; Freeze drying and dehydrating equipment; Freezers and canning machineries;Packing machines;Equipment maintenance and safety.

53 AQUATIC ENVIRONMENT MANAGEMENT

Unit 1: Fundamentals of Environmental Sciences

Definition and scope of environment science, its interrelationship with other sciences and fisheries; Origin and evolution of the earth and its environments-atmosphere, hydrosphere, lithosphere and biosphere; Basic ecological concepts: Habitat ecology, systems ecology, synecology, autecology; Air pollution: Sources and classification of major air pollutants; Climate change: weather and climate, Global warming and greenhouse effect, sources and sinks of greenhouse gases; Impact of climate change on aquatic environment& polar ecosystem; Photochemical smog and SPM; Use of green and sustainable technology; Environmental impacts assessment and environmental auditing; Environmental policies and laws in India.

Unit 2: Aquatic Ecosystem, Biodiversity and Marine Ecology

Productivity and carrying capacity; Trophic relationships, energy flow and nutrient cycling;Ecological stability and homeostasis; Resistance and resilience; Natality and mortality; r and k selection; Categories of biodiversity:Species diversity, genetic diversity and habitat diversity; Biodiversity indices and their significance; Concepts of index of biotic integrity (IBI);Ecosystem services and economic appraisal of biodiversity; International conventions on biodiversity; Environmental economics; Ecological standards;Environmental regulations; Environmental ethics; Disaster Management; Biodiversity hotspots, biosphere reserves, National parks, sanctuaries, marine protected areas;Ramsar convention; Eco-labelling; Ocean acidification;Climate change and food security; Carbon footprint in fisheries and aquaculture; Projected trends of climate change and disaster; International conventions on climate change; Stratospheric ozone layer depletion: effect of UV radiation on human health and ecosystem; Adaptation and mitigation strategies of climate change;Carbon sequestration;Carbon credit; Green technology; Rain water harvesting;Mangrove ecosystem; Sea grass; Sandy beach; lagoon and estuary; Integrated Coastal Zone Management (ICZM); River continuum concept; River linking; Water budget and its significance in water conservation; Constructed wetlands.

Unit 3: Chemical Interaction in the Aquatic Environment and Analytical Techniques

Chemical kinetics; Redox chemistry; Solubility concept; Weathering of rocks; Soil formation; Soil profile, sediment texture;Structure of oxide and silicate minerals, source of charge; Double layer; Ion exchange:Concept and source of cation exchange capacity (CEC); Sediment texture; Chemistry of soil- nutrient interactions and water permeability; Nutrient dynamics: Nutrient holding capacity of sediments and fixation; Processes in the degradation and conversion of organic matter; Transport of substances; Humus and biogeochemical substances;Bio-availability;Bio-accumulation and biomagnifications;Photometric techniques: Theory, instrumentation and application of colorimetry and spectrophotometry; Gravimetric and volumetric analyses: Principles and precautions; Use of stable and radioactive isotopes in environmental analysis.

Unit 4: Aquatic Pollution and Microbiology

Aquatic pollution:Sources, types and their impact; Pollution problems of groundwater resources (arsenic, fluoride, nitrate, pesticides), sources of contamination and management issues; Sewage, radioactive wastes, biomedical wastes, hazardous chemicals, plastics, nanoparticles; Eutrophication; Ecological sanitation: closing the loop;Toxins from fish/aquatic organisms and fish poisoning; Factors influencing toxicity; Ecological effects of toxicants; Metabolism of toxic substances; Comparative toxicology; Genotoxicity; Neurotoxicity; Ecological engineering: concepts and applications, biomanipulation, bioremediation; Restoration ecology and rehabilitation;Wastewaters: Types and characteristics of sewage and industrial effluents; Conventional and advanced treatment methods of waste water; Solid waste management, Biological and chemical methods for recovery of nutrients from liquid and solid wastes; Wastewater utilization for algal cultivation; Waste recycling in aquaculture; Microbial community in freshwater; estuary and marine environment (types and abundance); Factors affecting microbial growth and abundance in aquatic environment; Extremophiles and their significance;Biogeochemical cycling; Microbial interaction; Microbial degradation; Water-borne pathogens of public health importance; Microbial criteria for water quality assessment; Indicator organisms; Principles and applications of bioprocesses; Microbial biomass production; Bio-fertilization; Biocontrol; Genetically-improved strains; Consortia of microbes for environmental protection; Bioreactors; Biosensors as a tool for biomonitoring; Biofuels, fermented products and biogas; Biopesticides, Microbial interaction with chemical pollutants in aquatic environment; Microorganisms as potential bioremediators; IPR issues related to environmental biotechnology; Culture dependent and culture independent approaches in aquatic microbiology;Microbial toxins; Dose-response relationship; Toxicity testing: microcosm and mesocosm tests; Probiotics;Bioprospecting;Disinfection methods.

Unit 5: Fisheries Oceanography

Marine topography;Effects of physicochemical and biological oceanographic factors on adaptation, behaviour, abundance and production of aquatic organisms; Space and time scales in oceanographic analysis; Magnitude of short-term productivity changes in the ocean; Synoptic oceanographic analysis: currents, waves, tides, El Nino- southern oscillation; Stratification, mudbanks, upwelling and circulation patterns; Application of remote sensing and GIS in fisheries; Environmental factors influence the seasonal variations in fish catch in the Arabian Sea and the Bay of Bengal; Fisheries enhancement:Artificial upwelling, ranching, artificial reefs, ocean fertilization.

54 AQUACULTURE

Unit 1: Status and Scope of Aquaculture

History and scope of aquaculture; Aquaculture practices in different parts of theworld; Status of world aquaculture: production trend, consumption scenario and emerging trends, important cultivable species of finfish and shellfish, aquatic plants and their culture practices; Criteria for candidate species selection;Criteria for site selection for various culture practices; Aquaculture practices for freshwater fish (carps, catfishes, snake heads, feather backs, tilapia, murrels, mahseer, trouts, etc.), freshwater prawn, brackishwater and marine shrimp and fish (seabass, milkfish, mullets, pearlspot, cobia, pompano, grouper, snappers, breams, perches), lobsters, freshwater and marine ornamentalexotics.

Unit 2: Design, Construction and Operational Management of Aqua-Farms

Design and construction of aqua-farms: nutrient and soil quality, site selection; Pond preparations: Fertilization, micro-organisms and their role;Nursery and grow-out rearing:Pre-stocking, stocking and post stocking management in cultureponds, water supply and water circulation, soil and water quality management, feeding;Construction of pens and cages:Design and construction, fixed cages, floating cages, semi-submerged and submerged cages; Carrying capacity of aquafarms;Use of biofilters andaerators; Wastewater-fed aquaculture; Best Management Practices (BMP) in aquaculture;Environmental Impact Assessment (EIA), Responsible aquaculture; Sanitary and phytosanitary (SPS) agreement; IPR in aquaculture; Ecosystem approach to aquaculture; CRZ implications, CAA and its role; Ecolabeling; Organic certification.

Unit 3: Broodstock Management and Seed Producton

Broodstock management and seed production technology:Natural seed resources and its management, collection techniques, holding, packaging and transportation; Reproductive physiology in fish and shellfish: Endocrine control of maturation, spermatogenesis, oogenesis, spawning and vitellogenesis; Assessment of gonadal maturation: evaluation of gamete quality; Improvement of seed quality through stock up-gradation, induced breeding, synthetic hormones and its analogues and their application;Incubation of eggs; cryopreservation of gametes; Hatchery seed production and management:Design andlayout of hatcheries;Live feed culture:Microalgae, rotifers, artemia,copepods etc.;Seed production of carps, snakeheads, mahseer, trout, tilapia, pearlspot, ornamentals, cobia, grouper, pompano, tilapia, mullets, milkfish, snappers, breams, shrimps (*Penaeus monodon, P. indicus, P. semisulcatus, P. vannamei*), sand lobster, spiny lobster, mud crab (*Scylla serrata*) blue swimmer crab (*Portunus pelagicus*), giant freshwater prawn (*Macrobrachium rosenbergii*), mussel, edible oyster, pearl oyster.

Unit 4: Aquaculture Systems

Different systems of Aquaculture: Traditional, extensive, semi- intensive, intensive; Farming methods:Ponds, pens, cages, raceway, raft rope rack, monoculture, polyculture, composite culture; Culture based capture fisheries;Integrated multi-trophic Aquaculture (IMTA); Integrated fish farming; Organic aquaculture; Sewage fed aquaculture; Hi-tech aquaculture systems: Biofloc, aquaponics, RAS systems and flow through systems; Genetic improvement of aquaculture candidates through selective breeding/ hybridisation.

55 FISH HEALTH MANAGEMENT/AQUATIC ANIMAL HEALTH MANAGEMENT

Unit 1: Introduction to Fish Health and Pathology

Definition of health and disease in fish: Pre-disposing factors, biotic and abiotic factors,stress and general adaptation syndrome; Host-pathogen-environment interaction; Role of physical (injuries, health, cold), chemical (pH, salinity, toxins, ammonia, nitrogenous waste, endogeneous chemical metabolities, free radicals, oxidants), soil and water parameters in fish health;General pathology: Degeneration, cellular adaptation and abnormalities; Neoplasms: Etiology, classification, morphology and behaviour; Inflammation and cell death; Wound healing and tissue repair; General anatomy and systemic pathological changescaused by viral, bacterial and parasitic diseases in finfish and crustaceans.

Unit 2: Diseases of Fish & Shellfish

Major bacterial (furunculosis, aeromoniasis, columnaris disease, bacterial gill disease, vibriosis, mycobacteriosis, nocardiosis, haemophilosis, edwardsiellosis, enteric red mouth, pasteurellosis, pisci rickettsiosis, streptococcosis and clostridium disease, bacterial diseases of shellfish such as vibriosis, AHPND, necrotizing hepatopancreatitis, rickettsial diseases, mycobacteriosis), viral (Epizootic Haematopoietic Necrosis (EHN), Infectious Haematopoietic Necrosis (IHN), Oncorhynchus Masou Virus (OMV), Viral Encephalopathy and Retinopathy (VER), Spring Viraemia of Carp (SVC), Viral Haemorrhagic Septicaemia (VHS), Lymphocystis, Koi Herpes Virus (KHV), infectious salmon anaemia, salmonid alphavirus and red seabream iridoviral disease, WSSV, YHV, TSV, IHHNV, MBV, HPV, BP, BMN, LSNV, GAV, MrNV & XSV, infectious myonecrosis virus), fungal (Aphanomycosis, cotton wool disease, branchiomycosis,&aspergillosis), parasitic and non-infectious diseases of fish and shellfish in aquaculture systems; Common bacterial infections in fish and shellfish: Epidemiology, virulence and pathogenesis of major bacterial infections; Fungal pathogens of shellfish viz.,*Lagenidium*, *Sirolpidium*, *Fusarium*;Classification of viruses, virus genome, replication of virus, virus-host relationships, molecular pathogenesis, major viruses infecting fish and shellfish and their pathogenesis, epidemiology; Virus isolation using cell lines, new antiviral compounds, virus and gene therapy; Life cycle, host-parasite relationship, treatment and control measures of important ecto- and endo-parasites infecting fish and shellfish; Fish-borne parasitic zoonoses; Patho-epizootiology, treatment and control of mycotoxicosis, EUS, saprolegniasis and other fungal pathogens of fish and shellfish.

Unit 3: Disease Diagnosis

Principles of disease diagnosis, specificity and sensitivity and efficiency of diagnostic techniques, conventional and rapid diagnostic methods of bacterial, viral, fungal, parasitic, non-infectious diseases of finfish and shellfish; Conventional clinical pathology and diagnosis of disease: Principles of sampling, sampling methodologies, physical examination, necropsy, hematology, clinical chemistry, microbiology and histopathology; Clinical laboratory examination of various biomaterials from fish and shellfish, normal picture of blood, serum

enzymology, disorders and their interpretations, examination of skin scrapings, gill, internal organs, other tissues, various immunological, serological and molecular diagnosis using PCR, RT-PCR, and real time PCR, LAMP, RPA, hybridization techniques, micro-arrayetc., and the principals involved in ELISA; Immunoperoxidase, immunochromatography, monoclonal antibody production, mAb-based diagnosis; Primer designing for probes; Cell lines and their use in viral diagnosis: Virus isolation, TCID50, electron microscopy, virus-neutralization test.

Unit 4: Defence System

Immune systems in fish: Organization and ontogeny of lymphoid system in fish, haematopoiesis; Innate and acquired immunity, antibody and cell mediated immunity in fish; Shellfish immune system: Organization, humoral and cellular factors and quasi immune response, trans-generational immune priming; Antigens: Structure and classification, antigen presentation, MHC restriction; Antibodies: Structure and types of antibodies, T-dependent and independent antibody production, antigen-antibody reactions, antibody class-switching; Immune response: Non-specific and specific, abnormalities in cell growth(aplasia, hypoplasia, atrophy, metaplasia, and dysplasia), macrophages, phagocyte systems, TOLL link receptors, RES, ROS, antigen presenting cells, non-specific humoral responses (complement system, lectins, antimicrobial peptides), B-cell and T-cell mediated immune response, subsets and nature of receptors, autoimmunity, immunological tolerances;Tumours and neoplasm growth, etiology, classification, morphology and behaviour, structure of tumour cell, tumour immunology, tissue responses to tumours, pathological features of neoplasms.

Unit 5: Disease Prevention and Control

Disease prophylaxis and therapeutics: Use of chemicals, antibiotics, conventional vaccines, viral vaccines, new antiviral compounds, prebiotics & probiotics, biochemical applications in disease control, DNA and RNA vaccines, recombinant vaccines, use of RNA interference, virus and gene therapy, SPF & SPR broodstock, certification, surveillance and reporting; Quarantine, biosecurity; Disease control through environmental management; Fish pharmacology: Principles, action mechanism of pharmacological agents of aquaculture importance, drug metabolism and regulation, drug application in aquaculture systems.

56 FISH NUTRITION AND FEED TECHNOLOGY

Unit 1: Principle of Fish Nutrition

Nutrients, sources, structure, classification, role/ function and biosynthesis; Metabolism of proteins, carbohydrates and lipids; Essential amino acids, their function and deficiency symptoms; Vitamins and minerals, their role in nutrition and deficiency symptoms; Importance of phospholipids and steroids in fish and crustacean nutrition;Strategies for improvement of carbohydrates utilization in fish;Energy Nutrition: Definition of energy, basic fish bioenergetics, energy partitioning & different forms of energy, energy budget equation, metabolic scope, principles of energy estimation, estimation of gross energy of feed and feed ingredients;Sparing action of nutrients; P:E ratio;Role of nutrients on growth and flesh quality: Concept of growth, growth curve, correlation of growth with body weight and length, biotic and abiotic factors affecting growth, critical nutrients for improving flesh quality;Assessing nutritional requirement of larvae, fingerlings, young fish, grow-out of commercially important finfish and shellfish;Methods and factors affecting nutritional requirements in different life stages of fish and shellfish;Food and feeding habits of fish and shellfish;Nutritive value of live food: Algae, artemia, cladocerans, ostracods, rotifers and copepods; Bio-enrichment of live food; Role of nutrients on reproduction.

Unit 2: Feed Formulation, Feed Technology and Feeding Management

Principles and methods of feed formulation; Feed ingredients, classification, evaluation of ingredient quality; Feed additives/supplements: Classification, function, dietary inclusion level; Antinutritional factorsand methods of detoxification, permissible level; Types of feed: Farm-made, commercial feed, experimental diets (reference/ basal diet, purified and semi-purified diet), moist, semi-moist, dry, crumble, pellet, sinking, slow sinking, floating, micro-bound, microencapsulated, micro-coated;Feed processing technology: Grinding, dosing/ weighing, homogenization/ mixing, conditioning (steam or extrusion cooking), pellet making, drying, crumbling, coating; high energy feed with vacuum coating of lipid; Equipments used in feed manufacture: Pulverizer/ grinder, mixer, pelletizer/extruder/expander, crumbler, drier, vacuum coater/ fat sprayer;Effect of processing on nutritional value of feeds;Feed and feed ingredients and quality control: Storage methods and monitoring, quality control of feed and ingredients during storage- physical, chemical and biological methods, prevention of spoilage from rancidity, fungus and associated toxins, vectors of fish disease in feed, nutritional value of feed in relation to storage; Economics of feed manufacturing**;**Fertilization and supplementary feeding, feeding in intensive culture: Feeding methods and devices- broad casting, bag feeding, tray/ basket feeding, raft feeding, box feeding, feeding by demand feeder, automatic feeder, feed blower etc.;Feeding practices: Ration size/feeding rate, feeding frequency, restricted feeding, and mixed feeding;Feeding schedule and Record keeping;Eco-friendly feeds; Legal aspects of feeds;Designer fish production.

Unit 3: Nutritional Physiology and Nutrigenomics

Morphology, anatomy and physiology of various types of fish such as herbivores, planktivores, omnivores, carnivores, detritivores; Nutrient digestion and digestive processes,control and regulation of digestion; Factors affecting feed intake, digestion, absorption, assimilation and digestibility Digestive enzymes in fish: Gastric, pancreatic and intestinal secretions and role of microorganisms in digestion;Transport of nutrients in the body, storage, conversion and utilization; Role of liver and muscles in fat and glycogen storage and release; Digestive hormones, nutrient regulation of endocrine functions;Effects of broodstock diets on eggs and larval quality; Ontogeny of larval digestive physiology; Digestibility: Types, estimation of digestibilityof nutrientsand energy of feed and feed ingredients, factors affecting digestibility; Nutrigenomics: Definition, classification- transcriptomics, proteomics and metabolomics; Nutrient-gene interaction and expression, reverse transcription and cDNA synthesis, real-time PCR, genetic control on metabolic pathways.

Unit 4: Nutrition and Fish Health

Nutrients and their effects on fish health:Nutritional imbalances, nutritional deficiency, nutrients and immunity, hyper- and hypo-vitaminosis;Dietary lipid and stress tolerance in fish larvae; Myco-toxin in fish feed:Factors favouring mycotoxin production, mycotoxins interactions and pathways, toxins binders, detoxification and amelioration methods; Phytase and phytate in feed ingredients;Role of dietary lipid, vitamin C, vitamin E and carotenoidsin stress mitigation and reproductive performance;Nutraceuticals: Role in immunity and disease resistance;Histological features of gut and associated organs during abnormal nutritional conditions.

57 FISH GENETICS AND BREEDING

Unit 1: Principles of Fish Genetics and Breeding

History and development of genetics;Mendel inheritance, genetic variation; Multiple factor inheritance; Epistasis; Chromosomal theory of inheritance; Sex determination in fish; Gametogenesis;Linkage and crossing over, DNA as genetic material; Genetic code; DNA replication; DNA and plasmid isolation;Fine structure of chromosomes, chromosomal spread preparation technique and karyotyping, chromosomal aberration, chromosomal banding techniques, chromosomal manipulation; Ploidy induction; Sex reversal; Gynogenesis;Androgenesis.

Unit 2: Population, Quantitative and Conservation Genetics

Genetics of population, gene and genotype frequencies and factors affecting them; Qualitative and quantitative traits of individual and population: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 bottleneck and mutation, genetic drift, Founder effect, population mean, variance, heritability, factors affecting heritability; Realized heritability; Limits to selection, asymmetry of response to selection; Evolution and genetic diversity, maintenance of genetic diversity in natural and captive population;Genetic variability and differentiation, equilibrium, null alleles, population genomics, outlier loci and adaptive variation in trait-related genes; Genetic variance components and their estimation; Breeding value and its properties.

Unit 3: Selective Breeding of Aquaculture Species

History of domestication of cultured aquatic species; Stock comparisons methods and mating designs; Genetic basis for selection of fish for breeding;Estimation of breeding values from different methods and source of information; Inbreeding depression and heterosis in aquaculture, managing inbreeding in hatchery population; Cross breeding and hybridization; Genetic gain; Response to selection, methods of selections, aids to selection, mating designs, threshold characters, application of markers QTL and MAS in selection program, selective breeding for ornamentation traits, selection for disease resistance, production of SPF and SPR; Genomic selection; Endocrine control of reproduction in fish and shellfish; Synchronization of spawning; Assessing the gamete quality; Controlled breeding; Genetic aspects of broodstock development and management; Methods of fish identification and pedigree maintenance; Packaging and transportation of fish seed and broodstock; Quarantine procedures; Aquaculture practices for genetically improved stocks; Breeding strategies for threatened species for restocking and live gene bank (LGB);*In situ* and *ex situ* conservation; Conservation and preservation of aquatic species: Issues and strategies;Mutation:Natural and induced;Growth curves; Tagging methods used in fish breeding.

Unit 4: Molecular Genetics and Bioinformatics

Collection and storage of samples for DNA fingerprinting; Isolation and quantification of DNA from different sources; Concept of recombinant DNA techniques cloning and gene mapping;DNA markers in stock identification: Allozymes, RFLP, RAPD, AFLP, microsatellites, ESTs, SNPs, Type I and II markers, mtDNA and nuclear DNA markers, real-time PCR and EST markers, lab assays for markers; Next generation sequencing, applications for species identification, hybridization, stock identification, genetic diversity and conservation, parentage; Linkage and QTL mapping, microarray genes; Transgenics, GMO and biosafety regulations, transgenic containment;Use of biotechnological tools to improve aquaculture production;Data mining tools and techniques, submission of DNA sequences, GenBank sequence database, genome diagnostics, genome and transcriptome analysis, protein information resource, EST database, phylogenetic analysis, microarray informatics;FISH (Florescence in-situ hybridization technique); Geno toxicity (MNT, sister chromosome exchange, comet assay); Synthesis and characterization of nanomaterials, application of nanotechnology in fisheries and aquaculture.

58 FISH BIOTECHNOLOGY

Unit 1: Cellular and Molecular Biology

Cell: cell membrane, cytoplasm, endoplasmic reticulum, golgi apparatus, lysosomes, mitochondria, nucleolus, peroxisomes, cytoskeletal systems-microtubules, microfilaments, and intermediate filaments, sub-nuclear structures; Cell division, cell cycle regulation and cell motility (actin- myosin filaments, cilia, flagella); Cell signalling and signal transduction;Active/passive membrane transport;Protein sorting and trafficking; Apoptosis;Genetic material: Structure of DNA & RNA, stereochemistry of bases and secondary structures, alternative forms of DNA structure; Organisation of the nucleic acids: chromatin structure, telomeres; Physico-chemical properties of DNA: Tm, hyperchromicity, kinetic classes, buoyant density, etc.; DNA replication, transcription and translation; Different types of transposons and intervening sequences; Gene structure; Regulation of gene expression in prokaryotes and eukaryotes: operon concept- Lac and Trp operon, post transcriptional gene regulation; Post translational modifications; Epigenetics; Methylation; CRISPER technologies.

Unit 2: Recombinant DNA Technology

Overview; DNA modifying enzymes: Types of restriction endonucleases (Type I, II and III), DNA polymerases, reverse transcriptase, alkaline phosphatases, kinases, exonucleases, ligases, terminal transferases; Isolation and quantitation of proteins and nucleic acids (DNA, RNA and plasmid); Gel electrophoresis techniques; Cloning and expression vectors in prokaryotes and eukaryotes: Plasmids (replication, copy number control and compatibility), phagemids,cosmids, high capacity vectors (eg. BAC), shuttle vectors, adapters, linkers, ligation, transformation and selection; Expression optimization strategies in eukaryotic and prokaryotic hosts; DNA libraries (Genome and cDNA); Screening and characterisation of clones; PCR technique and types; DNA delivery into prokaryotes and eukaryotes; Site directed mutagenesis; Blotting techniques, nucleic acid probes and labelling; Hybridization; Gene expression analysis (RT-PCR, real time PCR); Applications of recombinant DNA technology (DNA vaccines, therapeutics, diagnostics); Bioremediation; Fermentation; Single cell protein; Transgenesis; Safety aspects & regulation of recombinant DNA technology.

Unit 3: Biochemical and Molecular Markers

Type I and Type II markers; Development and applications of allozymes, mtDNA markers, RFLP, RAPD, AFLP, minisatellites, microsatellites and SNPs, ESTs, DNA barcoding;DNA sequencing technologies: Chemical sequencing, chain termination and NGS, application of NGS for developing molecular markers; Whole genome and transcriptome sequencing and their applications;Functional Genomics: Genomic resources in aquaculture species, gene expression pattern during various development stages of fish, genomic responses to stress challenges in fish, functional genomics in fish/shrimp disease control; Nutrigenomics; Metagenomics: Concepts and applications; Protein information resources; Tools in sequence alignment (pairwise and multiple) and sequence retrieval; Primary and secondary structure database, sequence analysis using various *in silico* tools.

Unit 4: Aquaculture and Marine Biotechnology

Transgenesis in fish: Methods of gene transfer in fishes, screening for transgenics, applications of transgenic fishes, transgenic fishes as bioreactors; Basic requirements for animal cell culture technology: Media and supplements, basic aseptic techniques, primary cell culture, cell lines, types of cell lines and their applications, characterization and maintenance of cells;Fish cell line repositories; Stem cells: Stem cell cultures, embryonic stem cells and their applications; Induced pluripotent stem cells and its applications;Bioreactors; Micromanipulation of cells; Seaweed tissue culture; Reproductive biotechnology: Induced breeding bysynthetic hormones and analogues; Cryopreservation and revival; Cryopreservation of fish gametes and embryos; Cell viability and cytotoxicity assays; Applications of nanotechnology in fish breeding; Disease diagnostic techniques (PCR, RT-PCR, LAMP); Therapeutics: DNA vaccines, hybridoma technology,monoclonal antibody productionand applications; Surrogate broodstock technology;Fuel production from microalgae using biotechnological approaches; Bioactive potential of marine organisms; Bioprospecting and drug from the sea.

59 FISH PHYSIOLOGY AND BIOCHEMISTRY

Unit 1: Introduction to Fish Physiology

Physiology of respiration: Gill morphology, structural and functional variations of respiratory pigments (haemoglobin), mechanism of gaseous exchange, mechanism of oxygen transport by haemoglobin, CO_2 transport, countercurrent principle, water flow across the gills, respiratory pumps, accessory respiratory organs, oxygen sensing, buffer system in blood; Cardiovascular system: Structure and functions of heart, ultrastructure of cardiocytes, physiology of cardiac pumping, blood circulation, blood pressure, composition of blood, heart and cardiac output, structure of blood/hemolymph pigments, cardiac plasticity in fishes; Physiology of osmoregulation and excretion: Excretory and osmoregulatory organs in fish and shellfish and their functions, osmoregulatory strategies in fishes, mechanism of osmotic and ionic regulation, ion transporters and channels, acid base regulation, hormonal regulation of osmoregulation; Mechanism of excretion of nitrogenous wastes; Physiology of digestion: Food and feeding habit, digestive system,physiology of gastro-intestinal tract, absorption and assimilation of nutrients, digestive enzymes, hormonal regulation of digestion, factors affecting digestion; Stress and adaptive physiology: Stages of stress response in fish, thermal stress in fish, responses of fish during hypoxia, C-reactive proteins, HSP, anti-freeze proteins and metallothioneins.

Unit 2: Reproductive Physiology and Endocrinology

Modes of reproduction in fishes:Sex determination and differentiation, sexual dimorphism, primary and secondary sex characters, bisexual reproduction, inter-sexes, hermaphroditism; Sex reversal; Parental care in fishes;Oogenesis; Spermatogenesis; Mechanism of oocyte maturation and ovulation, spawning, gamete activation and fertilization, environmental and neuroendocrine regulation of reproduction in fish, neuroendocrine system in crustaceans; Synthetic hormones for breeding in aquaculture;Endocrinology: Endocrine, paracrine and autocrine regulation of hormones, endocrine functions of pituitary, hypophthalamus, gonads and peripheral endocrine glands; Classification and functional properties of different hormones, hormone receptors and their regulation, mechanism of hormone action at cellular level.

Unit 3: Fish Biochemistry

Carbohydrates: Definition, classification and biological significance, isomers, structure and properties of monosaccharides, disaccharides, polysaccharides and mucopolysaccharides; Proteins:Definition, classification, protein structure, biological significance; Amino acids: structure, classification and functions; Lipids**:**Definition, classification, biological significance; Fatty acids: Structure, properties and chemical reactions, saponification and iodine number, peroxide value of fats, cholesterol, glycolipids, phospholipids, prostaglandins, PUFA; Biochemistry of vitamins and minerals;Enzymology: Nomenclature, classification of enzymes, active site, concepts of activation energy, transition state and enzyme-substrate complex, units of enzyme activity, factors affecting enzyme activity, enzyme kinetics,Michaelis-Menten equation,

Km and Vmax values,Lineweaver and Burke Plots, enzyme inhibition, enzymes of clinical importance; Biochemical techniques: Principle and applications of spectrophotometry, chromatography, HPLC, RIA and ELISA.

Unit 4: Metabolism of Biomolecules

Carbohydrate metabolism: Glycolysis, TCA cycle, pentose phosphate pathway, gluconeogenesis, glycogen metabolism, regulation of blood glucose level;Protein and amino acid metabolism: Biosynthesis of protein, oxidative and non-oxidative degradation of amino acids, transamination and deamination, urea cycle, biosynthesis ofnon-essential amino acids; Lipid metabolism: Biosynthesis of fatty acids, oxidation of fatty acids, ketone bodies, desaturation and elongation of fatty acids, control of fatty acid metabolism, synthesis of prostaglandins; Synthesis and degradation of nucleic acids.

60 FORESTRY/AGROFORESTRY

Unit 1: Forests and Forest Policy

Forests-extent, basis for classification and distribution in India; Geographical distribution and salient features of major world forest types; Phylogeographical regions and vegetation of India; Role of forests in national economy - productive, protective and ameliorative, tribal and rural livelihoods; Forest types of India: distribution and types; Succession, climax and retrogression; Concepts of biomass, productivity, energy flow and nutrient cycling in forest ecosystem; Migration and dispersal mechanism.
National Forest Policy 1894, 1952 and 1988 ; Indian Forest Act, 1927; Forest Conservation Act,1980 and Wildlife Protection Act, 1972; Amendments 1991, 2003 and 2006, Biological Diversity Act, 2002, The Scheduled Tribes and Other traditional forest dwellers (Recognition of Forest Rights) Act, 2006. National Agroforestry Policy, 2014

Unit 2: Silviculture

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; Seed collection, processing, storage, viability and pre-treatment; Seed dormancy and methods for breaking dormancy; Seed testing and germination tests; Seed certification and ISTA Rules; Forest nursery - need, selection and preparation of site, layout and design of nursery beds; Types of containers; Root trainers; Growing media and sowing methods; Management of nursery-shading, watering, manuring, fertilizer application, weed control, insect pest and diseases control; Planting techniques: site selection, evaluation and protection; Soil working techniques for various edaphic and climatic conditions; Planting patterns; Plant spacing, manure and fertilizer application, irrigation/moisture conservation techniques; Choice of species. Afforestation on difficult sites: saline-alkaline soils, coastal sands, lateritic soils, wetlands, ravines and sand dunes, dry and rocky areas, cold desert; Tending operations - weeding, cleaning, climber cutting, thinning - mechanical, ordinary, crown and selection thinning, improvement felling, pruning and girdling;Silviculture of important tree species- *Populus, Eucalyptus, Dalbergia, Acacia, Tectona, Shorea, Prosopis, Casuarina, Pinus, Gmelina, Azadirachta, Diospyros, Pterocarpus, Anogeissus, Santalum, Quercus and Albizia, bamboos, Melia dubia, Ailanthus excelsa , Simarouba and Karanja.* Plantation forestry – industrialand energy plantations

Unit 3: Forest Biology and Tree improvement

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, Hardy weinberg 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; Role of growth substances in vegetative propagation.

Unit 4: Forest Mensuration

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

Unit 5: Social forestry and Agroforestry

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

Unit 6: Agroforestry management

Plant management practices in agroforestry; Tree-crop interactions: ecological and economic; Concept of complementarity, supplementarity and competition; Productivity, nutrient cycling and light, water and nutrient competition in agroforestry; Concept of allelopathy and its impact on agroforestry; Agroforestry practices and systems in different agro - ecological zones of India..

Unit 7: Wood Science and Forest Products

Logging and ergonomics- wood anatomy, wood seasoning and preservation techniques; Forest Products and utilization- Manufacturing and utilization of wood products (timber and composite wood)and non-wood forest products such as fibres, flosses, dyes, gums, resins & tannins, medicinal plants, essential oils, edible fruits, spices, bamboo and canes.

Unit 8: Forest Degradation and Protection

Extent and causes of land denudation; Effects of deforestation on soil erosion,land degradation. Wastelands: their extent, characteristics and reclamation; Watershed management and its role in social, economic and ecological development; Forest fires: causes, types, impacts and control measures; Major forest pests, **diseases**and weeds and **its management**.

Unit 9: Forest Management and Forest Economics

Forest management: definition and scope; Concept of sustained yield and normal forest; Rotation; Estimation of growing stock, density and site quality; Management of even aged and uneven aged forest; Regulation of yield in regular and irregular forests by area, volume, increment and number of trees; land equivalent ratio; 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.Ecosystem services. Economic evaluation of agroforestry systems: cost benefit analysis and land equivalent ratio

Unit 10 : Wildlife

Wildlife biology, ornithology, herpetology, wild life management - Population estimation in wildlife – census methods, Man-animal conflicts and management strategies.

Unit 11 : Forest Genetic Resources and Ecotourism

Role of green revolution in forest conservation in India. *In situ* and *ex situ* conservation of forest genetic resources – Sacred groves; Urban forestry – Choice of species, design, development and management, Eco-tourism.

Unit 12 Climate change and mitigation

Climate change: greenhouse effect, sources and sinks of greenhouse gases, major greenhouses gases; Global climate change – its history and future predictions; Impact of climate change on agriculture, forestry, wildlife, 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 - environmental conservation-carbon sequestration.

Unit 13 : Statistics

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.

61 AGRICULTURAL METEOROLOGY

Unit 1 : General Meteorology

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

Unit 2 : General Climatology

Elements of weather and climate; Climatic controls, factors affecting climate Seasonal distribution of radiation, rainfall. temperature sunshine, wind pressure over India; Climatic classification - Koppen and Thornthwaite; Hargreaves and Trolls classification; Climatology principles of weather phenomena occurring in four main seasons of India; Mechanism of Indian monsoons; Climatic variability,recent trends, Mitigation and adaptation strategies, 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, polar maritime and monsoon climates, El-Niño, La Nino and their impact on Indian rainfall systems.

Unit 3 : Agricultural Climatology

Meaning and scope; Effect of thermal environment, Diurnal variation; on growth and yield of crops; Cardinal temperatures; Thermoperiodism, photoperiodism; Vont Hoff's law, phenology of crops; Heat unit concept, thermal time and thermal use-efficiency and their applications; Length of growing period determination. contingency planning far different weather aberrations, and

extreme weather events; Meteorological factors associated with incidence and development of crop pests and disease, pest and disease out breaks etc.; Effect of climate on humans and animals, warm and cold season indices for comfort zones, role of weather in animal disease and protection against weather hazards.

Unit 4 : Micrometeorology

Concept of micro, meso and macro meteorology; Micrometeorological processes near bare ground and crop surfaces; Shearing stress, molecular and eddy diffusion, forced and tree convection; Boundary layer, frictional velocity, roughness length and zero plane displacement; Micrometeorology of crops, rice and wheat; Day and night radiation, humidity, temperature, wind and CO2 profiles in crop canopies; Richardson number, Reynolds analogy, exchange coefficients, fluxes of momentum, water vapors, CO2 and heat; Inversion and its effect on smoke plume distribution; Windbreaks and shelterbelts, different methods on modification of field microclimate; Frost protection, hail suppression spectral properties of vegetation; Light interception by crop canopies as influenced by leaf area index, leaf arrangement and leaf transmissibility, extinction coefficient and radiation use–efficiency; Microclimate of field crops, forest and orchards etc.

Unit 5 : Evapotranspiration

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

Unit 6 : Crop Weather Modeling

Concepts of mechanistic and deterministic models; General features of dynamical and statistical modeling techniques; Crop weather models and their use in crop yield assessments; Crop weather analysis models, empirical, statistical models, and differentcrop growth simulation models for yield assessment; concepts for crop growth and yield; Advantages and limitations of modeling, climatic change, greenhouse effect, CO2 increase, global warming and their impact on agriculture.

Unit 7 : Weather Forecasting for Agriculture

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

62 ENVIRONMENTAL SCIENCES

Unit 1

Definition and scope of environmentalscience and its interrelationship with other sciences and agriculture; Segmentsatmosphere: hydrosphere, Lithosphere and biosphere; Components of environment - biotic, abiotic and social; Ecological Foot prints.Natural resources: land, soil, water and forest and; present status - Land degradation – Wasteland: their extent, characteristics and reclamation; water conservation : watershed management and rain water harvesting - Major river projects and its impacts; Mineral resources - Environmental effects of mining; Food resources – problems; Ecology concepts – types – habitat ecology, systems ecology, synecology, autecology; Ecosystem: Structure- Functions; Population -characteristics and measurement; Communities - habitats, niches, biomes, population dynamics, species and individual in the ecosystem; Recent trends in ecology; Characteristic features - structure and function of forest, grassland, plantation, desert; Aquatic and agro-ecosystem. Energy flow in ecosystems and environment; Energy exchange and productivity-food chains and food webs-ecological pyramids; Ecological succession - types and causes. Biogeochemical cycles; nutrient cycles and recycle pathways.

Unit 2

Biodiversity concepts, levels and types, Values and Significance of biodiversity; Theories on biodiversity; Agro-biodiversity – Transgenic crops and animals – Impact on Environment. Plant genetic resources, exploration and collection; Biogeographical zones of India;Biodiversity hot spots in India and world; Loss of biodiversity – Causes - Crop domestication, plant introductions - exotics and invasive plants - IUCN clauses and concept of threatened and endangered species; - Methods of conservation - *in-situ* and *ex-situ*-national parks, wildlife sanctuaries, biosphere reserves; National and global conservation measures - institutions and conventions - Indian Biodiversity Act 2002; World heritage sites; Wetlands – Mangroves – Ramsarconvention.

Unit 3

Environmental Pollution - Point and non-point sources - Atmosphere – stratification - Composition of air-; Air pollution: sources and classification - Criteria pollutants - Indoor and out-door air pollution,; Types - primary and secondary pollutants – Thermal Inversion - Air pollution Episodes -Air Quality standards –Greenhouse gases – Global warming – Ozone depletion – Acid rain – Impacts on Environment - Effects of air pollutants on vegetation, animals and human health; mitigation measures for combating air pollution; Automobile pollution, Noise pollution-sourceand effects, Disasters and their management: floods, droughts, earthquakes; Tsunami, cyclones and landslides; Adaptation and mitigation strategies of climate change - Carbon sequestration and clean development mechanism. National and international laws and policies on air pollution. Environmental treaties; Role of NGO's in environmental protection; Corporate Social. Responsibility (CSR) of industries in environmental protection; Advance tools

for ecosystem analysis – Remote Sensing (RS) and Geographic Information Systems (GIS). EIA and Environmental Auditing.

Unit 4

Urban and Industrial wastewater - Pollution ofponds, lakes, rivers and ground water. Impacts of water pollutants on Environment- Effluent Treatment Processes –Energy production recycling of treated wastewaterand value addition to wastes -Permissible limits.
Soil pollution - sources - Organic and inorganic contaminants, Xenobiotics and their effect on agriculture: Heavy metals and pesticides -Effects of pollutants on soil health and productivity; Radioactive pollutants – Impacts; Remediation of contaminated soil – Microbial, chemical ameliorants, phytoremediation and Nano remediation; Permissible limits of organic and inorganic pollutants.

Unit 5

Solid waste – sources – Categories - hazardous and non-hazardous - impact on Environment – Management strategies – 5 R concepts - Thermal conversions – Pyrolysis – Gasification – Incineration;Biodegradation of organic wastes - Composting, Vermicomposting, Mushroom production,SCP; Energy recovery- biogas, landfill, etc. E- waste - impacts and resource recovery; Solid waste management rules in India.

Unit 6

Energy - Types -of renewable sources of energy; Solar energy: Energy transfer and applications- Solar thermal system and their applications Wind energy –Types Geothermal and tidal energy; Bioenergy from biomass
Liquid fuels from petro crops,-
Concepts of producer gas; types of
gasifiers; Briquetting of agro-wastes for fuel; Potential of renewable energy sources in India, Integrated rural energy programme;
Nuclear energy–

Unit 7

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

63 AGRICULTURAL PHYSICS

Unit 1: Basic Physics

Conservation of mass, energy and momentum; Forces in nature; Measurement of heat, specific heat, transfer of heat; Huygen's principle, reflection, refraction, diffraction, polarization, interference and scattering of light waves; Optics theory, principles of optical instruments; Change of phase and polarization, equation of state, Laws of thermodynamics; Free energy, Entropy and concept of negative entropy; Vont Hoff's law; Cathode rays; Radio activity, alpha-, beta-, and gamma- rays, detection and measurement of radiation; Properties of X-rays; Bragg's law; Nuclear fission, fusion, nuclear reactions, neutron moderation, nuclear energy, atomic power; Radioactivity and its applications in agriculture.

Unit 2: Soil Physics

Factors and processes of soil formation; Physical, physicochemical and biological properties of soils; Soil water retention and movement under saturated and unsaturated conditions; Infiltration, redistribution and evaporation of soil water; Field water balance and water use efficiency; Soil aeration; Thermal properties of soil and heat transport; Influence of soil water, temperature and aeration on crop growth and their management; Soil erosion and control; Soil physical constraints and their management..

Unit 3: Radiation Physics

Basics of Electromagnetic spectrum and its interaction with matter; Laws of radiation, scattering, reflection, transmission, absorption, emission, diffuse and specular radiations; Radiation units, flux, intensity, emittance, inter conversion of radiometric units; Energy balance of land surfaces.

Unit 4: Plant Biophysics and Nano Technology

Introduction and scope of biophysics; Structure and properties of water; Experimental techniques used for separation and characterization of biomolecules sedimentation, ultra-centrifugation, diffusion, osmosis, viscosity, polarization and electrophoresis, chromatography; Fibre physics; Basic Spectroscopic techniques, UV-Visible, IR, NMR, EPR spectroscopy, X-ray diffraction; Chlorophyll fluorescence; Nanostructures, Properties and characterization of nanomaterials; Nano-biology, hazards of nanomaterial; Applications of nanotechnology in agriculture.

Unit 5: Remote sensing

Electromagnetic radiation, and interactions with the matter, remote sensing system – active and passive, sensor and platform; Radiometric quantities; Spectral signatures of natural targets and its physical basis, spectral indices; Satellite characteristics, spatial, spectral, radiometric and temporal resolutions; Air borne remote sensing; Imaging and non-imaging systems; Multispectral, hyperspectral, thermal and microwave remote sensing; Digital image processing;

National and International satellite systems for land, weather, ocean and other observations; Applications of remote sensing in agriculture.

Unit 6: Geoinformatics

Basic concepts and principles: Hardware and software requirements; Common terminologies of geographic information system (GIS); Maps and projections, principles of cartography; Basic geodesy: Geiod /Datum/Ellipsoid; Cartographic projections, coordinate systems, types and scales; Accuracy of maps; Raster and Vector data model; DBMS; Geostatistical analyses; Spatial interpolation - Thiessen polygon; Inverse square distance; Digital Elevation Model; Principles of GPS; DGPS; Errors in GPS data and correction; GPS constellations; Geoinformatics application in agriculture and natural resource management.

Unit 7: 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; Weather forecasting: numerical weather prediction; El Nino, La Nina and ENSO; Climate change, global warming, impacts of climate change on agro-ecosystems; 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; Exchange of mass, momentum and energy between surface and atmosphere, exchange coefficients; Richardson number & Reynold's analogy; Boundary layer; Eddy covariance techniques; Wind profile; Modification of microclimate; Radiation distribution within the plant canopy; Concept of evapotranspiration: potential, reference and actual evapotranspiration, crop coefficient; Measurement of evapotranspiration.

Unit 8: Mathematical Modelling of soil-plant-atmosphere system

Applications of matrices: Differentiation and integration; Numerical modelling: finite difference and finite element; Spatial statistics: Variogram and interpolation techniques; Surface modelling; Root water uptake models; Simulation models for water, heat, and solute movement in two- and three dimensional porous media; Fundamentals of dynamic simulation, systems, models and simulation; Mechanistic, stochastic and deterministic models; Model calibration, validation and sensitivity analysis; Crop weather models and its use in crop yield estimation; Advantage and limitations of modelling.

64 AGRONOMY

Unit 1: Crop Ecology and Geography

Principles of crop ecology; Ecosystem-concept and determinants of crop productivity; 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, detection and indices; Remote sensing: Spectral indices and their application in agriculture.

Unit 2: Weed Management

Scope and principles of weed management; Weed classification, biology, ecology and allelopathy; Weed seed dormancy, Crop weed competition, weed threshold; Herbicides classification, formulations, mode of action, selectivity and resistance; Persistence of herbicides in soils and plants; Application methods and equipment; Cultural, physical, chemical and biological weed control, bio-herbicides: Integrated weed management; Special weeds, parasitic and aquatic weeds and their management in cropped and non-cropped lands; weed control schedules in field crops, vegetables and plantation crops; Role of Genetically Modified (GM) crops in weed management.

Unit 3: Soil Fertility and Fertilizer Use

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

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, effect on plant growth,

drought resistance, drought avoidance, drought management; Crop Planning including contingency, crop diversification, varieties, cropping systems 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; Summer ploughing, seed hardening, pre-monsoon sowing, weed and nutrient management; Concept and importance of watershed management in dryland areas.

Unit 5: Crop Production

Crop production techniques for cereals, millets, pulses /grain legumes, oilseeds, fiber crops, sugarcane, tobacco, fodder and pasture crops including origin, history, distribution, adaptation, climate, soil, season, modern varieties, seed rate, fertilizer requirements, crop geometry, intercultural operations, water requirement, weed control, harvest, quality components, industrial use, economics and post-harvest technology. Package of practices in the respective locations.

Unit 6: Agricultural Statistics

Frequency distribution, standard error and deviation, correlation and regression analyses, co-efficient of variation; Tests of significancet test, F test and chi-square (x_2); Data transformation and missing plot techniques; Design of experiments and their basic principles, completely randomized, randomized block, split plot, strip-plot, factorial and simple confounding designs; Efficiency of designs; Methods of statistical analysis for cropping systems including intercropping; Pooled analysis.

Unit 7 : Sustainable Land Use Systems

Tillage - Concept, types, tilth, tools and implements; Modern concepts of tillage and conservation agriculture; Land capability classification, Alternate land use and Agro forestry systems; Types, extent and causes of wasteland; Shifting cultivation; Concept of sustainability; Sustainability parameters and indicators; Agricultural and agro-industrial residues and its recycling.

Unit 8: Soil-Plant-Water Relationship

Importance of water in agriculture; Hydrological cycle; runoff and infiltration, factors affecting infiltration; Soil water relations, water retention by soil, soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water; Soil irrigability classifications, Determination of soil water content, computation of soil water depletion, soil water potential and its components; Movement of soil water-saturated and unsaturated water flow; Evapotranspiration (ET), PET, AET and its measurements. Crop co-efficient; Plant water relations: Concept of plant water potential, its components; Methods of moisture estimation in plants. Soil and water conservation – measures – agronomical, mechanical and agrostological.

Unit 9: Irrigation Water Management

History of irrigation in India; Major irrigation projects in India; Water resource development; Crop water requirements; Concepts of irrigation scheduling, Different approaches of irrigation scheduling; Concept of critical stages of crop growth in relation to water supplies; Methods of

irrigation *viz.* surface, subsurface and pressurized irrigation methods, merits and demerits; Measurement of irrigation water, application and distribution efficiencies. Conjunctive use of water; Interaction between irrigation and fertilizers.

Unit 10: Management of Problematic Soils and Crop Production

Problem soils and their distribution in India, acidic, saline, waterlogged and mined- soils; Response of crop to acidity, salinity, 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; Degraded lands and their rehabilitation. Management strategies for flood prone areas; Drainage for improving water logged soils for crop production; Crop production and alternate use of problematic soils and poor quality water for agricultural.

Unit 11: Cropping and Farming Systems and Organic Farming

Cropping system – Definition, principles, classification; Cropping system for different ecosystem; Interaction and indices; Non-monetary inputs and low cost technologies.LEIA, HEIA and LEISA;Farming systems – type – natural, bio-dynamic, bio-intensive, response, precision, biological and organic farming; organic and bio inputs, Soil health and organic matter and Integrated organic farming systems; IFS – concepts, models for different ecosystem, resource recycling and evaluation.

65 SOIL SCIENCE/SOIL SCIENCE & AGRICULTURAL CHEMISTRY

Unit 1: Pedology

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, Interpretation of soil survey data for land capability and crop suitability classifications, Fertility Capability Classification- Nutrient indexing. Macro-morphological study of soils. Application and use of global positioning system for soil survey. Soil survey- types **and** techniques. Soil series characterization and procedure for establishing soil series, benchmark soils and soil correlations. Study of base maps: cadastral maps, toposheets, aerial photographs and satellite imageries. Use of geographical information system for preparing thematic maps. Application of Remote Sensing in soil survey and mapping. Soils of India

Unit 2: Soil Physics

Significance of soil physical properties. Soil texture – Stoke's Law- textural classes. Soil structure – classification, soil aggregation and significance, soil consistency, 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- saturated and unsaturated flow- Darcy's law - hydraulic conductivity - infiltration, percolation, permeability, drainage and methods of determination of soil moisture. Thermal properties of soils, soil temperature. Soil air- composition, gaseous exchange, influence of soil temperature and air on plant growth. Soil physical constraints affecting crop production and their management strategies.Methods of soil analysis - particle size distribution, bulk and particle density, moisture constants. Soil erosion - types, effects,. Rain erosivity and soil erodibility. Runoff - methods of measurement, factors and management. Soil conservation measures. Characterization and evaluation of soil and land quality indicators; Causes of land degradation; Management of soil physical properties for prevention/restoration of land degradation; management of waste lands; Concept of watershed – its characterization and management.

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; Charge development on clays and organic matter; pH-charge relations; Buffer capacity of soils. Inorganic and organic colloids- surface charge characteristics, diffuse double layer, zeta potential. Soil organic matter fractionation, humus formation and theories clay-organic interactions. Cation exchange – Hysteresis-definition. Nitrogen, potassium, phosphorus and ammonium fixation in soils and management aspects.

Unit 4: Soil Fertility

Essential elements in plant nutrition; Nutrient cycles in soil; Transformation and movement of nutrients (Macro and micro nutrients) in soil; Manures and fertilizers; Fate and reactions of fertilizers in soils; Slow release fertilizers and nitrification retarders- Soil fertility evaluation- Concepts and approaches ;. FCO Soil fertility evaluation – soil testing, plant and tissue tests and biological methods; Common soil test methods for fertilizer recommendation; Nutrient Management concepts- INM, IPNS, SSNM- Soil test-crop response correlations; Fertilizer application methods- Nutrient use efficiency- Macro and micronutrients. Nature, properties and development of acid, acid sulphate, saline and alkali soils and their management; Lime and gypsum requirements of soils; Irrigation water quality - EC, SAR, RSC. Fertility status of soils of India. Pollution: types, causes, and management. Carbon sequestration and carbon trading. Modern methods of soil, plant and fertilizer analysis; Flame photometry and inductively coupled plasma optical emission spectroscopy; Spectrophotometry - visible, ultra-violet and infrared; Atomic absorption spectrophotometry; Potentiometry and conductimetry; X-ray diffractometry; Mass spectrometry.

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, 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. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures. Biofertilizers – definition, classification, specifications, method of production and role in crop production.

Unit 6: Statistics

Experimental designs for pot culture and field experiments; Statistical measures of central tendency and dispersion; Correlation and regression; Tests of significance - t and F tests; Computer use in soil research, Geostatistics.

66 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, SN1 and SN2 reactions, reaction involving free radicals, and carbene intermediates, Organic reagents and catalysts in organic synthesis,. Beckmann, Claisen condensation, Hofmann-Loffler-Freytag reaction, Petrno-Buchi reaction, Curlius, Michael, Kolbes, Arndt-Eistert and Wittig reaction. Reformatsky reaction., Barton reaction, Umpolung reaction, Norrish Type I & II reactions.

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, FTIR; 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 polymers. Chemisty of terpenoids, alkaloids, phenolics, plant pigments, steroidal and triterpenic saponins and sapogenins; juvenile and moulting hormones; Plant derived nutraceuticals; Chemistry of natural antioxidants and food colorants and their application in human and crop health. Biosynthetic pathways of natural products.

Unit 4 : Naturally Occurring Insecticides

Natural pyrethroids, nicotine, rotenone, neem and karanj based botanical pesticides; microbial macrolides (avermectins and milbemycins), agricultural antibiotics, semiochemicals; insect pheromones-types and uses, insect hormones, insect growth regulators; Plant hormones, phytoalexins, essential oils and their pest control properties; advantages and limitations of natural pesticides; juvenile hormones, juvenile hormone mimics and anti-JH; chemosterilants, insect antifeedants, insect attractants and repellents; microbial pesticides; Application of plant biotechnology in crop protection, herbicide tolerant and insect resistant transgenic plants

Unit 5: Synthetic Insecticides, Fungicides, Nematicides and Rodenticides

History, scope and principles of chemical insect control; Insecticides and their classification Chemistry of major groups of insecticides (organo-chlorine, organo-phosphorus, organo-carbamates, synthetic pyrethroids, neonicotinoids), fungicides (inorganics, dithiocarbamates, OP's, phenols, quinines, 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 toxicological properties 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, antioxidants, stabilizers; Application - devices and quality of deposits; Types of spray appliances, seed treatment and dressing; nanotechnology in crop protection, Tools to develop and measure nanoparticles.

Unit 8: Pesticide Residues and their Dynamics in the Environment

Pesticide residues- concepts and toxicological significance; pesticide dynamics in agro ecosystem, biotic and abiotic transformations affecting fate of pesticides. 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, microbial and photochemical degradation, adsorption/ desorption, leaching in soil.

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 insecticides; 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, Accreditation certificate, Pesticide stewardship. (at PG level syllabus-SRF).

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 fertilizers and 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; Effect of pesticide on soil health, persistent organic pollutants, and their effect on ecosystem. Adverse effect of industrial effluent on the soil and aquatic environment; disposal of obsolete and outdated pesticides; physical, chemical and microbial decontamination and detoxification of pesticides. Agrochemicals and homeland security, misuse of agrochemicals (pesticides and fertilizers), hazard mitigation plans or strategies, analytical and bioassay techniques to assess off-farm migration of agrochemicals into natural waters, ozone depletion causing agrochemicals.

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.

67 WATER SCIENCE AND TECHNOLOGY

Unit 1: General Concepts of Water Resources Management

Water Resources of India, their Development; History of irrigation in India; Major irrigation projects in India; Type of Water-Green/Blue/Grey; Water Resources Distribution. Present Water requirement and needs for future in different Sectors. Rainfall(South-west monsoon, north-east monsoon, winter and hot weather period); Water budget of India; Irrigation Legislation-interstate water dispute, Concept of Water Pricing, Sustainable use and management of Water Resources, Impact of Climate Change on Water Resources and its availability in space and time, Interlinking of rivers.

Unit 2: Soil Water Plant and Atmosphere Relationships

Soil characteristics in relation to profile and soil horizon, Soil water potential, its various components and method of their measurements. Movement of water in soils and its measurement, Properties of soil in relation to irrigation. Physical, Chemical, Biological Properties of Water; Plant water relations and role of water in plants,water loss through transpiration and factors affecting it, its measurement and the factors influencing it, Water stress in plants and its effect on growth, quality and yield. Water relationship of cell and whole plant, Water uptake by plants and its movement mechanism. Weather parameters influencing soil-water-plant relations and its measurements, Water footprint.

Unit 3: Crop Water Requirement

Concepts of crop water requirements, irrigation planning and its factors, factors affecting irrigation water requirement. Soil Moisture Constant and its management, Soil Moisture Characteristics Curve, Soil Moisture Measurement; methods and its constraints, Introduction to Methods of estimation of reference evapo-transpiration and crop consumptive use, soil and land irritability assessment, Water Productivity, Concept of field water balance, various components of field water balance their estimation of crop planning in relation to changing scenario of input availability, Estimation of seasonal and annual water requirement of various field crops, progressive peak and seasonal consumptive water use and their significance in operation of irrigation projects.

Unit 4: Soil and Water Conservation

Concept of Soil and Water conservation, Relevance of soil and water conservation in Agriculture, Problems caused by soil erosion, factors affecting soil erosion, Types of soil erosion, mechanics of water and wind erosion, Erosivity and Erodibility, Measurement of soil erosion, Hydraulic jump and energy dissipater for erosion central structures, design of Soil and Water Conservation Structures-Drop structures, Drop-inlet Spillway, Chute Spillways; Farm ponds and temporary storage reservoirs,. Sediment yield and transport, water detention

structures.

Unit 5: Hydrology and Watershed Management

Hydrological cycle, Precipitation; types and forms, characteristics, Rainfall measurement and analysis, Abstraction/Initial loss from precipitation, Principles of Evaporation and its measurement Rainfall-Runoff Relationship, Stream flow measurement, Hydrographs, flood routing.
Concept of watershed, principles and objectives, characterization, priority watershed, integrated watershed management, Water harvesting technique small storage and traditional methods, Integrated watershed management, people participation; Watershed management programme in the country-overview, planning and guidelines success and failures, economic evaluation, watershed policy formulation for planning and management, evaluation and environmental assessment, watershed policy formulation for planning and management, Extension strategy, RRA, PRA and PAR, economic issues, institutions and water users associations.

Unit 6: Irrigation Water Management & Drainage

Measurement of irrigation water, application and distribution efficiencies; Management of water resources (rain, canal and ground water) for agricultural production; Management of irrigation water; Concepts of irrigation scheduling, Different approaches of irrigation scheduling; Soil water depletion plant indices and climatic parameters; Concept of critical stages of crop growth in relation to water supplies; crop coefficients, Methods of irrigation *viz.* surface methods, merits and demerits of various methods, design and evaluation of irrigation methods, Conjunctive use of irrigation water, irrigation strategies under different situation of water availability, Irrigation efficiencies; Canal water Distribution, Design of irrigation structures.
Drainage- concepts and classsification; Field drainage system with special emphasis on crop production and soil salinity. Inter relationship of drainage with cropping patterns and types of farming; Drainage requirement of crops and method of field drainage , their layout and spacing.

Unit 7: Management and Remediation of Poor quality Soil and Water

Irrigation water quality, rating and suitability; Eutrophication, Management of brackish water for irrigation, Salt Balance**,** Area and distribution of problem soil – acidic, saline, sodic and physically degraded soils;origin and basic concept of problematic soils, and factors responsible for it. Morphological features and of saline, sodic and saline-sodic soils; Basic Concept of Soluble salts, ESP, pH, physical, chemical and microbiological properties. Acid soils–nature of soil acidity, sources of soil acidity, effect on plant growth, lime requirement. Management of acid soils. Management of saline and sodic soils; salt tolerance of crops – mechanism and rating; monitoring of soil salinity in the field.

Unit 8: Basics of pressurized irrigation system

Introduction to Micro- Irrigation, Merits and Demerits of Micro Irrigation, Scope and Applications of Micro Irrigation,Types & components of Micro-Irrigation Systems -Drip, Sprinkler, Sub-Surface, Bubbler; Basic Design, operation and maintenance of Sprinkler System. Fertigation System.

Unit 9: Rainfed Agriculture

Prospects of rainfed agriculture, climate change and its impact, characterization of rainfed areas, moisture stress and low productivity, rainfall analysis, dry and wet spells, Application of Remote Sensing in rainfed farming, Resource conservation techniques, Drought- types and constraints , Drought resistance in crops, mechanism for drought tolerance and crop adaptability to drought situations, Soil moisture conservation and utilization, moisture retention and availability concepts, water adsorption by plants under stress conditions. Water loss through evaporation and transpiration, conservation tillage, irrigation techniques, mulches and evaporation suppressant its management under stress conditions, mulches, anti-transparent – their kinds, effectiveness and economics.

Unit 10: Ground Water Management, Wells and Pumps

Scope of groundwater development, Aquifer types, properties and parameters, Principles of groundwater flow, Management of declining and rising water table, Natural and artificial groundwater recharge, Groundwater recharge basins and injection wells, Groundwater management in irrigation command, conjunctive water use, water lifting, different types of pumps, selection of pumps, pump characteristics curve, cost of groundwater pumping.

68 AGRICULTURAL ECONOMICS

Unit 1: Economic Theory

Nature, Scope and methods of economics-Economic systems- Basic economics concepts in economics- Theory of consumer behaviour –cardinal utility approach-ordinal utility approach-indifference curve analysis-income and substitution effect-derivation of demand – applications of indifference curve analysis- revealed preference hypothesis- elasticity of demand and determinants-consumer surplus- Neo-classical theory of Production- Production function – Isoquants – Properties – homogenous production functions and Returns to scale - Technical progress– definition and types. -Profit maximization –Neoclassical theory of costs – Derivation of various types of cost curves- Cost minimization vs. profit maximization. Modern theory of costs-Derivation of supply and lay of supply-producer's surplus.

Market classification-pure and perfect competition. Characteristics and price determination under perfect and imperfect markets (monopoly, oligopoly and monopolistic competition)-- Theory of income distribution and factor shares- General Equilibrium theory- Pareto optimality- Social welfare function- National income-concepts and measurement methods- Theory of employment-classical. Keynesian and post Keynesian theories of income determination. Consumption, Investment and saving functions-Concept of multipliers and accelarators- general equilibrium of product and money markets-IS and LM framework-inflation-types and control measures, Monetary and fiscal policies-instruments and effectiveness.

Unit 2: Economic and Agricultural Development

Concept of economic development and economic growth-indicators and measurement-Criteria and characteristics of developing nations-economic and non-economic factors of economic growth-, stages and theories of economic development- economic growth models-classical and neo-classical growth models, role of state, markets and civil society in economic development, institutions and economic development, international development institutionsObjective and processes for economic planning in India, economic and trade reforms in India.

Role of agriculture in economic development, theories of agricultural development, agricultural policies (price, land, credit, R&D, trade, subsidy, etc.)-agricultural development issues-poverty, inequality, unemployment and environmental degradation-agricultural development programmes in India, issues of water, energy, environment, food and nutrition security, agro-eco -regional planning, assessment of ecosystem services, farm-non-farm linkages.

Unit 3: Public Finance and International Economics

Public Finance: Public and private finance. General principles of public finance. Principle of maximum social advantage. Public revenue. Incidence of tax and financial policies. Public expenditure and economic development. Balanced and unbalanced budgets. Limitations of fiscal policies. Fiscal policy as an instrument of development. Structure of development taxation. Public debt policy and economic development, international Economics: Principle of

comparative advantage. Factor endowment theory, Balance of payments. . Trade with many goods and countries; Leontief paradox; human skills; technological gaps; the product cycleTrade policy: Protection; tariff and non-tariff measures; trade and market structure; trade liberalisation; factor mobility and movements; role of multinational enterprises. National competitive advantage – Porter's diamondProblems of international monetary systems, Foreign trade and foreign capital. Export promotion and input substitution. Past experiences and future strategies.

Unit 4: Farm Management Economics

Definition of farm management and its relationship to technical and social sciences. Characteristics of modern farming. Role and functions of farm management under Indian condition. Measurement of management. Measures of farm efficiency. Cost concepts. Evaluation of farm assets and liabilities. Decision theory and decision making models. Decision making under different knowledge situations. Tools and techniques in farm decision making. Farm planning and budgeting-sources of data and illustration. Linear programming. Problem formulation in farm planning. Farm records and accounts. Farm inventory with applications to farming enterprises. Farm cost accounting for managerial analysis. Management of farm resources-land, labour, capital and machinery. Review of farm management research, education and extension in relation to changing needs. Systems approach in agriculture. Farming systems, identification of farming system inputs and outputs, sub-systems and the circuitry connecting these systems. Systems analysis to find out needed changes in policies and programmes.

Unit 5: Agricultural Production Economics

Nature and scope of agricultural production economics vis-à-vis farm management. Relative importance of farm production economics and farm management in developed and developing countries. Economics of farm production- resource allocation and use under static and dynamic conditions. Resource — product relationships in agriculture. Types of production functions, frontiers technical and allocative efficiency. General rules of their economics application. Technological change and production function analysis. Principles of choice and allocation of resources. Resource combination and cost minimization economies of scale and economies of size. Types of risk in agriculture, resource allocation and enterprise combination under risk and risk diffusion mechanisms. Nature of costs and family farm theory. Returns to scale and farm size. Dualities between production, cost and profit functions; Derivation of supply and factor demand functions from production and profit functions.

Unit 6: Agricultural Finance and Co-operation

Role of credit in agriculture and rural development. Estimates of agricultural credit requirements-investment, production, marketing and consumption. Role of public and private section banks and cooperatives in development financing. Classification of agricultural credit. Rural credit structure. Principles of agricultural finance and financial management. Agricultural finance as a part of public finance. Nexus between commercial banks and cooperative credit institutions. Recent innovations in extension of credit to agriculture. Rural credit supply and

credit gap. Multiagency approach and coordination of credit structure at different levels. Agriculture credit policy. Principles and practices of cooperation. Success and failure of cooperative sector in India. Credit and non-credit institutions. National federations of cooperative organizations. Review of reforms in cooperative structure. Single window approach in agricultural input supply and output marketing. Bureaucracy and cooperatives. Management of cooperative institutions. Professionalization and revitalization of cooperatives. Role of cooperatives under new economic policy Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes – yield loss and weather based insurance and their applications.

Unit 7: Agricultural Marketing

Nature and scope of marketing in a developing economy. Classification of markets. Problems of marketing agricultural produce. Functions of marketing. Marketable surplus and marketed surplus. Channels of marketing agricultural produce and price spread Market Sructure, Conduct and Performance (SCP). Marketing institutions, their role and functions. Regulated markets and other state interventions in agricultural marketing. Role of commission on agriculture cost and prices and parastatal organizations in agricultural marketing. Cooperative marketing. Marketing practices and cost-marketing of grains, pulses, commercial crops, fruits, vegetables, livestock and livestock products and inputs. Processing, transportation, storage and warehousing, equity aspects of marketing. Marketing efficiency. Marketing finance-methods and practices. Forward trading and speculation. Future markets. Market management. Agricultural price analysis. Seasonal and spatial variations in prices in agricultural price policy. Agricultural exports, problems and prospects. Role of information technology and telecommunication in agricultural marketing.

Unit 8: Agricultural Project Analysis

Definition of project in agriculture. Need for project approach for agricultural development. Project cycle. Project identification and formulation. Project appraisal-ex-ante and ex-post. Projection worth measures-discounting techniques,net work techniques –PERT and CPM. Project monitoring and mid-course corrections. Project funding.

Unit 9: Research Methodology and Econometrics

Agricultural economics research, steps and themes, collection and analysis of data, scientific report writing., econometric and statistical methods, sampling methods, probability theory. Multiple regression analysis, ordinary and generalized least squares estimators, BLUE, multicollinearity, heteroscedasticity, auto correlation, dummy variables. Simultaneous equation methods

69 AGRIBUSINESS MANAGEMENT

Unit 1: Basics of management &Organizational Behavior

Management – Nature, Scope and Significance of Management - Evolution of Management Thought - Classical School of management, Hawthorne studies, Modern theories of management - Approaches to Management- Functions of management – Planning, organising, staffing, directing (motivation, supervision, communication, leadership) controlling.

Models of organizational behavior. Micro organizational behavior-Personality, perception, attitude.Motivational theories. Leadership styles& theories. Group dynamics - Stages of group development, types of teams. Conflict management.

Unit 2: Human Resource Management

Human Resource planning- Job analysis- Job designing. Recruitment and selection – Training - orientation, Types of training, management development - Performance appraisal. Promotions and Transfers – Types, separation, absenteeism. Wage and salary administration- Types of wages, employee benefits. Employee welfare -Industry relations- Collective bargaining. Quality of work life - Grievance handling.

Unit 3: Financial Management & Managerial Accounting

Financial management objectives & functions – Financial statement analysis - balance sheet, income statement, cash flow statement - Capital Structure, Determinants of size and composition of Capital Structure, Capital Structure Theories; Long term financing and Cost of Capital-Working Capital Management, Determinants of Size and Composition of Working Capital, Cash and receivables management, Working Capital Management Theories,Financing of Working Capital- Financial planning and Forecasting, proforma statements - mergers & acquisition, Capital Budgeting**,** Undiscounted and Discounted methods of Investment Appraisal (Internal Rate of Return (IRR), Benefit Cost (B-C) ratio analysis); Hybrid finance and lease finance - Indian Financial Institutions, markets and intermediaries, Dividend decision - venture capital financing and its stages, micro finance

Importance of agricultural finance; rural credit structure-demand, supply, sources and forms - reforms in agricultural credit policy; innovations in agricultural financing - microfinance, Kisan credit cards - role of institutions in agri-finance - public and private sector banks; cooperatives, micro- finance institutions (MF1s), SHGs;

Financial Accounting- Meaning, Need, Concepts and Conventions -Management Accounting-Meaning, Functions, Scope, Utility, Limitations and Tools of Management Accounting - Cost Accounting – Nature, Significance of Cost Accounting; Classification of Cost, Marginal Costing and cost volume profit Analysis- Its Significance, Uses and Limitations -Budgeting and Profit Planning, Different Types of Budgets and their Preparations, Sales Budget, Purchase Budget, Production Budget, Cash Budget, Flexible Budget, Master Budget, Zero Based Budgeting.

Unit 4: Marketing Management and International Marketing of Agri-products

Agricultural marketing; interventions by institutions, regulated markets, buffer stock operations, price stabilization measures and policies, Forward trading and futures market; contract farming; cooperative and collective farming,Farmer Producer Organizations. Marketing of agricultural inputs, role of private sector in input and output marketing; Rural marketing.

The Concepts of Marketing Management; Marketing Environment; Marketing Mix, Strategic Marketing, Market Segmentation, Targeting, and Positioning; Market Competition Analysis - Consumer buying behavior - Marketing Information System - Marketing potential and demand forecasting, Classification of Products; Product Life Cycle; New Product Development; Product Line and Product Mix; Branding, Packaging and labeling -Factors affecting prices; Pricing Policies and Strategies; Pricing Methods-Types of Distribution Channels; Functions of Channel Members; Channel Management Decisions - Promotion Mix; Introduction to Advertising, Personal Selling, Sales Promotion, Publicity and Public Relations; managing integrated marketing promotion, Customer Relationship Management. Direct & E-marketing and cause related marketing.

International Marketing: Meaning, nature and importance; International marketing environment. International Marketing Segmentation, targeting and Positioning: Screening and selection of markets; International marketing entry strategies. International Product and Pricing Strategies: Product standardization vs. adaptation; product life cycle, Factors affecting International price determination; Managing International Distribution and Distribution channel strategy. International promotion strategies: communications across countries, international promotion mix. International marketing decision making, implementation and control; ecological concerns and international marketing ethics. WTO, agri-exports, procedures for export; analysis of export markets, export promotion organizations, tools and techniques for optimizing the export functions.

Unit 5: Operations management

Nature and Scope of Production and Operations Management; Its relationship with Other Systems in the Organization -Facility location, capacity planning and Layouts, Types of Manufacturing Systems - Process design-Types of process and operations systems: continuous, custom, job shop, batch processing, assembly line. Process - product matrix. Production Planning and Control-Forecasting - Aggregate production planning – Production strategies-Level, chase and mixed strategy. Master production scheduling. Work study- Method and Time study, Maintenance management - Overview of Materials Management, Purchase Management, Determination of Material Requirement, Material Planning, MRP, MRP II - Enterprise Resources Planning. Inventory management, JIT, Pull and Push Systems, Kanban system. Quality Assurance, Acceptance Sampling, Statistical Process Control, Total Quality Management, BIS, ISO and AGMARK quality standards, HACCP procedure, Productivity Variables and Productivity Measurement, Reengineering, value engineering, Value Analysis, Waste and lean Management

Logistics – Introduction, Scope, Functions and Objectives, Role of Logistics in competitive

strategy, E- Logistics – Structure and Operation, Reverse logistics. 3 PL and 4 PL. Warehousing functions, Types- Material Handling and Storage Systems- Distribution Management – Strategies, Transportation system –Infrastructure, Networks and Transport economies. Packaging – Consumer and Industrial packaging. Supply chain – Fundamentals, Drivers - Decisions in Supply Chain. Supply chain coordination, Current Trends in Supply Chain Management – E business. IT Applications in SCM and value chain management

Unit 6: Managerial economics

Scope of managerial economics, objective of the firm and basic economic principles; Consumer theory. Demand analysis - meaning, types and determinants of demand; demand function; demand elasticity; demand forecasting-need and techniques. Production, cost and supply analysis- production function, least-cost input combination, factor productivities and returns to scale, cost concepts, cost-output relationship, Pricing-determinants of price-pricing under different market structures. Price discrimination- Factor prices-pricing under different market structures, government policies and pricing. National income; circular flow of income: consumption, investment and saving: money-functions, demand & supply; inflation; economic growth; business cycles and business policies; Recent developments in the national and international economic and agricultural scenarios.

Unit 7: Research methods

Objectives, types, and process of research; Problem formulation; formulation of hypothesis and testing - Scales of measurement; Sampling design, Types of sampling - Probability and non-probability sampling techniques, sample size determination, sampling and non-sampling errors. Role and uses of quantitative techniques in business decision making, Data collection methods – sources of data – Data editing, coding tabulation – data analysis – statistical methods- Univariate and multivariate techniques - Report writing.

Unit 8: Operations research

Linear Programming: Objective, Assumptions, Formulation of Linear Programming Problem, Graphic Method, Simplex method; Transportation and Assignment Problems; Inventory control Models, Costs Involved in Inventory Management, Types of Inventory; Waiting Line Models: Waiting Line Problem, Characteristics of a Waiting Line System; Decision making under Risk and uncertainties, Decision tree ; Game Theory- Two -Person Zero-Sum Game; Simulation; Network analysis - Markov Chains.

Unit 9: Agribusiness Environment and Policy

Role of agriculture in Indian economy; problems and challenges related to farm supplies, farm production, agricultural finance, agro-processing, agricultural marketing, etc. in the country.

Agribusiness - definition and nature, components of agribusiness management, changing dimensions of agribusiness. Micro and Macro environment in Agribusiness. Structure of Agriculture - Linkages among sub-sectors of the Agribusiness; economic reforms and Indian agriculture; impact of liberalization, privatization and globalization on Agri-business sector.

Emerging trends in production, processing, marketing and exports; policy controls and regulations relating to the industrial sector with specific reference to agro-industries.

Agribusiness policies- concept and formulation - Foreign investment policy in India: Types, advantages and disadvantages of FDI -Emerging trends in production, processing, marketing and exports.

Unit 10: Strategic Management

Corporate strategy, mission and objectives. Values, ethics, corporate social responsibility, corporate governance and strategy. Environment, competitor, industry and internal analysis - Generic strategies, vertical integration and capacity expansion, entry into new business and - growth and diversification strategies - Strategies during industry maturity and decline Strategy in fragmented industries - Strategy implementation. Strategy and managing change. Evaluation of corporate strategy – control, motivation, criteria, corrective action.

Unit 11: Project Management and Entrepreneurship Development

Concept, Characteristics of projects, types of projects, project identification, and Project's life cycle - Project feasibility- market feasibility, technical feasibility, financial feasibility, and economic feasibility, social cost-benefit analysis, project risk analysis - Network Methods: Meaning, Network Analysis, Requirements for Network Analysis, Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT), Project scheduling and resource allocation - Financial appraisal/evaluation techniques- Project implementation, Project control and information system.

Entrepreneurship, Significance of entrepreneurship in economic development and qualities of entrepreneur.

Entrepreneurship for Micro, Small and Medium Scale Enterprises (MSME); Innovation – sources and roles. Entrepreneurial Competencies; Steps involved in setting up of MSME. Establishing MSME Enterprises: Opportunities, Scanning-Choice of Enterprise; Market Assessment for MSME; Choice of Technology and Selection of Site. Enterprises-Getting organized: Financing New enterprises; sources and issues, preparation of business plan; ownership structure and organizational framework. Financial management; Technology and Business incubation process and services in India. Government policy for promotion of agribusiness entrepreneurship. Commercialization of technologies, Intellectual Property Rights – Types, and legislations. Management issues in MSMEs; Management Performance assessment and control; Strategies for stabilization and growth; Managing family enterprises.

70 AGRICULTURAL EXTENSION/EXTENSION EDUCATION/COMMUNICATION

Unit 1: Fundamentals of Extension Education and Programme Planning

Extension Education – Meaning, objectives, concepts, principles and philosophy. Adult Education and Distance Education. Steps in Extension Teaching-Teaching Learning process and Extension approaches of ICAR. Pioneering Extension efforts and their implications in Indian Agricultural Extension –ICAR and SAU, State Departments Extension system and NGOs. Community development and Poverty Alleviation Programmes – SGSY, SGRY, PMGSY, DPAP, DDP, CAPART – Employment Generation Programmes – NREGP, Women Development Programmes – ICDS, MSY, RMK, Problems in Rural Development. National level agricultural development programmes - NADP, NMAE&T, NFSM, Prime Minister seven point strategies for doubling the income of farmers and ARYA. Extension efforts and Rural Development Programmes in pre-independence era (Sriniketan, Marthandam, Firka Development scheme, Gurgaon Experiment, Sevagram, IVS,GMFC) Post – independence era(Etawah pilot project, Nilokheri Experiment, CDP, NES, IAAP, IADP, HYVP, MCP, IRDP, ICDS, DWCRA, TRYSEM, IAY, JRY, SFDA, MFAL). Ongoing development programmes in Agriculture/ Rural/ Animal Husbandry launched by ICAR/Govt. of India (T & V System, BBES, KVK, ATIC, ATMA, NAAP, NATP, NARP, NAIP, NADP, SADP, MGNREGS, PM Kisan, ARYA, NMAET, PMFBY).Different Approaches in Extension- PRA, RRA, PTD, PLA, FAR, PAME, AEA, FSRE, Market – Led – Extension, Farmers' Field School, Kisan Call Centers and ATMA. Programme Planning –Steps, Principles. Monitoring and Evaluation- Steps, Keys and Principles

Unit 2: Extension Methods & Farm Journalism

Extension Methods – Definition, Individual, group and mass approaches in extension, audio-visual aids- classification, selection, use and production. Traditional media for communication in development programmes. Modularized communication- concept, approach, need, process of designing instruction for transfer of communication. Basics of agricultural journalism, types of publications – bulletins, folders, leaflets, booklets, newsletters, popular and scientific articles.

Selection, planning and use of different extension teaching methods like demonstration, exhibition, farmers fairs, field days, tours, extension literature, etc. Preparation and presentation of different projected and non-projected audio-visual aids. Public speaking. Preparation of radio/*vide*o script. Principles of photography and its use in extension.

Unit 3: Information & Communication Technologies and Development Communication

Communication – models, types, elements, characteristics and barriers, Modern extension approaches(Private Extension, PPP, Market and Farmer led Extension, Group approaches – FIGs, CIGs, FPOs and ICT enabled extension), Transfer of Technology – Models, Development Communication– Theories. ICT and Development Communication – Role in abridging Digital divide. Concept of ICT and its role in agriculture and rural development. ICT tools- print and

electronic media- Satellite Radio, Community Radio, Internet Radio, Television, Interactive Television, Newspapers, e-publications, e-mail, Internet, Multimedia, Mobile phony, Video and teleconferencing, computer-assisted instructions, web technologies – Web portals, Mobile apps and Social Media tools,e-learning- information resources, information kiosks, sharing and networking. Types of network – PAN, LAN, WAN. AGRISNET, AKIS, Indian National Agricultural Research database. ICT programmes in agriculture and allied sectors - Problems and prospects. Artificial Intelligence in Agricultural Extension- Expert system, Decision Support System.

Unit 4: Training and Human Resource Development

Human Resource Development – Meaning & importance. Steps in HRD- Recruitment, Induction Staff Training and Development, Career planning; Social and Organizational Culture: Indian environment perspective. Organizational and Managerial values and ethics, organizational commitment; Motivation- Theories – Maslow's hierarchy of needs, techniques & productivity. Job description , Job analysis and Performance appraisal. Human Resource management: Collective bargaining, Negotiation skills, Human Resource Accounting (HRA): Information Management for HR.: Collective behaviour, learning, and perception; Stress and coping mechanisms. Communication and Feedback and Inter personal processes & interpersonal styles. Organizational communication, Team building Process and functioning, Conflict management, Collaboration and Competition. HRD & role of supervisors: Task Analysis, Capacity Building, Counseling and Mentoring; Role of a Professional Manager. Task of a Professional Manager. Managerial skills and Soft Stills required for Extension workers. Decision Making: Decision making models, Management by Objective. Leadership styles – Group dynamics. Training – Meaning, types, models, methods and evaluation, techniques for trainees' participation.

Unit 5: Research Methodology in Extension Education

Science – Four methods of knowing things. Research – Meaning, importance, Types and methods of Research – Fundamental, Applied and Action research, Exploratory, Descriptive, Diagnostic, Evaluation, Experimental, Analytical, Historical, Survey and Case Study. Different steps in scientific research– selection of problem, hypothesis, review of literature, objectives, variables and types, different data collection tools, Sampling techniques and different statistical analysis. Measurement – Meaning, postulates and levels of measurement, Steps in test construction, Item writing and Item analysis. Research Designs– types, MAXMINCON Principle. Meaning and Types of Reliability & validity, Rating scales, Observation, Case studies. Social survey – Meaning, objectives, types and steps. Data processing – meaning, coding, preparation of master code sheet, Analysis and tabulation of data – Parametric and Non-Parametric statistical tools. Report writing – Meaning, guidelines to be followed in scientific report writing, References in reporting.

Unit 6: Diffusion and Adoption of Innovations

Diffusion – Elements, Innovation- Development process; Adoption – Process, Stages; Innovation decision process- Types of innovation decision-Optional, collective and authoritative and contingent; Consequences of innovation decisions- Desirable or undesirable, direct or indirect, anticipated or unanticipated consequences. Innovativeness – concept and types; Adopter categories- Characteristics of adopter categories, Attributes of innovation, Rate of adoption of innovation and barriers in adoption process, Factors influencing rate of adoption; Diffusion effect, Over adoption, Re-invention; Opinion leadership- Measurement and characteristics of opinion leaders- Monomorphic and polymorphic opinion leadership. Models and theories of diffusion- One step flow model, Hypodermic Needle model, Multi-step flow of innovation. Concept of homophily and heterophily and their influence on flow of innovation, Decision making-Meaning, definition and theories , Process and steps and factor influencing of decision making- Role of Change Agents.

Unit 7: Management in Extension

Management – Meaning, concept, nature and importance, Approaches to management, Levels of management, Extension Management - Concept, Importance, Principles and functions of management, Planning – Concept, Nature, Importance, Types. Change Management- Decision making – Concept, Types of decisions - Steps in Decision Making Process, Organizing - Meaning of Organization, Concept, principles, Span of Management, Departmentalization, Authority and responsibility, Delegation and decentralization, line and staff relations

Management by Objective (MBO) and Total Quality Management (TQM). Logical Frame Working (LFW) and Project Management Techniques. Personal management, scope of Agribusiness Management and Institutions - National Institute of Agricultural Extension and Management (MANAGE). Indian Institute of Plantation Management (IIPM), NIRD, EEl and NAARM. Monitoring, evaluation and impact analysis of extension programmes. Critical analysis of organizational set up of extension administration at various levels.

Unit 8: Entrepreneurship Development

Entrepreneurship – Concept, characteristics, Approaches, Theories and Need. Agri – entrepreneurship – Concept, characteristics, Nature and importance for Sustainable Livelihood. Traits of entrepreneurs. Leadership, Decision making, Planning, Organizing, Coordinating and Marketing, Types of Entrepreneurs. Stages of establishing enterprise, steps to be considered in setting up an enterprise, Project Management and Appraisal – Market, Technical, Financial, Social Appraisal of Projects. Micro enterprises – Profitable Agri-enterprises in India – Agro Processing, KVIC industries. Micro financing – meaning, Sources of Finance, Banks, Small scale industries development organizations. Marketing for enterprises – Product sales and promotion.

Unit 9: Market - Led Extension

Agricultural marketing- Concept. Market led extension – Dimensions, emerging perspectives issues and challenges. Development of a marketing plan, pricing concepts and pricing strategy; Consumer behaviour; Market Intelligence, Supply Chain Management, Marketing communication and promotional strategies; Marketing research process; Agricultural trade liberalization and its impact; International marketing opportunities; Implications of AOA, TRIPS and IPR agreements on agriculture; Agreement on SPS and TBT. Commodity features marketing. Public private linkages in market led extension; FPOs and SHG in market led extension; Contract farming.

Unit 10: Gender Sensitization and Empowerment

Gender concepts, Gender roles, gender balance, status, need and scope; Gender analysis – Tools and Techniques. Gender development policies of Govt. of India – The historical evolution.Developmental programmes for women; Gender mainstreaming in agriculture and allied sectors. Gender budgeting. Women empowerment – Dimensions; Women empowerment through SHG approach; Women entrepreneurship and its role. Public Private Partnership for the economic empowerment of women; Building rural institution for women empowerment; Women rights, issues and development.

71 AGRICULTURAL STATISTICS

Unit 1: Statistical Methods I

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

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

Unit 2: Statistical Methods II

Correlation, rank correlation, correlation ratio, intra-class correlation. Simple and multiple regression analysis, partial and multiple correlation. Examination of residuals. Model-adequacy, Selecting best regression. Compound and truncated distribution, Order statistics. Non-parametric tests: run, sign, rank, Wilcoxon, Kruskal-Wallis, Mann-Whitney, Cochran and Friedman's tests. Contingency tables. Log linear models. Sequential analysis, sequential probability ratio test. Components of time series. Multivariate normal distribution: estimation of mean vector and dispersion matrix. Wishart distribution, Hotelling T^2, multivariate analysis of variance, principal component analysis, factor analysis, discriminant analysis, cluster analysis. Linear Programming: formulation and graphical solution, simplex method, duality, transportation and assignment problems.

Unit 3: Statistical Genetics

Statistical analysis of segregation, detection and estimation of linkage. Gene and genotypic frequencies. Random mating and equilibrium in large populations. Disequilibrium due to linkages for two pairs of genes and for sex linked genes. Selection, mutation and migration. Equilibrium between forces in large population. Polymorphism. Fisher's fundamental theorem of natural selection. Polygenic systems for quantitative characters, Concepts of breeding value, dominance, average effect of gene and epistatic interactions. Genetic variance and its partitioning. Correlation between relatives. Regular system of inbreeding, effects of inbreeding. Genotype and environment interaction, stability parameters. Estimation of heritability,

repeatability and genetic correlation. Path coefficient analysis. Heterosis, concepts of general and specific combining abilities. Diallel crosses and line × tester analysis. Response due to selection. Prediction of response to individual, family and combined selections. Construction of selection index.

Unit 4: Design of Experiments

Linear models: Random, fixed and mixed effects. Nested and crossed classifications. Gauss-Markoff theorem. Analysis of variance. Principles of design of experiments. Uniformity trials. Completely randomized design. Randomized complete block design. Latin square design. Factorial experiments: 2^n and 3^n series and asymmetrical factorial experiments, confounding in 2^n and 3^n experiments, split and strip-plot designs, crossover designs. Multiple comparison procedures. Missing plot techniques. Analysis of covariance. Variance stabilizing transformations. Analysis of general block design. Balanced incomplete block designs: construction and analysis. Partially balanced incomplete block designs with two associate classes, lattice designs. Youden square design. Groups of experiments.

Unit 5: Sample Surveys

Sampling versus complete enumeration. Concept of probability sampling. Simple random sampling. Stratified sampling, allocation in stratified sampling, choice of strata, construction of strata boundaries and collapsing of strata. Use of auxiliary information in sample surveys, ratio and regression methods of estimation. Systematic sampling. Cluster and multi-stage sampling with equal probability. Sampling with unequal probabilities with and without replacement, sampling schemes with inclusion probabilities proportional to size. Double sampling, sampling on successive occasions. Non-sampling errors: sources and classification. Randomized response techniques, imputation methods. Design and organization of pilot and large scale surveys. National sample surveys. Agricultural statistics system in the country-land use statistics, crop estimation surveys, livestock and fishery statistics.

72 BIOINFORMATICS

Unit 1: Molecular Biology and Biotechnology

Structure of DNA and RNA, Basics of replication, transcription and translation. Post-transcriptional and translational modifications. Transcriptional and translation control of prokaryotes and eukaryotes. Features of genetic code in prokaryotes and eukaryotes. Gene expression. General principles of recombinant DNA technology, restriction enzymes. Methods of gene transfer-plasmid and viruses as vectors, genomic and cDNA library construction, chromosome walking. Basics of genome organization and mapping, Non-coding RNA, Genome Editing, Gene silencing. Bio-chips.

Unit 2: Preliminaries of Bioinformatics

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, Multiple sequence alignment: PRAS, CLUSTALW.

Unit 3: Genome assembly

Types and methods of genome sequence data generation; Shot gun sequencing method; Problems of genome assembly, Approaches of genome assembly: Comparative Assembly, DE novo Assembly; Read coverages; Sequencing errors, Sequence Quality Matrix, Assembly Evaluation; Challenges in Genome Assembly. Various tools and related methods of genome assembly: MIRA, Velvet, ABySS, ALLPATHS-LG, Bambus2, Celera Assembler, SGA, SOAPdenovo etc.

Unit 4: Evolutionary Biology

Phylogenetic trees and their comparison: Definition and description, various types of trees; Consensus (strict, semi-strict, Adams, majority rule, Nelson); Data partitioning and combination Tree to tree distances, similarity; Phylogenetic analysis algorithms: Maximum Parsimony, Distance based: UPGMA, Transformed Distance, Neighbors-Relation, Neighbor-Joining. Probabilistic models of evolution, Maximum likelihood algorithm; Approaches for tree reconstruction: Character optimization; delayed and accelerated transformation, Reliability of trees, Bootstrap, jackknife, decay, randomization tests.

Unit 5: Statistical Genomics

Frequency distributions, Graphical representations and Descriptive statistics. Elements of probability theory, Conditional probability, Bayes' theorem. Random variable- discrete and continuous. Mathematical expectation. Moment generating and characteristic functions. Probability distributions-Binomial, Poisson and Normal distribution and its application. Sampling distributions and its properties- Chi-square, t, and F. Testing of hypotheses - types of

errors, level of significance and power of a test, Tests of significance based on Z, t, chi-square and F distributions. Concept of sampling, Sampling vs. Complete Enumeration, Simple Random Sampling. Correlation and regression analysis.

Fundamentals of Population genetics: Gene and genotypic frequencies. Random mating and equilibrium in large populations, Hardy –Weinberg law, Effect of systematic forces on changes in gene frequency- Selection, mutation and migration. Equilibrium between forces in large population. Polymorphism. Fisher's fundamental theorem of natural selection. Polygenic systems for quantitative characters, Principles of Quantitative genetics: Values, Means and Variances, Concepts of breeding value, dominance, average effect of gene and epistatic interactions. Detection and Estimation of Linkage, Genetic variance and its partitioning. Correlation between relatives. Genotype and environment interaction. Estimation of genetic parameters. Genome wide association study.

Unit 6: Protein Structure Prediction

Nature of proteomic data; Overview of protein data bases; SWISSPROT, UniProtKB; PIR-PSD, PDB, Prosite, BLOCKS, Pfam/Prodom etc.; Structure analysis: Exploring the Database searches on PDB and CSD, WHATIF Molecular visualization tools; Visualization of tertiary structures, quaternary structures, architectures and topologies of proteins using molecular visualization softwares such as RasMol, Cn3D, SPDBV, Chime, Mol4D etc.

Structure prediction tools and homology modeling: Prediction of secondary structures of proteins using different methods with analysis and interpretation of the results; Comparison of the performance of the different methods for various classes of proteins. (Fasman method, Garnier Osguthorpe Robson (GOR), Neural Network based; methods); NLP approach for secondary structure prediction of RNA; Introduction to mfold and Vienna packages; Prediction of tertiary structures of proteins using Homology Modeling approach: SWISSMODEL, SWISS-PDB Viewer; along with analysis and interpretation of results. Molecular dynamics simulation and docking.

Unit 7: Biological Database Management System

Database Management System (DBMS): definition and purpose of DBMS, Advantages of DBMS, DBMS Architecture- Three level Architecture for DBMS –internal, conceptual and external levels and their Schemas and Mapping, Role of Schemas, Data Abstraction, Data independence-Physical and Logical data independence. Data Models-Relational, Network, Hierarchical. Relational data models (binary, ternary, quaternary & n-ary relations) Components: Relation, Tuple, cardinality, degree. Network model- Entity Relationship (E-R) model-Components of E-R model: Entities, Attributes, Relationships. Relational Databases-, Important terms in relational database system, Primary and Foreign keys. Relational Data Integrity and constraints: Domain Constraints, Entity Integrity, Referential constraints. Normal forms. Structured Query Language- Commands, Queries, Data Definition Language (DDL), Data Manipulation Language (DML). Primary, secondary and derived biological databases, submitting sequence to the Database and retrieval.

Unit 8: Bio-programming and Computational Biology

Object oriented programming, classes, objects, Abstract data types, Data types, Operators (Arithmetic, Logical and Comparison) and expressions. Data encapsulation- modules and interfaces; Polymorphism - Static and dynamic binding, Inheritance: class and object inheritance. Perl: Introduction, Scalar, Arrays and List Data, Control Structures, Hashes, String Handling, Regular Expressions; Subroutines, File handling, BioPERL modules. Machine learning techniques, Supervised and unsupervised learning, Discsion tree, hidden markov model, Artificial Neural Network, Support Vector Machine and genetic algorithms. Pre-processing of gene expression data; Data Normalization techniques, Data quality control: Modelling of errors, Imputation etc; High-throughput screening.

73 COMPUTER APPLICATION & IT

Unit 1: Computer organization and architecture

Boolean algebra, Number system, Basic concepts of floating point number system, Sequential and combinational circuits, 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 language (C++/JAVA)

Computer algorithms, Flow Charts, Encapsulation, Inheritance, Polymorphism, Building blocks, Control structures, Arrays, Pointers, Dynamic memory allocation, File management.

Unit 3: Internet programming

Hyper Text Markup Language (HTML), Building static and dynamic web pages, Client side and server side scripting languages, Interaction with database.

Unit 4: Data structures

Representation of character, string and their manipulation, Linear list structure, Stack, Queue, Heaps, Linked list, Arrays, Tree, Graph, Sorting and Searching algorithms.

Unit 5: Software engineering

Requirement analysis and specification, Software Development Phases, Process models, Project structure, Project team structure, Role of metrics, Measurement, Software quality factors, Coding tools and techniques, Testing, Maintenance, Gantt charts, PERT and CPM, CASE tools.

Unit 6: Networking

Types of Networks, Network topology, Network Management, Data communication and transmission, ISO-OSI reference model, TCP/IP reference model, Internet standards and services, Cryptography, Data compression, Authentication and firewalls.

Unit 7: Compilers and translators

Regular expression, Finite automata, Formal languages, Finite state machines, Lexical analysis, Semantic analysis, Parsing algorithms, Symbol tables, Error handling, Intermediate code optimization, Machine code generation, Machine dependent optimization.

Unit 8: 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; Distributed operating systems.

Unit 9: 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, Indexes, Backup and recovery; Distributed Databases – Concepts,

Architecture, Design; Structured Query Language (SQL), PL/SQL.

Unit 10: Numerical analysis

Interpolation, Numerical integration, Solution of ordinary differential equations, Solution of linear and non-linear system of equations; Statistical methods – Summarization of data, 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). Probability Distributions: Binomial, Poisson, Normal Distributions and their Applications. Concept of sampling, Sampling vs. Complete Enumeration, Sampling from a Finite Population, Simple Random Sampling. Test of significance based on normal, chi-square, t and F distributions, Curve fitting, Point estimation.

NOTE 4: The syllabus mentioned above is illustrative only. Questions relating to recent/current developments taking place in agriculture and allied sciences in general and in the concerned subject areas in particular can also be included in the question papers as may be deemed appropriate by subject- paper experts.