

41. AGRICULTURAL METEOROLOGY

Unit 1 : General Meteorology

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

Unit 2 : General Climatology

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

Unit 3 : Agricultural Climatology

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

Unit 4 : Micrometeorology

Concept of micro, meso and macro meteorology; Micrometeorological processes near bare ground and crop surfaces; Shearing stress, molecular and eddy diffusion, forced and tree convection; Boundary layer, frictional velocity, roughness length and zero plane displacement; Micrometeorology of crops, rice and wheat; Day and night radiation, humidity, temperature, wind and 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, spectral properties of vegetation; Light interception by crop canopies as influenced by leaf area index, leaf arrangement and leaf transmissibility, extinction coefficient and radiation use-efficiency; Microclimate of field crops, forest and orchards etc.

Unit 5 : Evapotranspiration

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

Unit 6 : Crop Weather Modeling

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

Unit 7 : Weather Forecasting for Agriculture

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

42. AGROFORESTRY

Unit 1

National Forest Policy 1894, 1952 and 1988; Indian Forest Act, 1927; Forest Conservation Act,

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

Unit 2

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

Unit 3

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

Unit 4

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

Unit 5

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

Unit 6

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

Unit 7

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

Unit 8

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

Unit 9

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

Unit 10

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

Unit 11

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

Unit 12

Climate change: greenhouse effect, sources and sinks of green house gases, major greenhouses gases; Global climate change – its history and future predictions; Impact of climate change on agriculture, forestry, water resources, sea level; Livestock, fishery and coastal ecosystems; International conventions on climate change; Global warming: effect of enhanced CO₂ on productivity; Ozone layer depletion; Disaster management, floods, droughts, earthquakes; Tsunami, cyclones and landslides; Agroforestry and carbon sequestration.

Unit 13

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

43. AGRONOMY

Unit 1 : Crop Ecology and Geography

Principles of crop ecology; Ecosystem concept and determinants of productivity of ecosystem; Physiological limits of crop yield and variability in relation to ecological optima; Crop adaptation; Climate shift and its ecological implication; Greenhouse effect; Agro-ecological and agro climatic regions of 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 CO₂ in relation to photosynthetic rates and efficiency; Physiological stress in crops; Remote sensing: Spectral indices and their application in agriculture, crop water stress indices and crop stress detection.

Unit 2 : Weed Management

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

Unit 3 : Soil Fertility and Fertilizer Use

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

Unit 4 : Dryland Agronomy

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

Unit 5 : Crop Production in Problem Soils

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

Unit 6 : Crop Production

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

Unit 7 : Agricultural Statistics

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

Unit 8 : Sustainable Land Use Systems

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

Unit 9 : Basics of Soil and Water

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

Unit 10 : Soil Water Relationship

Soil water relations, water retention by soil, soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water; Soil irrigability, classifications, factors affecting profile water storage; Determination of soil water content, computation of soil water depletion, soil water potential and its components, hydraulic head; Movement of soil water saturated and unsaturated water flow; Field water budget, water gains and water losses from soil, deep percolation beyond root zone, capillary rise; Evapotranspiration (ET), scope for economizing water, measures for reducing direct evaporation from soil and crop canopies; Soil physical properties in relation to plant growth and development; Erodability of soils and their prevention.

Unit 11 : Plant Water Relationship

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

Unit 12 : Irrigation Water Management

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

Unit 13 : Management of Problematic Soils and Water

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

44. ENVIRONMENTAL SCIENCE

Unit 1

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

Unit 2

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

Unit 3

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

Unit 4

Composition of air; Air pollution: sources and classification of major air pollutants; Smoke, smog, photochemical smog and SPM; Methods of air pollution monitoring; Effects of air pollutants on crops, vegetation, animals and human health; mitigation measures for combating air pollution; Factors affecting plant response to air pollution; Acid rain, physiological and biochemical effects of SO₂, HF, PAN and O₃ on vegetation, toxicity symptoms on vegetation, defence mechanism against air pollutants in plants, sensitive and tolerant plant species to air pollutants. National and international laws and policies on air pollution; Permissible limits of air pollutants in the residential, commercial and industrial areas; Noise pollution-concept and effects.

Unit 5

Soil and water pollution: sources and types of soil and water pollutants; Effects of pollutants on soil health and productivity; Radioactive pollutants, their life time and disposal; Point and non-point sources of water pollution, major types of water pollutants, their impacts on environment and agro-ecosystems; Pollution in fresh water bodies, ponds, lakes, rivers and wells. Effects of soil and water pollutants on crop plants, animals, microorganism and human health; National and International laws and maximum permissible limits of soil and water pollutants; Biomagnification

and its impact on loss of biodiversity; Physical, chemical and biological properties of wastes; Effluent treatment processes for major industries viz. distilleries; paper and pulp, sugar, sewage and other agro-industrial wastes; Resource, product recovery, recycling and value addition to wastes; Biodegradation and bioconversion of organic wastes, composting, landfills; Vermicomposting, biogas, animal feed, mushroom cultivation etc.; Use of sludge, flyash, effluents and other agro industrial wastes in agriculture; Microbial, chemical and phytoremediation processes; Microbiological and public health aspects of waste disposal; Heavy metal contamination of environments, source and sinks of heavy metals.

Unit 6

Climate change: Global warming and greenhouse effect, sources and sinks of greenhouse gases, major GHGs, analytical techniques of monitoring greenhouse gases in atmosphere; Global climate change - its history and future predictions. Impact of climate change on agriculture, forestry, water resources, sea level rise, livestock, fisheries, coastal ecosystem and dynamics and pests and diseases and overall ecological processes; Climate change and food security; Contribution of agriculture and forestry to climate change; International conventions on climate change; Stratospheric ozone layer depletion-effect of UV radiation on plants and human health; Adaptation and mitigation strategies of climate change, global dimming agrobiological effects of CO₂ fertilization on crops; Carbon sequestration and clean development mechanism.

Unit 7

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

Unit 8

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

environmental awareness; Human rights; Role of information technology in environmental and human health; Industrial pollutants; Sea weeds and their utilization in agar, alginic acid, carrageenan, agarose and agaropectin production; Impact of green revolution on the environments.

Unit 9

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

45. Soil Science

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, categories of the system and their criteria; Interpretation of soil survey data for land capability and crop suitability classifications, Macro-morphological study of soils.

Application and use of global positioning system for soil survey. Soil survey- types, 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.

Unit 2: Soil Physics

Soil physical constraints affecting crop production. Soil texture - textural classes. Soil structure - classification, soil aggregation and significance, soil consistency, soil crusting, bulk density and particle density of soils and porosity, their significance and manipulation. Soil water- retention and potentials. Soil moisture constants. Movement of soil water - infiltration, percolation, permeability, drainage and methods of determination of soil moisture. Darcy's law. Thermal properties of soils, soil temperature, Soil air- composition, gaseous exchange, influence of soil temperature and air on plant growth. Soil erosion by water- types, effects, mechanics. Rain erosivity and soil erodibility. Runoff - methods of measurement, factors and management, runoff farming. 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; Identification, monitoring and management of waste lands; Land use- land cover mapping and land use planning using conventional and remote sensing techniques; Concept of watershed - its characterization and management.

Unit 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.

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

Unit 4: Soil Fertility

Essential elements in plant nutrition; Nutrient cycles in soil; Transformation and transport of nutrients (Macro and micro nutrients) in soil; Manures and fertilizers; Fate and reactions of fertilizers in soils; Chemistry of production of different fertilizers; Slow release fertilizers and nitrification retarders; Quality control of fertilizers. Soil fertility evaluation – soil testing, plant and tissue tests and biological methods; Common soil test methods for fertilizer recommendation; Soil test-crop response correlations; Integrated nutrient management; Use of isotopic tracers in soil research; Nature, properties and development of acid, acid sulphate, saline and alkali and their management; Lime and gypsum requirements of soils; Irrigation water quality - EC, SAR, RSC and specifications. Fertility status of major soil groups of India. Pollution: types, causes, methods of measurement, standards and management. Heavy metal toxicity and soil pollution; Chemical and bio-remediation of contaminated soils; Soil factors in emission of greenhouse gases; Carbon sequestration in mitigating greenhouse effect; Radio-active contamination of soil.

Unit 5: Soil Microbiology

Soil biota, soil microbial ecology, types of organisms. Soil microbial biomass, microbial interactions, unculturable soil biota. Microbiology and biochemistry of root-soil interface. Phyllosphere. Soil enzymes, origin, 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.

Methods of soil analysis - particle size distribution, bulk and particle density, moisture constants, Modern methods of soil, plant and fertilizer analysis; Flame photometry and inductively coupled plasma optical emission spectroscopy; Spectrophotometry - visible, ultra-violet and infrared; Atomic absorption spectrophotometry; Potentiometry and conductimetry; X-ray diffractometry; Mass spectrometry.

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.

46. Agri Business Management

Unit 1: General Management

Management processes, planning, controlling, organizing, motivating; managerial skills; level of managers; decision making; organizational context of decisions; decision making models; management by objectives; organizational conflicts; managing change; leadership styles; group dynamics. Human resource planning, job analysis and design; recruitment, selection, induction and placement; human resource training and development; management development; performance management; wage and salary administration; promotions, transfers, separation, absenteeism and employee turnover, employee welfare and safety; morale; participative management; introduction to industrial relations; conflict management. Case analysis forms a part of this unit.

Unit 2: Business Accounting & Financial Management

Financial Accounting- Meaning, Need, Concepts and Conventions; Advantages and Limitations , Standards of financial accounting; The Double Entry System- Its Meaning, Scope and Operation, Analysis of Financial Statements- Ratios, Comparative and Common Size Statements, Cash Flow and Funds Flow Analysis. Cost Accounting – Significance of Cost Accounting; Classification of Cost; Marginal Costing and Cost Volume Profit Analysis; Standard Costing and Variance Analysis- Material, Labour and Overhead; CPP and CCA Methods; Budget and Budgetary Control; Objectives and functions of financial management; capital structure theories; working capital management; dividend decision; Capital Budgeting and Project Appraisal criteria- NPV, ARR, IRR, Benefit Cost (B-C); Project feasibility- market feasibility, technical feasibility, financial feasibility, and economic feasibility, social cost-benefit analysis, project risk analysis. Importance of agricultural finance; rural credit structure-demand, supply, sources and forms; estimation of credit requirement; cost of credit/capital; credit appraisal- 3 Rs and 3 Cs of credit; reforms in agricultural credit policy; innovations in agricultural financing; role of institutions in agricultural; cooperatives, micro-finance institutions (MFIs), SHGs; principles of agricultural financial management; successes and failures of rural finance co-operative sector in India. Numerical analysis forms a part of this unit.

Unit 3: Marketing Management

Marketing Orientation; consumer behavior; marketing information system; formulating marketing strategy i.e. segmentation, targeting and positioning; marketing mix decisions; marketing organization; wholesaling and retailing ; challenges of international marketing. Agricultural marketing system, market structure; marketable and marketed surplus; marketing functions; channels in marketing, price spread and efficiency; government interventions including regulated markets, procurement, buffer stock operations, co-operative marketing, price stabilization measures and policies ; pricing of agricultural goods and marketing policies; public distribution system and related policies; rural retailing; forward trading and futures markets; marketing of agricultural inputs; challenges of marketing in rural areas; challenges of marketing goods manufactured in rural areas. Case analysis forms a part of this unit.

Unit 4: Managerial Economics and Farm Management

Scope of managerial economics, objective of the firm and basic economic principles; Consumer theory; Demand analysis; demand function; demand elasticity; demand forecasting. Production, cost and supply analysis- production function, least-cost input combination, factor productivities and returns to scale, cost concepts, cost-output relationship, Pricing. National income; circular flow of income: consumption, investment and saving; money-functions, demand & supply; inflation; economic growth; basics of business cycles. Farm Management problems and decisions; Farm Management principles; Farm planning and budgeting; Risk and Uncertainty in Farming; Overview of management of poultry & hatchery, fishery, livestock, feed, seed production, agrochemicals, farm power and machinery, veterinary hospital, floriculture and landscaping businesses. Case analysis forms a part of this unit.

Unit 5: Quantitative Techniques

Linear Programming: Objective, Assumptions, Formulation of Linear Programming Problem, Graphic Method, Simplex method; Transportation and Assignment Problems; Inventory Control Models; Waiting Line Models; Decision making under risk and uncertainties; Game Theory - Two -Person Zero-Sum Game; Simulation; Project's life cycle and Network analysis –PERT & CPM. Objectives, types, and process of research; types of research in management- exploratory, descriptive, experimental; Problem formulation; Scales of measurement; Primary and secondary data; Sampling and sampling techniques. Use of Equations, Use of Determinants and Matrices in business decisions, Frequency Distribution, Measures of Central Tendency, Measures of Variation, Skewness and Kurtosis, Simple, partial, and multiple correlation, Rank correlation, Simple and Multiple regression, Discriminant and dummy variable analysis, Index Numbers, Hypothesis testing, ANOVA, Statistical Quality Control. Numerical analysis forms a part of this unit.

Unit 6: Strategic Management and Entrepreneurship

Role of agriculture in Indian economy; problems and policies relating to farm supplies, farm production, agro processing, agricultural marketing, agricultural finance etc. in the country. Agribusiness – definition and nature, components of agribusiness management, changing dimensions of agricultural business; Structure of Agriculture - Linkages among sub-sectors of the agribusiness sector; economic reforms and Indian agriculture; impact of liberalization, privatization and globalization on agribusiness sector; Trends in production, processing, marketing, exports, policy controls and regulations relevant to the industrial sector with specific reference to agro-industries; Policies for agribusinesses - concept and formulation; new dimensions in Agribusiness environment and policy. International trade- basic concepts, WTO and its implications for Indian Economy in general and agriculture sector in particular. Strategic management – meaning, concept and scope; process of strategic management; strategic analysis i.e. SWOT analysis; strategy formulation; strategy implementation- strategy and structure, strategy and procedural implementation, strategy and leadership, total quality management, creating competitive advantage, strategic evaluation. Significance of entrepreneurship in economic development, qualities of an entrepreneur, environmental factors affecting success of a new business, strategy formulation for new businesses, life cycles of new business, reasons for the failure and visible problems for business, Characteristics of an effective business plan. Case analysis forms a part of this unit.

47. AGRICULTURAL ECONOMICS

Unit 1: Economic Theory

Nature and tools of economic analysis; theory of consumer behavior; production theory; costs theory; theory of firm; price determination under different markets, price discrimination, effect of taxation under different market conditions; welfare economics; market failure; nature of macroeconomic analysis; national income; consumption; saving and investment, employment, theory of business cycle, functions and demand for money; inflation; income and interest determination; IS-LM functions; **general equilibrium analysis**; monetary and fiscal policies, economic reforms.

Unit 2: Agricultural Development and Policy

Role of agriculture in economic development, economic growth and development; present development challenges, theories of development; role of economic, technological, social, political and environmental factors; **Green GNP**, nature, sources and impact of technological change; agricultural development in Asia; poverty, inequality and development; growth models – Harrod-Domar, Neo-Classical, Rostow's growth stages, Lewis-fei-Ranis model, **induced innovation model**, five-year plans and agriculture, land reforms; theory of share tenancy; institutions and development; agricultural growth analysis-determinants of agricultural growth and their measurements; features of planning in capitalists, socialist and mixed economics; role of infrastructure and technological change; agricultural policy analysis and reforms – input and output price policy, rural and irrigation infrastructure; credit policy etc; policies and programmes for development of agro-industry, dairy and fisheries; **policy options for sustainable agriculture development**, measurement of poverty and poverty alleviation programmes.

Unit 3: Natural Resource and Production Economics

Characteristics and classification of natural resources, sustainability issues in natural resource, **property rights, externalities, transaction costs ,need for collective action**, role of economics in natural resources accounting, planning, management and policy formulation; social welfare function; allocation of renewable and non-renewable resources (forests, fisheries, minerals water, land etc.) under various market structure; valuation of non-market resources; government programmes for conservation and development of natural resources; **climate changes, mitigation and policies, environmental regulations** basic principles of farm management-marginal returns, opportunity cost, input-output, output-output and input-input relationships; time comparison and comparative advantage, cost principles, farm efficiency measures and financial analysis, farm planning and budgeting, farm records, measurement and management of risk and uncertainty in agriculture; diversification and insurance in agriculture and allied sectors; forms and applications of production functions – linear, quadratic, square root, spillman, cubic, semi-log, Cobb-Douglas, constant elasticity of substitution (CES), variable elasticity of substitution (VES), etc; dualities between production, cost and profit functions; derivation of supply and factor demand functions from production and profit functions, optimization of resource allocation, resource-use efficiency and returns to scale, frontier production function; total factor productivity, decision making under risk and uncertainties.

Unit 4: Agricultural Finance and Project Management

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

Unit 5: Agricultural Marketing and Price Analysis

Concepts of agricultural marketing; marketing functions-processing, transportation, storage and ware housing; channels of marketing agricultural produce-price spread and efficiency, structure, conduct and performance analysis; market integration; marketing institutions-role and functions; government interventions including administrated price policy; regulated markets, marker segmentation, **supply chain and value chain analysis in agril. commodities**, buffer stock operations, price stabilization measures and policies etc. **price forecasting for crop area allocation**, marketing of agricultural inputs, role of private sector in input and output marketing; forward trading and futures market e-NAM, commodity boards and contract farming; marketed surplus models; competitive and comparative advantage in trade, trade policies, models and agreements; regulations and reforms for marketing and trade, WTO, SPS measures and competitiveness; ecological concerns and marketing ethics.

Unit 6: Operations Research and Research Methods

Objective, types and process of research; role and uses of quantitative technique in business decision making; sampling techniques and sample size determination; sampling and non-sampling errors; index numbers, hypothesis testing. ANOVA, factor analysis, cluster analysis; measures of central tendency, measures of variation, skewness and kurtosis; correlation and regression, discriminant and dummy variable analysis; OLS, **MLE** estimation-assumptions and their violations, properties, simultaneous equations systems: identification and estimation; Linear programming; objective, assumptions, formulation of linear programming problem, simplex method; primal and dual LP problems, role of business decision making models.

48. AGRICULTURAL EXTENSION

Unit 1: Fundamentals of Extension and Communication

Concepts and scope of extension and communication particularly for primary and secondary agriculture. Historical and emerging perspectives of agricultural, veterinary and animal husbandry extension education in India and other countries. Community Development and Integrated Rural Development- concept, principles and objectives. Role of agricultural extension in different sectors of agriculture and rural development. Agricultural Extension in the context of enhancing productivity, Quality, Nutrition, post harvest technology, product processing, Profitability, Income and Employment. Concepts of yield gaps. FLD and OFT in relation to TOT programmes. Farming System Research and Extension (FSR&E) and participatory development approaches. Concept and modules of communication, credibility, fidelity, empathy and feedback in communication. Similarities and dissimilarities among extension education, adult education and continuing/distance education. Andragogy and theories of adult learning. Human behavioural dimensions and gender sensitivity in extension education programmes. Meaning and characteristics of attitude, factors affecting attitude change; Understanding of basic rural institutions, social structure, culture and norms. Social and technological change processes, group dynamics, concepts and theories of rural leadership. Group and mass communication, Interpersonal and Intrapersonal Communication Skills, Key communicators and their role in animal husbandry development. Acquiring communication skills for development of local leaders and key communicators for livestock development. Organizational communication. Rapport building with clientele. Problems and barriers in communication; distortion and noise in communication. Importance of feedback in veterinary extension, impact analysis of extension programmes.

Unit 2: Extension Methods & Farm Journalism

Concepts of teaching and learning processes-principles of learning as applied to agricultural extension. 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/video script. Principles of photography and its use in extension.

Unit 3: Information Communication Technologies (ICT)

Concept of ICT and its role in agriculture and rural development. ICT tools- print and electronic media, e-mail, Internet, use of multimedia, use of mobile phony, video and teleconferencing, computer-assisted instructions, touch screens, micro-computers, web technologies and information kiosks. Networking system of information and challenges in the use of ICT. E-learning, information resources, sharing and networking. Types of net work – PAN, LAN, WAN, Internet, AGRINET, AKIS, Indian National Agricultural Research database. ICT programmes in livestock development, Problems and prospects of ICTs in livestock development, Digitisation, Simulation models, Utilization of Internet for promoting advanced veterinary and animal 116

husbandry practices; communication with rural, semi-urban and urban livestock owners.

Unit 4: Training & Human Resource Development

Human resources and their importance in agricultural development. Concept of human resource management. Training and development of human resources. Identifying training needs and assessment of training impact. Training – principles, importance, methods and factors. Phases of training - pre training and post training. Developing training modules, training requirements, training methods. Lecture cum demonstration method, case method, group brain storming, syndicate method, business games, simulation exercises, in basket exercise, programmed instruction, experiential learning techniques such as sensitivity training, T-group, transactional analysis and fish bowl exercise. Evaluation of training - types and techniques of training evaluation. Motivation, stress management and organizational behaviour as facilitators of human resource development. Capacity Building in relation to Dairying, Poultry, Piggery, Goat and Sheep farming, cottage industries, Rabbit farming, Apiculture, Sericulture, Biofertilizer, Floriculture, and Biopesticides.

Unit 5: Research Methodology in Extension Education

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

Unit 6: Programme Planning, Evaluation & Diffusion and Adoption of Innovations

Concept, steps, principles and theories of programme planning. Steps in programme planning for livestock development, organizing campaigns, mass vaccination programmes and variety of extension activities, evaluation of veterinary extension programmes, compilation and report writing. Evaluation of animal husbandry development programmes and schemes. Monitoring and evaluation – concept, significance, types, methods and tools. Theoretical models of programme planning. Felt needs; need-based programmes. Social action. Five Year Plans – critical analysis with special reference to programmes for women, children and youth. SWOT/TOWS analysis of development programmes. Concept and elements of diffusion and adoption for social change. Diffusion process, adoption process, models of diffusion and adoption, adopter categories and their characteristics. Factors influencing adoption and attributes of innovations. Concept and stages of Innovation-decision process, consequences of innovations.

Unit 7: Extension Management

Concept and principles of administration and management, classical and modern theories, schools of management thought. Functions of management – planning, organizing, staffing, directing and leading, controlling, coordinating, reporting and budgeting. Types and methods of administrative communication. Decision-making in organization. Organizational effectiveness, organizational climate, organizational behaviour, organizational development, job satisfaction and morale. Time management. Performance appraisal. Coordination at different levels of extension 117

management, methods of coordination. Management by Objective (MBO) and Total Quality Management (TQM). Project Evaluation and Review Technique (PERT). 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. Agricultural Technology Information Centers (ATIC). Technology Parks. Management Information System. Management of Agricultural Knowledge System (MAKS) and use of Expert System. Traditional media for communication in development programmes. Problem Solving Techniques / Negotiation, Motivational Theories & Techniques, Work motivation Organizational climate; Resource management: concept and methods; Team building: process and strategies at organizational and village levels. Mobilization and empowerment skills: concept and strategies in mobilization, concretisation and empowerment of rural people.

Unit 8: Entrepreneurial Development

Concept, significance and scope. Programmes and agencies promoting entrepreneurship. Types and techniques of training for developing entrepreneurial activities in various areas. Self Help Groups – concepts, organisation, mobilization, micro-finance and functioning of SHG for empowerment and sustainability. Agripreneurship- agriclincs and agribusiness centers. International cooperation in agriculture - SAIC, Commonwealth, FAO, USAID, DFID and CGIAR system. Critical analysis of extension systems of SAARC, BRICS and other selected countries (USA, UK, Japan, Philippines, Israel etc.).

Unit 9: Developmental Strategies and Issues in Extension

Extension policies. National Agricultural Extension System and Networking of State development Departments, NARS, NGOs, producers companies, agricultural cooperatives, rural banks, insurance and private sectors. History of Veterinary extension programmes- NPCBB, PM assistance livestock development programmes and rural development programmes. Developmental strategies such as Watershed Development Programmes; Technology Mission, Horticulture Mission. Front Line Extension Programmes of ICAR/TAR-IVLP, NATP, NAIP, IRDP, ATMA, ITD, SREP, Research-Extension-Farmer-Interface. Identification, characterization, documentation and validation of ITKs. Privatization of extension, market led extension, production to consumption and end to end innovative approaches. Issues related to globalization and IPR. Rural, Agricultural, Animal Husbandry, Dairy and Women Developmental Programmes implemented by Govt. of India. Krishi Vigyan Kendras (KVKs).

Unit 10: Gender Sensitization and Empowerment

Gender and empowerment: meaning, gender related definitions and importance for empowering women; need and focus on gender sensitization, gender in community diversity and its implication for empowerment. Gender perspectives in development of women, social characteristics, roles, responsibilities, resources, constraints, legal issues and opportunities; economical, educational and other parameters. Gender tools and methodologies: Dimensions and methodologies for empowerment; gender budgeting; gender analysis framework- context, activities, resources and programme action profile; technologies and empowerment - gender specific technologies, household technology interface, socio-cultural interface and women as consumer of technologies. Gender issues and development: health and nutrition, violence, governance, education and media.

49. AGRICULTURAL STATISTICS

UNIT 1: Mathematical Methods in Statistics

Limit and continuity; Differentiation of functions, Successive differentiation, Partial differentiation. Mean value theorems, Taylor and Maclaurin's series; Integration of rational, irrational and trigonometric functions.

Differential equations of first order, Linear differential equations of higher order with constant coefficients.

Simple interpolation; Divided differences; Numerical differentiation and integration.

Group, Ring, Field and Vector spaces, Subspaces, Basis, Gram Schmidt's orthogonalization; Galois field, Fermat's theorem and primitive elements.

Linear independence and dependence of vectors, Row and column spaces; Sub-matrices and partitioned matrices; Determinant, rank and inverse of a matrix; Determinant and inverse of partitioned matrices; Special matrices - Unitary, Similar, Hadamard, Circulant, Helmert's, Idempotent and Orthogonal. Eigen values and eigen vectors. Spectral decomposition of matrices.

Kronecker and Hadamard product of matrices, Kronecker sum of matrices, Permutation matrices, Full rank factorization. Grammian root of a symmetric matrix.

Generalized inverses, Moore-Penrose inverse, Applications of generalized inverse; Generalized inverse of partitioned matrices; Solutions of linear equations, Equations having many solutions; Spectral decomposition of matrices; Differentiation and integration of matrices; Quadratic forms.

UNIT 2: Probability and Mathematical Statistics

Elements of measure theory, Borel field, Probability measure; Random variable, Axiomatic approach to probability; Laws of addition and multiplication; Bayes' theorem.

Discrete and continuous variables; Functions of random variables; Distribution function and its properties. Univariate and bivariate probability distributions; Conditional and marginal distributions; Independence of random variables; Transformation of random variables. Chebyshev's inequality; Bernoulli weak law of large numbers; Kolmogorov strong law of large numbers; Central limit theorem; Demoviere-Laplace central limit theorem.

Bernoulli, Binomial, Poisson, Negative binomial, Geometric, Hypergeometric and Uniform distributions. Rectangular, Normal, Exponential, Gamma, Beta, Cauchy and Lognormal distributions. Bivariate normal distribution. Probability distributions of functions of random variables. Family of Pearson distributions.

Mathematical expectation; Mathematical expectation of functions of random variables; Moment generating function, Characteristic function; Raw and central moments. Mean and variance of above mentioned distributions. Sampling distributions; Distribution of mean, difference between two means and correlation coefficient; Central t , F and chi-square distributions, their properties and interrelationships; Variance stabilizing transformations.

Order statistics; Distribution of r^{th} order statistic; Joint distribution of several order statistics and their functions; Distribution of range and median.

UNIT 3: Statistical Inference

Point estimation: Mean square error; Unbiasedness, Consistency, Sufficiency, Completeness; Neyman factorization theorem with application; Minimum variance unbiased estimator; Cramer Rao inequality; Rao Blackwell theorem.

Methods of estimation: Method of moments, Method of minimum chisquare, Method of maximum likelihood, their properties and applications. Confidence interval estimation for parameters of Normal, Exponential, Binomial and Poisson distributions.

Testing of hypothesis; Neyman Pearson lemma; Unbiased test; Uniformly most powerful unbiased tests and their constructions. One and two-sample tests about mean, variance, proportion, simple correlation coefficient and simple regression coefficient; Behrens-Fisher problem; Bartlett's chi-square test; Likelihood ratio test and its asymptotic properties. Chi-square tests of goodness of fit and independence.

Non-parametric tests, Robust statistics, One and two-sample sign and Wilcoxon sign rank tests, run test for randomness, Wilcoxon-Mann-Whitney U test, Kruskal-Wallis and Friedman's tests, Kendall's coefficient of concordance.

Elements of sequential analysis; Wald's sequential probability ratio test.

UNIT 4: Applied Multivariate Analysis

Concept of random vector, Expectation operator, Dispersion matrix, Marginal and joint distribution, Conditional distribution and Independence of random vectors.

Multinomial distribution. Multivariate normal distribution, Marginal and conditional distributions. Sample mean vector and its distribution; Maximum likelihood estimates of mean vector and dispersion matrix. Tests of hypotheses about mean vector.

Wishart distribution and its properties; Hotelling's T^2 and Mahalanobis' D^2 statistics; Null distribution of Hotelling's T^2 ; Rao's U statistic and its distribution.

Multivariate analysis of variance; Wilk's lambda criterion and its properties; Discriminant analysis, Computation of linear discriminant function (LDF), Classification between two multivariate normal populations based upon LDF and Mahalanobis' D^2 .

Canonical correlations; Factor analysis; Principal component analysis; Principal co-ordinate analysis; Cluster analysis, Similarities and Dissimilarities, Hierarchical clustering, Single and complete linkage methods.

Path analysis and computation of path coefficients; Multi-dimensional scaling; Categorical data analysis.

UNIT 5: Design of Experiments

Theory of linear estimation; Gauss Markoff theorem; Aitkin's transformation; Hypothesis testing and analysis of variance; Analysis of covariance; Restricted estimation; Random, fixed and mixed effects models.

Basic principles of design of experiments; Orthogonality; Contrast, Mutually orthogonal contrasts.

Completely randomized, Randomized complete block and Latin square designs; Missing plot technique; Orthogonal and mutually orthogonal Latin squares; Graeco Latin square designs.

Balanced incomplete block (BIB) designs, Symmetrical BIB designs, General properties, Analysis without and with recovery of intra-block information, Construction of BIB designs; Partially balanced incomplete block (PBIB) designs with two associate classes, General properties; Lattice designs; Alpha designs; Cyclic designs; Augmented designs; General analysis of block designs; Youden square

designs; Cross-over designs.

Factorial experiments, Confounding in 2^n and 3^n factorial experiments, Partial and total confounding; Fractional factorial designs for symmetrical factorials. Asymmetrical factorials. Split-plot and strip-plot designs. Combined analysis of experiments.

Designs for fitting first order and second order response surfaces, Second order rotatable designs.

Multiple comparison procedures; Sampling in field experiments.

UNIT 6: Sample Surveys

Complete survey *vs* sample survey; Probability sampling *vs* purposive sampling; Sampling error; Sample space, Sampling design, Sampling strategy; Confidence interval.

Simple random sampling with and without replacement, Estimation of population mean and population proportion; Inverse sampling; Stratified random sampling, Optimum allocation, Number of strata, Construction of strata boundaries, Collapsing of strata. Determination of sample size.

Ratio, regression and product methods of estimation; Separate and combined ratio estimators; Cluster sampling; Multi-stage sampling with equal probability of selection of units at each stage; Two-phase sampling; Successive sampling over two occasions.

Sampling with varying probability with and without replacement, Probability proportional to size sampling - Cumulative method and Lahiri's method of selection; Horvitz Thompson estimator, Ordered and unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran; Inclusion probability proportional to size sampling.

Systematic sampling; Probability proportional to size systematic sampling.

Non-sampling errors, sources and classification, Non-response in surveys; Response error, Interpenetrating sub-samples, Imputation methods; Warner's randomized response technique.

Unbiased ratio and regression type estimators; Multivariate ratio and regression type estimators.

UNIT 7: Statistical Genetics

Physical basis of inheritance, Segregation and Linkage; Analysis of segregation, Detection and estimation of linkage for qualitative characters; Amount of information about linkage; Combined estimation, Disturbed segregation.

Gene and genotypic frequencies; Random mating; Hardy-Weinberg law of equilibrium; Disequilibrium due to linkage for two pairs of genes and sex-linked genes; Forces affecting gene frequency; Equilibrium between forces in large populations, Polymorphism; Fisher's fundamental theorem of natural selection; Random genetic drift; Effect of finite population size.

Polygenic system for quantitative characters; Average effect of gene; Average effect of gene substitution; Dominance deviation; Breeding value; Epistatic interaction deviation; Genotype- environment correlation, genotype-environment interaction and its application; Multiple allelism in continuous variations; Maternal effects; Different components of genetic variance and their partitioning; Effect of inbreeding on quantitative characters; Heterosis; Inbreeding depression; Effect of inbreeding on mean and variance of quantitative characters.

Resemblance between relatives; Phenotypic and genetic covariance between different relatives; Concept and estimation of genetic parameters; Heritability, Repeatability and Genetic correlation; Response due to selection, Selection index and its applications in plant and animal genetic improvement programmes; Correlated response to selection; Restricted selection index.

Mating designs; North Carolina designs and their analysis; Line $\times$ Tester Analysis; Diallel and partial diallel crosses including their construction and analysis.

Survival analysis; Phylogeny and analysis of molecular variance.

UNIT 8: Applied Regression Analysis

Simple and multiple linear regression models and their analysis; Estimation and testing of regression parameters, Sub-hypothesis testing, Restricted estimation; Polynomial regression: Use of orthogonal polynomials. Use of dummy variables. Regression with ordinal data. Logistic regression. Multiple and partial correlation coefficients;

Selection of variables, Stepwise and Stagewise regressions.

Regression diagnostics; Adequacy and validation of models. Examination of residuals - specification error, auto-correlation, Durbin-Watson statistic, Heteroscedasticity, Multi-collinearity. Weighted Least Squares, Outliers, Influential observations. Remedial measures - regression under non-normal errors, transformation of data, Generalized least squares, Model over-fitting, model under-fitting.

Parameter estimation in non-linear models.

Components of time-series. Fitting of different trend models. Auto-correlation and Partial Auto-Correlation functions. Correlogram. Determination of cyclical variations. Periodogram analysis. Linear Stationary models - Auto-Regressive, moving average and mixed processes. Linear non-stationary models. Forecasting.

Simultaneous equation models. Indirect Least Squares. Pooling of cross-section and time-series data.

Demand and Supply curves. Determination of demand curves from market data. Engel's curves. Poreto curves.

UNIT 9: Optimization Techniques and Soft Computing

Classical optimization techniques. Constrained optimization. Optimization and inequality. Cauchy-Sehwarz inequality, Jensen inequality, Markov inequality. Numerical methods of optimization. Direct Search method, Sequential Search method, Random Search method, Simplex Search method, Gradient method and Method of Steepest Ascent.

Linear Programming Techniques - Simplex method, Duality and sensitivity analysis. Two-person zero-sum game and linear programming; Integer Programming. Statistical applications.

Non-linear programming. Kuhn-Tucker conditions. Quadratic programming. Elements of Multiple objective programming. Dynamic programming. Optimal control theory.

Soft computing tools - Artificial Neural Network, Support vector machines and probabilistic reasoning. Genetic algorithm, decision tree, Bayes classifiers, Fuzzy Logic. Rough Set. Hierarchical and non- hierarchical clustering algorithm.

Simulation methods for various probability models. Resampling techniques: Jackknife and Bootstrap; Monte Carlo simulation.

50. HOME SCIENCE

Unit 1:- Human Nutrition, Health and Interventions.

Balanced diet-Food groups, Food pyramid. Macro and micro nutrients in human nutrition-Carbohydrates, proteins, lipids, vitamins, minerals and water - requirements, sources, functions, metabolism and effects of deficiency and toxicity of the nutrients. Nutrients interrelationship. Inborn errors of metabolism. Phytochemicals, antioxidants, prebiotics and probiotics, functional foods and nutraceuticals. Drug and nutrient interaction.

Diet & nutritional therapy in disorders of obesity, underweight, gastro intestinal tract, kidney, liver, heart, lungs, cancer, diabetes mellitus, food allergies and intolerances,. Major Public Health and Nutritional problems in India-Causes, magnitude and distribution. Assessment of Community Nutritional status by Standard methods. National Nutrition Policy, National and International organizations' programmes to combat malnutrition. Nutritional epidemiology, Public health aspects of human nutrition. Objectives, Principles and Importance of Nutrition education, Nutrition monitoring and Surveillance.

Unit 2:- Food Science and Processing Technologies

Need & Scope of Food Science, Physico-chemical properties of foods, Methods of cooking-merits & demerits, factors affecting cooking. Sensory evaluation and Consumer acceptability, Food fortification, enrichment and supplementation. Food additives and Preservatives. Anti-nutritional factors & Toxicants in foods. Food hygiene and sanitation, Food-borne illnesses, infections and food poisoning. Food Adulteration, Food Standards, Laws & Regulations for food safety.

Post harvest losses, food spoilage and its causes. Food Processing techniques, effects on nutritional value, food packaging and labeling. Quantitative and Qualitative changes during post harvest handling and processing of foods. Principles and methods of food processing, drying, concentration, freezing, cryogenic freezing fermentation, irradiation, canning, sterilization, pasteurization. Processing & packaging techniques for cereals, millets and legumes, milk and milk products, fruits and vegetables, nuts and oilseeds, meat, fish and poultry. Role of warehousing corporation and Food Corporation of India on post harvest conservation. Storage of perishable and non-perishable foods, traditional and modern food storage.

Unit 3 : Textile Science, Fashion Designing and Garment Production

Natural and Man-made fibers: Classification and Processing. Textile testing and Quality Control, importance of textile and apparel testing; textile performance standards and various organizations associated. Fibre, yarn and fabric testing, Dyes and Pigments - classification dyeing techniques (solution dyeing, fibre dyeing, yarn dyeing, piece and garment dyeing), resist dyeing. Methods of printing (block, screen, stencil, roller, transfer printing and batik). Principles of weaving - basic weaves, (plain, twill and satin), decorative/fancy weaves (jacquard, dobby, leno, double cloth, warp and weft figuring, pile weave). Knitting (principles, classification and knitting machines). Technological advances in dyeing and printing. Finishes- Principles and methods of washing and finishing. Stain removal. Care and Storage of clothes.

Anthropometric measurements (importance and techniques); clothing construction (basic principles of drafting, flat pattern and draping methods), flat pattern making, principles of pattern making, draping; standards, grading and alteration of basic block; Clothing requirements for different age groups, factors affecting clothing choices and fashion trends. Use of CAD in textile industry. Role and importance of textile and garment industry in Indian economy. Marketing of textiles and clothing- Price determination (different methods of pricing), Export and import procedure and

policies, Sale promotion techniques. Status of Textile and Apparel industries in the Global Scenario.

Unit 4 : Human Development and Family Dynamics

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

Socio-cultural aspects of population growth and population policies. Developmental programmes for women and children. Status of women in India, rights of women and children, national policy for children, national commission for women. Marriage - concept and meaning. Readiness for marriage-physiological, social, psychological and others. Premarital association, premarital guidance and counseling. Approaches to study family-developmental social, psychological and educational. Family planning. Legal aspects: laws regarding marriage, adoption, divorce, inheritance. Children with special needs (types of impairments: physical, visual, auditory, mental retardation, cerebral palsy, speech defects, and learning disabilities). Special education for children with developmental challenge. Trends and issues in early childhood care and education. Parent and community education. Theories of Personality development. Pubertal changes and effects on personality development. Developmental tasks of adolescence and problems faced.

Unit 5 : Family Resource Management and Consumer Science

Systems approach to Family Resource Management, Concept, Planning, Resources, management processes communication. Art principles and Interior enrichment, Housing and Space design, household energy and equipment, Family finance and Consumer education. Process of management. Decision making process. Application of management process to time, money and energy for work simplification. Application of Mundel's classes of change in household work, agricultural and allied tasks.

Energy crisis, its causes and implications for energy management in homes. Equipment, tools and accessories for rural and urban houses. Guidelines for budgeting. Banking, e-banking and insurance. Credit. Consumer rights, Consumer Protection Act and other laws.

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

Functional design and arrangement of work places for different occupational activities. Ergonomic designing of furniture and equipment. Determining physiological cost of work. Planning interiors for people with special needs. Environment and health hazards due to pollution. Concepts of household and farm waste and its utilization techniques. Environmental education and rain water harvesting.

Unit 6: Home Science Extension and Communication Communication Methods

Home Science extension education: concept, principles, philosophy, objectives and approaches. Genesis of rural development programmes in India. Community Development and Integrated Rural Development- concept, principles and objectives. Relationship between family and community development. Gender sensitivity in extension education programmes. Leadership-concept, types, identification, training and mobilizing local leaders for community participation. Problems of women leaders. Panchayati Raj-philosophy, concept, functioning and scope.

Extension methods and audio-visual aids. classification, selection, use and production. 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. Participatory communication – theories and models, designing and developing participatory message. 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. 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.