

SCHOOL OF AGRICULTURE

Ph.D in Agricultural Engineering and Technology

Courses Offered:

- 1. Farm Machinery and Power Engineering**
- 2. Soil and Water Conservation Engineering / Soil and Water Engineering**
- 3. Irrigation Water Management Engineering/Irrigation & Drainage Engineering**

SYLLABUS

01. Farm Machinery and Power Engineering

1: Design of Tillage and Planting Machinery

Modern trends, principles, procedures, fundamentals and economic considerations for design and development of farm machinery. Design considerations, procedure and their applications in tillage and planting 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 disc ploughs. 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 tiller tynes, forces acting and power requirement. Machines with working tools executing an 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.

2. Design of Plant Protection and Harvesting Equipments

Modern trends, principles, procedures, fundamentals and economic considerations for design and development of plant protection and harvesting machinery. 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 electrostatic sprayers. Design of sprayer components, pumps, pressure vessel, nozzle, materials of construction. Spray droplets 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 the drive 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.

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 of primary & 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.

4. Tractor Design Principles

Functional Requirement and Limitations, Systems and power outlets, Technical specifications of tractors available in India and modern trends in tractor design and development. Special design features of tractors in relation to Indian agriculture. Parameters affecting design of tractor engine and their selection. Design of fuel efficient 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. Tractor implements matching and operation.

5. Ergonomics and Safety in Farm operations

Ergonomics, scope, concepts and areas of application. System concept to human factors. Human factor in system development, basic processes in system development. 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 in various 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 and operator' 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.

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 independent 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 tool systems, 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 vehicles and machines.

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.

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.

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.

02. Soil and Water Conservation Engineering / Soil and Water Engineering

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.

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.

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.

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 runoff 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.

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.

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.

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.

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.

9. Protected Cultivation

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

03. Irrigation Water Management Engineering/Irrigation & Drainage Engineering

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.

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.

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.

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.

5. Protected Cultivation & Landscaping

Types of Protected Cultivation Net house and Greenhouse - orientation and layout. Energy Balance. Structural design & Construction of greenhouses –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

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.

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 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. Hydrologic flood routing: channel and reservoir routing.

Design, construction and Management of Farm Ponds and Percolation ponds

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.