ICAR JRF Syllabus

AGRICULTURAL ENGINEERING AND TECHNOLOGY

1.1 Farm Machinery and Power Engineering,

1.2 Soil and Water Conservation Engineering/Soil and Water Engineering,

1.3 Agricultural Processing and Food Engineering,

1.4 Renewable Energy Engineering,

1.5 Irrigation Water Management Engineering/Irrigation & Drainage Engineering

1.1 FARM MACHINERY AND POWER ENGINEEERING

Unit 1: Farm Mechanization and Equipment Status and scope of farm mechanization in India. Power availability on the farm. Identification of need based priorities of mechanization for various cropping systems. Hand tools used for different kinds of farm work, design considerations and materials for construction. Functional requirements, principles of working, construction, design, operation and management of animal-and power-operated equipment for tillage, land development, sowing, planting, fertilizer application, inter-cultivation, mowing, chaff cutting and baling. Special equipment for crops such as sugarcane, cotton, groundnut, and potato.

Unit 2: Design of Farm Machinery Components Design and selection of machinery elements: gear, pulleys, chains and sprockets, belts and simple clutches. Dynamic balancing and stability of farm machines. Force analysis on agricultural tools and implements. Pull, draft, unit draft and energy calculations for animal and power operated equipment. Machinery systems design.

Unit 3: Testing and Management of Farm Machinery Calibration of seed drills, planters, sprayers and fertilizer applicators. Performance and losses in harvesting and threshing. Calculations of field capacity, efficiency and rate of seed, fertilizer and chemicals applicators, threshers, harvesters and chaff cutters. Methods of testing of tillage equipment, seed-drills, seeders, planters, sprayers, threshers, and combines. Farm machinery selection for different soils, crops and operations. Cost analysis of implements and operations. Estimation of power-energy requirements. Reliability of farm machinery.

Unit 4: Engines and Tractor Systems Engineering thermodynamics. Various systems of spark and compression ignition engines. Operations, adjustment and trouble shooting on the working of the systems. Calculations on horse power, torque, speed, firing arrangement and intervals, heat load and power transmission from piston to the fly wheel. Tractor transmission, Types of clutch, gear trains, differential and final drives. Tractor chassis mechanics. Tractor power outlets. Mechanical and power steering systems. Hydraulics and hitching systems, ADDC. Tractor performance tests. Maintenance schedules of tractors and power tillers. Recent trends in tractor design.

Unit 5: Ergonomics and Safety Anthropometry in equipment design, physiological cost and effect of work on physiological responses, fatigue and comfort; ergonomics in design of farm tools; safety aspects

of agricultural machinery; effect of noise and vibration on work performance; chemical hazards and control measures; operator's protective gadgets; 125 design of tractor controls viz., hand and foot controls, visual range and limitations, seat design, etc.

Unit 6: Soil Dynamics in Tillage and Traction Dynamic properties of soil and their measurements; stress-strain relationships; theories of soil failure, mechanics of tillage tools; design parameters and performance of tillage tools. Introduction to traction devices, tyre function and size, their selection, mechanics of traction devices, traction theories, slippage and sinkage of wheels, evaluation and prediction of traction performance; soil compaction - causes and methods for alleviating the effect on soil and crop responses.

Unit 7: Manufacturing Technology Specification of materials, surface roughness, production drawing, computer aided drawing heat treatment, workshop practices applied in prototype production, common tools and press operations, metal cutting and machining, jigs, fixtures and gauges, casting and die-casting processes; basic joining processes, welding processes, testing of joints and metallurgy. Unit 8: Instrumentation and Measurement Techniques Mechanical measurements, sensors and transducers, application of electrical strain gauges, signal transmission and processing, dynamic measurements; measurement of temperature, pressure, strain, force, torque, power vibrations etc.; determination of calorific value, fluid flow rates etc; signal conditioning and monitoring, data acquisition and storage. Unit 9: Energy in Agriculture Conventional and renewable energy sources in agriculture; solar radiation and its measurement; characteristics of solar spectrum; solar energy collection, storage and applications; solar photovoltaic conversion and SPV powered systems. Types of wind mills and their applications; thermo-chemical conversion of biomass, direct combustion, Pyrolysis and gasification, chemical conversion processes, carbonization, briquetting, pelletization and densification of biomass; bioconversion into alcohols, methyl and ethyl esters, organic acids, solvents of amino acids; types of biogas plants, biogas properties, uses and distribution, alternate fuels for IC engines. Energy requirement in agricultural production systems, energy ratio and specific energy value, inflow and outflow of energy in unit agricultural operation, energy audit, accounting and analysis.

1.2 SOIL AND WATER CONSERVATION ENGINEERING/SOIL AND WATER ENGINEERING

Unit 1: Groundwater Development, Wells and Pumps Water resources of India. Present status of development and utilization of water resources of India and scope for additional use. Irrigation potential and contribution of groundwater, scope of groundwater development. Application of groundwater models for groundwater development and management. Aquifer types and parameters. Principles of groundwater flow, interaction between surface and groundwater, natural and artificial groundwater recharge. Salt water intrusion in inland and coastal aquifers. Groundwater exploration techniques. Hydraulics of fully and partially penetrating wells. Design, construction and development of irrigation wells. Water lifts, pumps and prime movers, well and pumps characteristics, performance evaluation and selection of pumps. Energy requirement in groundwater pumping. Design of centrifugal pumps. Groundwater pollution. Conjunctive use of surface and groundwater.

Unit 2: Open Channel Hydraulics Hydraulics of open channel flow, energy and momentum principles, specific energy, Hydraulic jump, classification and its use as energy dissipater. Design of different types of irrigation channels. Irrigation water measurement: using velocity area method, water meters, weirs, notches, flumes, orifices etc. Water conveyance and control. Conveyance losses and lining of irrigation channels. Irrigation water delivery and distribution.

Unit 3: Soil, Plant, Water and Atmosphere Relationship Soil physical characteristics influencing irrigation. Soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water. Soil irrigability classifications, factors affecting water storage profile. Determination of soil water content, computation of soil water depletion, soil water potential and its components, hydraulic head. Field water budget: water gains and water losses from soil, deep percolation beyond root zone, capillary rise. Evapotranspiration (ET) and irrigation requirement, critical stages of crop growth in relation to irrigation. Irrigation scheduling. Plant water relations, concept of plant water potential. Water movement through soil plant atmosphere system. Uptake and transport of water by roots. Management strategies to improve crop productivity under limited water supplies. Contingent crop plans and other strategies for aberrant weather conditions. Cropping patterns, alternate land use and crop diversification in rainfed regions.

Unit 4: Watershed Hydrology Hydrologic cycle, precipitation, infiltration and surface runoff. Measurement and analysis of hydrologic data. Intensity duration frequency analysis. Hortonian and saturation overland flow theories, partial source area concept of surface runoff generation. Rainfall and run off relationships, stream gauging and runoff measurement. Different methods of surface runoff estimation, hydrographs, S-hydrograph, IUH, Synthetic hydrograph, unit hydrograph theory and its application. Concept of hydraulic flood routing: channel and reservoir routing.

Unit 5: Soil and Water Conservation Soil erosion and types of erosion. Quantitative soil loss estimation, universal soil loss equation and its subsequent modifications. In-situ measurement of soil loss. Field practices in controlling erosion by water and wind. Soil and Water conservation structures and their design. Gully control: vegetative measures, temporary, semi-permanent and permanent structures for gully control and reclamation and their design. Design and construction of farm pond and reservoir. Seepage theory. Design of earthen dams and retaining walls, stability analysis on slopes. Application of RS and GIS in soil and water conservation.

Unit 6: Watershed Management Watershed concept, Identification and characterization of watersheds. Surveying: topographic, reconnaissance. Soil types and depth properties. Soil maps and their scales. Meteorological observations, monitoring, reclamation and conservation of agricultural and forest watersheds, hill slopes and ravines. Hydrological and geomorphological characteristics of watersheds. Land capability and irrigability classification and soil maps. Principles of watershed management. Development of watershed management plans, its feasibility and economic evaluation. Land levelling and grading, Criteria for land levelling, design methods. Machineries and equipments for land levelling.

Unit 7: Irrigation Water Management History of irrigation in India. Management of irrigation water. Major irrigation projects in India. Crop water requirements. Soil water depletion, plant indices and

climatic parameters. Methods of irrigation, surface methods, overhead methods, Pressurized irrigation system such as drip and sprinkler irrigation. Merits and demerits of various methods. Hydraulics of furrow, check basin and border irrigation, Hydraulics and design of pressurized irrigation systems. Irrigation efficiency and economics of different irrigation systems. Agronomic considerations in the design and operation of irrigation projects, characteristics of irrigation and farming systems affecting irrigation management. Irrigation strategies under different situation of water availability, optimum crop plans and cropping patterns in canal command areas. Quality of irrigation water and irrigation with poor quality water. On farm water management, socio-economic aspects of on farm water management.

Unit 8: Management of Degraded, Waterlogged and Other Problematic Soils and Water Problem soils and their distribution in India. Excess salt and salt tolerant crops. Hydrological imbalances and their corrective measures. Concept of critical water table depths for crop growth. Contribution of shallow water table to crop water requirements. Management strategies for flood prone areas and crop calendar for flood affected areas. Crop production and alternate use of problematic soils. Agricultural field drainage, drainage techniques and theory of flow in saturated soil. Flow net theory and its application. Drainage investigations. Drainage characteristics of various type of soils. Water table contour maps and isobaths maps. Drainage coefficient. 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.

1.3 AGRICULTURAL PROCESSINGAND FOOD ENGINEERING

Unit 1: Engineering Properties and Quality of Biomaterials Uniqueness of bio-materials, Importance of engineering properties of biological materials; physical characteristics viz. shape, size, volume, density, porosity, surface areas, Frictional characteristics viz., rolling resistance, angle of repose. Properties of bulk particulate solids viz. specific surface area, mean diameter, flow rate. Aerodynamics characteristics viz. drag coefficient and terminal velocity. Pressure drop through packed beds. Thermal properties viz. specific heat, thermal conductivity, thermal diffusivity. Dielectric properties viz. dielectric and microwave radiation, dielectric constant, energy absorption, heating. Optical properties and transmittance and reflectance. Rheological properties and stress-strain-time relationship, rheological models, visco-elasticity, Hertz's theory of contact stresses. Food Quality and BIS specifications for quality of food materials, milling quality analysis, cooking and baking qualities. Organoleptic and sensory evaluation of product quality. Determination of protein, oil content, carbohydrates, colour, hardness, texture, nutritive value, bio- availability and microbial loads, non- destructive quality evaluation techniques. Measurement techniques and instruments for food quality determination, destructive and non-destructive quality evaluation, UV VIS NIR spectroscopy, X-ray, CT, NMR, machine vision. Maturity, ripening stages and indices of fruits and vegetables.

Unit 2: Heat and Mass Transfer Basic laws of thermodynamics, thermodynamic properties and processes, energy equations, heat, work, heat engine, heat pump, refrigeration and steam tables. EMC,

sorption and desorption isotherms, water activity and psychrometry. Modes of heat transfer, heat exchanger. Mass transfer and mass-heat-momentum transfer analogies. Fluid statics, fluid dynamics, continuity equation and Bernoulli's theorem. Dimensional analysis and simulation. Simulation models and mathematical modeling. Finite difference analysis, Finite element analysis.

Unit 3: Post Harvest Unit Operations Grading, cleaning, washing, sorting, shelling, dehusking, decortication, milling, polishing, pearling, drying (evaporative, osmotic and freeze drying), pasteurization and sterilization of liquid foods, kinetics of microbial death, size reduction, cryogenic grinding, granulation, crystallization, membrane separation processes viz. micro filtration, ultra-filtration, nano-filtration, reverse osmosis; Evaporation, Distillation, Mixing, coagulation, mechanical separation processes, viz. sedimentation, clarification filtration, pressing, expelling, leaching, extraction, pelleting, extrusion and industrial fermentation and processing.

Unit 4: Process Technology and Machinery Pre-milling/ conditioning treatments. Process technology and machinery for cereals, pulses, oil seeds, fruits, vegetables, flowers, spices, condiments, plantation crops, animal products, sea-foods, fiber crops, animal feed, natural resins and gums. Bioprocess engineering, enzyme reaction kinetics, Industrial fermentation and processing, down-stream processing, bio-separation. Minimal processing of fruits and vegetables, high pressure processing, ohmic heating, ultraviolet light, pulsed electric field, pulsed light field, micro and nanoencapsulation of food ingredients, Food nanotechnology. Seed processing and technology, Agricultural by-products/residue utilization, Waste disposal of food processing plants, different methods and equipment.

Unit 5: Design of Processing Machinery Design of grain cleaners, graders, dryers, parboiling plants, size reduction machines, bioreactors, fermenters, centrifuges, cyclone separator, heat-exchanger, evaporators, filters, extrusion cookers. Computer aided design and analysis of machines and machine components. Materials, manufacturing processes, design of elements and selection of standard parts viz. pulley, chains, sprockets, bearings, belts, fasteners, hydraulic components, pipes, hoses.

Unit 6: Material Handling, Packaging and Transport Bulk conveying equipments, viz. belt conveyors, screw/auger conveyors, bucket elevators and drag/chain conveyors. Estimation of energy requirement and capacity, damage to products during mechanical handling. Operation and maintenance of conveying equipment. Packaging material characteristics and selection. Packaging techniques and equipment for liquid, powder and granular materials, and horticultural produce. Transportation of agro-produce by bullock-carts, trailers, trucks, rail wagons and containers. Cold chain design and operation. Safety standards in handling, packaging and transport of agricultural produce.

Unit 7: Storage Engineering Storage environment and its interaction with stored product. Factors/parameters influencing the shelf life of the stored product, climatograph and deterioration index. Modeling of metabolic activities and predication of storage life, quality deterioration mechanisms and their control. Storage practices (including fumigation) for food grains. Design of bulk storage and aeration system. Analysis of heat, moisture and gas transfer in bulk storage structures. Bag storage structures, their design and management. Storage of perishables in ventilated, refrigerated, controlled

and modified atmosphere storage systems and their design, smart storage system. Quality analysis of stored produce.

Unit 8: Process Plant Design Plant design concepts and general design considerations, plant location, product and process design, process flow charts, equipment selection, plant layout. Design and selection of machinery for handling utilities like water, steam, fuel etc. and disposal of effluents and residues.

Unit 9: Instrumentation and Process Control Static and dynamic characteristics of instruments, Transducers elements, intermediate elements, indicating and recording elements. Measurement of motion, force, torque, power, temperature, humidity, pressure and flow. Physical and chemical sensors, biosensors, Fuzzy logic, neural networks and control. Monitoring of plant parameters through Internet, Programmable logic controller, Data loggers, Data Acquisition Systems (DAS). Introduction to Direct Digital Control (DDC), Supervisory Control and Data Acquisition Systems (SCADA), and Virtual Instrumentation.

Unit 10 : Agri-Project Planning and Management Project development. market survey and time motion analysis. Selection of equipment, technology option, techno - economic feasibility. processing in production catchment. Product and process design, PERT, CPM, transport model, simplex, linear and dynamic programming, operation log book. Material balance and efficiency analysis, performance testing, performance indices, energy requirement and consumption. Marketing of agricultural products, market positioning. BIS/ FSSAI/ ISO standards/ guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed.

1.4 RENEWABLE ENERGY ENGINEERING

1.5 IRRIGATION WATER MANAGEMENT ENGINEERING/IRRIGATION & DRAINAGE ENGINEERING

For 1.4 and 1.5, the syllabus would be the same as covered under 1.1 to 1.3 above