



AGRICULTURAL / BIOSYSTEMS / BIORESOURCE / FOOD ENGINEERING SYLLABUS OF EXAMINATIONS 2004 EDITION

For textbook information please refer to the **Textbooks** section on page 5 of the document entitled **Information for Examination Candidates and Students**.

GROUP A COMPULSORY EXAMINATIONS (SIX REQUIRED) (FOOD ENGINEERS: 5 REQUIRED: A3 – A7)

04-Agric-A1 Applied Plant, Animal or Human Physiology

The student can choose to discuss “Plant Physiology”, or “Animal or Human Physiology”.

Plant Physiology

Application of engineering principles to plant production systems. Basic plant and crop physiology including cell structure and cell function. Photosynthesis and respiration as related to biomass production. Plant growth dynamics as influenced by light, temperature, carbon dioxide, water, nutrient supply, and other environmental factors. Seed structure and germination. Plant structure and life cycles. Energy relationships in the plant and crop microclimates. Plant tolerance to stress. Environmental requirements for greenhouse and growth chamber design. Environmental requirements for product storage. Introduction to modelling of plant and crop growth.

Animal or Human Physiology

Engineering considerations in animal production systems or human dwellings. General treatment of mammalian and avian physiology. Physiological basis for design parameters for temperature, humidity, air movement, radiation, space, sound and other environmental requirements. Physiological mechanisms for control of body temperature, cardiovascular function, respiratory function, digestion, and other body processes. Comparison of animal species reproductive efficiencies. Introduction to modelling of animal or human production to predict the influence of environmental factors on performance.

04-Agric-A2 Soil Physics and Mechanics

Soil origin and classification systems. Physical properties of soils related to tillage, soil conservation and land use. Particle size distribution, water retention in soils, water movement into and within soils. Clay mineralogy, swelling and shrinking, soil structure and its measurements, soil temperature and freezing. Soil shear strength and laboratory and field methods for measurement. Subsurface exploration methods, foundation design, soil cutting and tillage, settlement, consolidation, compaction, and slope stability.

04-Agric-A3 Heat Engineering

Heat Sources: Mineral fuels, biomass, solar energy, electric energy.

Heat Transfer: Heat balances, enthalpy, heat capacity and latent heat, steam tables. Heat conduction through plane and curved sections, single and multiple layers. Thermal properties of building and biological materials. Forced and free convection, film and overall heat transfer coefficients. Radiation heat transfer, view factors. Non-steady state heat transfer, use of Heisler

charts for slabs, cylinders and spheres. Numerical solution of transient heat transfer problems. Heat exchanger calculations.

Heat Utilization: Air and liquid distribution systems, including ducts, piping and controls. Radiant heating applications. Measurement of heat utilization variables and instrumentation of heating and cooling systems. Principles of refrigeration systems.

04-Agric-A4 Fluid Flow

Piping networks. Rotational flow applied to sprinklers. Flow in porous media. Newtonian and non-Newtonian fluids. Pumping of food and agricultural products, both homogeneous and non-homogeneous. Special requirements for pumps and piping systems for food and other products that may have special requirements (e.g., high pH). Cavitation. Fans and fan control. Flow control in pipes and open channels. Hydraulic jumps.

04-Agric-A5 Principles of Instrumentation

Basic concepts of error, resolution, accuracy, precision, sensitivity, and calibration. Analysis and interpretation of data. Transducers for the sensing of strain, displacement, velocity, acceleration, pressure, flow, temperature, humidity, moisture content, and electromagnetic radiation. Signal conditioning for noise reduction and control. Operational amplifiers, filters, and bridges. Systems for data acquisition, telemetry, display, recording and processing. Microcomputer interfacing.

04-Agric-A6 Physical Properties of Biological Materials and Food Products

Measurement and use of physical properties in the design and control of handling, classifying, and processing systems for biological materials and food products. These properties include size, shape, bulk and solid densities, aerodynamic, frictional, mechanical, dielectric, rheological, thermal, optical and electromagnetic properties.

04-Agric-A7 Chemistry and Microbiology of Foods

Chemistry: Water molecule and water activity. Proteins: composition, structure, denaturation, functional properties, and enzymes. Fats: structure, physical and chemical properties. Carbohydrates: structure, chemical reactions, and functional properties. Kinetics in food systems. Phase transition in food systems. Food nutritive value (e.g. texture, colour, vitamins) and the impact of treatment and storage systems on such values.

Microbiology: Bacteria, virus, yeasts and fungi. Factors affecting the development of microorganisms in foods. Alterations of food and means of controls.

GROUP B

ELECTIVE EXAMINATIONS (THREE REQUIRED) (FOOD ENGINEERS (FOUR REQUIRED))

04-Agric-B1 Systems Engineering and Materials Handling

Systems Engineering and Materials Handling: Introductory principles of systems engineering and analysis, materials handling techniques and equipment.

Environment Control: Heat, moisture, and gas production and environmental modification. Summer and winter ventilation systems. Controlled atmosphere, modified atmosphere, and ventilated storage systems.

Functional Requirements: Factors affecting the functional requirements of agricultural and food processing buildings, including principles of planning and economics of design. Design of electronic systems to control the performance of the operations.

04-Agric-B2 Structural Design for Agricultural, Biosystems, and Food Industries

Properties of composite materials, concrete, polymers. Loads on agricultural structures. Various methods of structural analysis. Complete design procedures for buildings. Principles of structural design applied to frames. Structural elements (beams, columns, and roof trusses) in steel and timber design. Riveted, bolted, welded, nailed, and glued connections. Limit states design for ultimate loading. Analysis and design of concrete structures, including reinforced beams and slabs, flat slabs, joist and other types of floors, columns, spread footings, and retaining walls. Design of prestressed sections. Concrete design based on ultimate strength design, shear resistance, bond, and anchorage.

04-Agric-B3 Machine Design for Agricultural, Biosystems, and Food Industries

Application of principles of stress analysis and materials behaviour to the design of mechanical power transmission systems using gears, brakes, clutches, belts, chains, and universal joints. Selection and specification of bearings, couplings, fasteners, and other machine elements. Design of hydraulic systems and components for machinery used in agriculture and other biosystems. Application of principles of friction, wear, and lubrication. Material types required for the agricultural, biological, and food industry.

04-Agric-B4 Machinery Analysis for Agricultural, Biosystems, and Food Industries

Integration of applied mechanics, functional requirements, and properties of biological materials in the analysis of biological machinery. Soil reaction forces, mechanics of tillage tools and towed wheels, soil/machine relationships. Dynamics and kinematics of particles and rigid bodies pertaining to processes and product/machine relationships involved in crop and food production. Machine vibrations and stability. Cost analysis and performance evaluation of machines.

04-Agric-B5 Power Units for Agricultural, Biosystems, and Food Industries

Internal combustion engines, fuels and combustion, engine design, energy conversion. Thermal efficiency, supercharging, and turbocharging. Power transmission systems, traction mechanics, concepts of motion resistance, sinkage, and slip. Theories of tractive propulsion and soil/vehicle mechanics, comparison of the performance of ground drive components, tractive efficiency, pull/weight ratios. Vehicle mechanics, equations of motion, force analysis, longitudinal and lateral stability. Implement hitch and control systems and their influence on tractor dynamics. Hydraulic power transmission systems, components and characteristics. Ergonomics of operator-controlled machines, human responses, sound, vibration, and comfort control. Pneumatic systems. Special requirements for power units for food processing systems.

04-Agric-B6 Irrigation, Drainage, and Erosion Control

Irrigation. Land classification, development, and preparation. Consumptive use of water, estimation of crop water requirements. Design of distribution systems, canals and structures, design of sprinkler and surface systems. Selection of nozzles, pipes, pump, and power units. Analysis of rate of advance and recession curves. Irrigation efficiencies. Design of low earth dams.

Drainage. Design, layout and installation of subsurface and surface systems. Spacing formulae for steady-state and transient conditions. Outlet ditch design. Flow through bridges and culverts. Drainage pumps, secondary drainage practices, surface drainage, grading, land levelling, water table control. Use of drainage systems to control water pollution. Implications of draining wetlands.

Erosion Control. Basic principles of wind and water erosion. Soil loss prediction methods and sustainability. Methods of soil erosion and sediment control including contouring, terracing, grass

waterways, silt fences, channel stabilization, and land management practices. Agroforestry and cropping systems.

04-Agric-B7 Principles of Hydrology

Fundamentals of hydrologic processes. Commonly used instrumentation. Collection, analysis, and interpretation of hydrologic data. Aerial depth and intensity/duration/frequency precipitation relationships, maximum probable precipitation and risk. Energy balance; estimation of amounts from land, lakes, and vegetative surfaces. Interception. Fundamentals of flow of water through saturated and partially saturated porous media, infiltration. Groundwater geology, well development and pump tests. Runoff hydrograph components and separation, prediction of peak flows, SCS curve number, runoff volume prediction, hydrograph synthesis, flood-routing, snow-melt. Effects of land management practices. Sedimentation. Hydrologic models.

04-Agric-B8 Food Process Engineering (Part 1)

Heating and cooling processes for foods: Steady-state heating and cooling of foods. Unsteady-state heating and cooling of foods. Heat exchangers used in the food process industry. Heat transfer in agitated vessels. Effects of heat on foods. Heat sources: steam, microwave, RF.

Thermal processes: Thermal inactivation kinetics. Thermal death time relationships. Process sterilizing value. Heat transfer in canned foods. Process calculations: general methods, Ball formula method. Commercial sterilization systems: batch and, continuous retort systems. Aseptic processing.

Food freezing and freeze concentration: Thermodynamics of food freezing. Phase diagrams. Properties of frozen foods. Freezing-time calculations. Freezing systems. Transport phenomena in freeze concentration. Economics of freeze concentration.

Evaporation and freeze concentration: Thermodynamics of food evaporation. Thermal sensitivity of foods. Physical and chemical properties of foods related to evaporation. Types of evaporators. Evaporator calculations: single and multiple effect evaporators. Vapor recompression. Transport phenomena in evaporation. Instrumentation, control, automation. Economics of evaporation.

04-Agric-B9 Food Process Engineering (Part 2)

Food dehydration: Equilibrium moisture content and water activity. Water sorption isotherms of foods. Drying rates. Transport phenomena in food dehydration. Quality changes in food during drying. Types of dryers. Dryer design and calculations. Microwave drying. Infrared radiation drying. Electric and magnetic field drying. Sun drying.

Filtration, sedimentation and centrifugation: Constant and falling rate filtration. Continuous filtration. Effects of compaction and of fouling. Filtration agents. Equipment. Sedimentation in air and in liquids. Centrifugation: equations, effects of concentration, equipment.

Membrane processes: Classification of pressure-driven membrane processes: microfiltration, ultrafiltration, and reverse osmosis. Membrane types and selection. Mechanisms of transport. Equipment.

Extrusion: Rheology of foods. Single and multiple screw extruders. Newtonian and non-Newtonian models for extruders. Dies. Power consumption. Residence-time distributions. Heat transfer in extruders.

Cleaning and sanitation: Types of soil. Cleanliness criteria. Cleaning procedures and techniques. CIP systems. Cleaning agents. Cleaning kinetics and mechanisms.

Practices to ensure food quality & safety: practices such as HACCP to ensure food quality and

safety during handling , processing, storage and distribution.

Principles of food packaging: mass transfer in packaging materials, properties of packaging materials, aseptic processing and packaging.

04-Agric-B10 Biochemical Engineering (04-Chem-B4)

Basic microbiology and chemistry of cells, biochemical kinetics, enzymes and metabolic pathways, energetics, transport phenomena, and reactor design as applied to biochemical reactors, scale-up, fermentation technology.

04-Agric-B11 Principles of Waste Management

Characterization of solid and liquid biological waste streams (e.g., C:N ratio, solids/moisture content, suspended solids, COD, BOD, pathogens, etc.). Sampling and analysis protocols. The potential to pollute and impact of waste streams on the environment (soil, air and water). Processes by which waste stream pollutants enter the environment and how their impact can be minimized through proper management and treatment. Site selection for farms, aquacultural facilities and agro-food industries. Handling and storage systems for waste management. Land application of organic wastes. Relevant guidelines and regulatory requirements for such design. Responsibility and role of the engineer in providing solutions and environmental impact analysis.

04-Agric-B12 Principles of Biological Waste Treatment

Microbiological, biochemical and physical principles underlying the design, specification, and operation of aerobic and anaerobic processes for treating solid and liquid wastes: Aeration, activated sludge, biological contactors (RBCs and trickling filters), composting systems, anaerobic digesters, constructed wetlands, and biofilters. Batch and continuous processes. Relevant guidelines and regulatory requirements for the siting, design and operation of the above. Water, soil and air quality parameters and how biological treatment processes must be designed to have a positive impact on these resources.

04-Agric-B13 Control and Monitoring

Control theory. Proportional, integral and derivative control. Transducers for biological applications. Analog monitoring systems. Microcomputer interface of transducers. Advantages and disadvantages of different types of transducers for heat, temperature, humidity, flow, pressure, level measurement, and seed counting. Special requirements for transducers and instrumentation in the biological environment.

04-Agric-B14 Aquacultural Engineering

Physiology of main species of finfish and shellfish. Water requirements. Filtering of fresh and salt water using passive and biological filters. Temperature, pH, ammonia, and oxygen/carbon dioxide, and suspended-solids control. Site selection. Design of on-land, recirculating and once through systems. Cage design for offshore systems. Feeding and monitoring of fish. Harvesting, handling and/or primary processing.

04-Agric-B15 Design of Buildings for Agricultural, Biosystems, and Food Industries

Types of structures and their insulation and vapour barrier requirements. Building codes and their applications. Site location and design requirements for greenhouse facilities, livestock shelters, fruit and vegetable storage, grain handling and storage, slaughter houses and milling facilities. Accessories required for such buildings: ventilation, waste management, roads, water supply, power and snow and wind protection.

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