

# Agricultural /Biosystems /Bioresource /Food engineering syllabus

## Agricultural /Biosystems /Bioresource /Food engineering examinations

### Group A - Compulsory examinations

(six required; up to three areas of knowledge from Group B may be substituted to satisfy requirements)

#### 22-Agric-A1 Applied Plant, Animal or Human Physiology

Choose one of the following:

##### 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. Biosecurity. Introduction to modelling of animal or human production to predict the influence of environmental factors on performance.

*Textbooks (most recent edition is recommended):*

*Plant physiology:*

- Hopkins, W.G. and N.P.A. Huner, Introduction to Plant Physiology, John Wiley & Sons

Animal physiology (either of the following):

- Steers, M., Agricultural animal physiology and morphology, Syrawood Publishing House
- Fuller Bazer, G. Cliff Lamb, Guoyao Wu, Animal agriculture, Academic Press

#### 22-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.

*Textbooks (most recent edition is recommended):*

- Baver, L.D., W.H. Gardner, and W.R. Gardner, Soil Physics, John Wiley & Sons
- Coduto, Donald P., Geotechnical Engineering: Principles and Practices, Prentice Hall
- Horton, Horn, Bachmann, and Peth, Essential Soil Physics, Schweizerbart and Borntraeger Science

## 22-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.

*Textbooks (most recent edition is recommended):*

- Yunus Cengel and Afshin Ghajar, Heat and Mass Transfer: Fundamentals and Applications, McGraw Hill
- Frank P. Incropera, T. L. Bergman, David P. DeWitt, Adrienne Lavine, K. N. Seetharamu, Seetharam T. R., Fundamentals of Heat and Mass Transfer, John Wiley & Sons

## 22-Agric-A4 Fluid Flow

Analysis of steady ideal and viscous fluid flow systems using the Continuity, Bernoulli and Momentum equations. Boundary layer theory. Dimensional analysis and dynamic similitude. Conduit and open channel systems.

*Textbooks (most recent edition is recommended):*

- White, F.M., Fluid Mechanics, McGraw-Hill
- Munson et al., Mécanique des fluides, Technique et Documentation
- R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot, Transport Phenomena, John Wiley & Sons

## 22-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.

*Textbooks (most recent edition is recommended):*

- Figliola, R.S. and D.E. Beasley, Theory and Design for Mechanical Measurements, John Wiley & Sons
- Henry, Zoerb and Birth, Instrumentation and Measurement for Environmental Sciences, ASAE

## 22-Agric-A6 Physical Properties of Biological Materials and Food Products

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

*Textbooks (most recent edition is recommended):*

- Stroshine, R., Physical Properties of Agricultural Materials and Food Products, West Lafayette

And either of the following:

- Chandra, S. Samsher, S.K. Goyal, D. Kumari, Engineering Properties of Agricultural Produce, CRC Press
- Rao, M.A., S.S.H. Rizvi, A.K. Datta, J. Ahmed, Engineering Properties of Foods, CRC Press

## 22-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: Important groups of microorganisms associated with food spoilage, food contamination, food fermentation. Intrinsic and extrinsic factors and their relationship to microbial growth, control of microorganisms by food processing and the use of antimicrobial food ingredients.

*Textbooks (most recent edition is recommended):*

- Jay, J.M., Modern Food Microbiology, D. Van Nostrand Co.
- deMan, John M., Principles of Food Chemistry, Aspen Publication

## Group B - Optional examinations

(**Three required**, in addition to those used to meet Group A requirements)

### 22-Agric-B1 Materials Handling

Methods for designing, assessing, and controlling materials handling systems. Characteristics of materials handling equipment. Methodology for equipment selection, including needs assessment, technical specifications, power requirements and safety considerations.

**Functional Requirements:** Factors affecting the functional requirements of agricultural and food processing equipment. Design of electronic systems to control the performance of the operations.

*Textbooks (most recent edition is recommended):*

- Tompkins, J. A., White, J. A., Bozer, Y. A., Tanchoco, J. M. A., Facilities Planning, John Wiley & Sons
- Claudio Benedetti, William J. Stevenson, La gestion des opérations, Produits et services, Chenelière

### 22-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. General design of steel posts and beams.

*Textbooks (most recent edition is recommended):*

- Massicotte, Bruno, Calcul des structures en béton armé - Concepts de base, Da Vinci
- Béton / Concrete design handbook, Cement Association of Canada / Association canadienne du ciment
- Code du bâtiment - Canada, National Building code (2015)
- Code national de construction de bâtiments agricoles/ National Farm Building Code of Canada, via NRC website
- Wood design manual / Manuel de calcul des charpentes en bois, Canadian Wood Council / Conseil canadien du bois

### 22-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.

*Textbooks (most recent edition is recommended):*

- Juvinal, R.C. and K.M. Marshek, Fundamentals of Machine Component Design, John Wiley & Sons
- Segerlind, J, Designing Structural Components in Machines, ASABE

## **22-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.

*Textbooks (most recent edition is recommended):*

- Srivastava, A.K. et al., Engineering Principles of Agricultural Machines, ASAE

## **22-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.

*Textbooks (most recent edition is recommended):*

- C.E. Goering, A.C. Hansen, Engine and Tractor Power, ASAE

For French, please use either of the following:

- Willy de Krem, Tracteurs : comprendre, choisir, entretenir, France Agricole
- Yvon Tremblay, Choix et entretien des tracteurs agricoles, Berger

## **22-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.

*Textbooks (most recent edition is recommended):*

- Rodney L. Huffman, Delmar D. Fangmeier, William J. Elliot, Stephen R. Workman, Soil and Water Conservation Engineering, ASAE
- Peter Waller, Muluneh Yitayew, Irrigation and Drainage Engineering, Springer
- A. K. Bhattacharya and A. M. Michael, Land Drainage: Principles, Methods and Applications, Konark Publishers Pvt Ltd

## **22-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.

*Textbooks (most recent edition is recommended):*

- Andy D. Ward, Stanley W. Trimble, Suzette R. Burckhard, John G. Lyon, Environmental Hydrology, CRC Press
- Elizabeth M. Shaw, Chapman & Hall, Hydrology in practice, Taylor & Francis

## **22-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, ohmic, 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 options and their packaging materials. 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.

*Textbooks (most recent edition is recommended):*

*Either of the following:*

- Toledo, R.T., Fundamentals of Food Process Engineering, Springer
- Singh, R.P. and D.R. Heldman, Introduction to Food Engineering, Academic Press

## **22-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. Dryer design and calculations. Types of dryers: Microwave, Infrared, electric and magnetic field, freeze, foam mat, solar and 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 and membrane fouling. Equipment design.

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

Cleaning and sanitation: Types of contaminants. 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.

*Textbooks (most recent edition is recommended):*

*Either of the following texts:*

- Toledo, R.T., R.K. Singh, and F. Kong, Fundamentals of Food Process Engineering, Springer
- Singh, R.P. and D.R. Heldman, Introduction to Food Engineering, Academic Press

## **22-Agric-B10 Biochemical Engineering (16-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, and fermentative production.

*Textbooks (most recent edition is recommended):*

- Shuler, M.L. et al., Bioprocess Engineering – Basic Concepts, Prentice Hall
- Doran, P., Bioprocess Engineering Principles, Academic Press

## **22-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. Organic waste production by farms and the agro-food industry: quantities, characteristics, challenges. Sustainable practices and approaches in integrated organic waste management, such as ecosystem capacity to recycle nutrients, lifecycle assessments, resource and energy recovery. Treatment processes including composting, anaerobic digestion and valorisation as soil amendment/nutrient source.

*Textbooks (most recent edition is recommended):*

- Hussain, C., Hait, S., Advanced organic waste management, Elsevier
- MacKenzie, L.D., Masten, S.J., ISE Principles of environmental engineering, McGraw Hill

## **22-Agric-B12 Principles of Biological Waste Treatment**

Microbial kinetics and their application to the design of biological waste treatment systems: aerobic and anaerobic: aerobic lagoons, activated sludge, biological contactors (RBCs and trickling filters), composting systems, anaerobic digesters, constructed wetlands, and biofilters. Batch versus continuous processes. Watercourse dissolved oxygen control for treated wastewater discharge. Soils as organic waste nutrient recycling system.

*Textbooks (most recent edition is recommended):*

- Davis, M.L., Water and wastewater engineering, McGraw Hill
- Tchobanoglous, G., Wastewater engineering: treatment and reuse, McGraw Hill

## 22-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.

*Textbooks (most recent edition is recommended):*

- Thomas Marlin, Process Control, Designing Processes and Control Systems for Dynamic Performance, McMaster University, available at: <http://www.pc-education.mcmaster.ca/Textbook%20WEB%20book%20with%20updates/Textbook%20Download.html>
- Georges Asch, Loïc Blum, Jacques Fouletier, Pierre Desgoutte, Bernard Créton et al., Les capteurs en instrumentation industrielle, Dunod

## 22-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. Waste management.

*Textbooks (most recent edition is recommended):*

- Lawson, Thomas B., Fundamentals of Aquacultural Engineering, Springer

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

Site location and design requirements for greenhouse facilities, livestock shelters, fruit and vegetable storage, grain handling and storage, slaughter houses and milling facilities. Integration of building functions: agro-food production and space requirement, materials handling of produce and inputs, air conditioning system, waste management, snow and wind protection.

Building envelope considerations: insulation, vapour barrier, thermal performance. Environmental control for plant and livestock production. Energy efficient buildings: energy saving strategies, building rating systems.

*Textbooks (most recent edition is recommended):*

- Manuel de ventilation des installations de bétail et de volaille, Ministère de l'agriculture, de l'alimentation et des affaires rurales de l'Ontario
- Ventilation for livestock and poultry buildings, Publication 833, OMAFRA

*Optional:*

- La ventilation des porcheries et autres bâtiments d'élevage, CPAQ-CPVQ
- Agriculture Canada, Canadian Farm Building Handbook, Research Branch, Agriculture Canada