INTRODUCTION

Nineteen engineering disciplines are included in the Examination Syllabus issued by the Canadian Engineering Qualifications Board of Engineers Canada

Each discipline examination syllabus is divided into two examination categories: compulsory and elective. A full set of Biomedical/Biochemical Engineering examinations consists of nine, three-hour examination papers. Candidates will be assigned examinations based on an assessment of their academic background. Examinations from discipline syllabi other than those specific to the candidates' discipline may be assigned at the discretion of the constituent Association/Ordre.

Before writing the discipline examinations, candidates must have passed, or have been exempted from, the Basic Studies Examinations.

The constituent Association/Ordre will supply information on examination scheduling, textbooks, materials provided or required, and whether the examinations are open or closed book.

BIOMEDICAL/BIOCHEMICAL ENGINEERING EXAMINATIONS

GROUP A

COMPULSORY EXAMINATIONS (SIX REQUIRED – A1, A2 AND FOUR OF THE REMAINING SEVEN)

04-Bio-A1 Biomaterials and Biocompatibility

Structure and properties of amorphous solids. Physical and chemical bases for properties exhibited by materials. Polymeric biomaterials. Metallic biomaterials. Ceramic biomaterials. Composite materials. Material properties including mechanical, electrical, magnetic and thermal behaviour. Applications of biomaterials in tissue and organ systems. Relationship between physical and chemical structure of materials and biological system response. Selection, fabrication and modification of materials for specific biomedical applications. Biomaterials processing. Biomaterials degradation. Implant requirements. Host-implants reactions including wound healing response and inflammatory response. Physiological and biomechanical basis for soft-tissue implants. Design of modified biomaterials. Bulk and surface characterization of materials. Regulatory and ethical concerns dealing with the implementation and commercialisation of biomaterials and medical devices.

04-Bio-A2 Process Dynamics and Control

Linear models of physical systems and processes, the concept of the transfer function. The transient response of linear systems to step, ramp and sinusoidal inputs. Bode plots and the frequency response analysis of systems. On-off, proportional, integral, derivative and combined control actions. Stability analysis of closed-loop systems using the root locus method and the Nyquist criterion. Feedback and feed-forward control. The state-space analysis of control systems. Modeling of nonlinear systems using the phase-plane and describing functions methods, stability of control systems involving nonlinear elements, the concept of limit cycles. A basic knowledge of sampled-data control systems including the z transform. The design of simple digital controllers. Application of the concepts of process dynamics and control to

biological systems with particular attention to neural physiology and homeostasis and bioreactors.

04-Bio-A3 Cellular and Molecular Biology and Biochemistry

Cell structure and function, including transport and chemical signals, adaptation of structure and function. Use of micro organisms in biotechnology. Biology of the prokarytoic cell. Chemical and physical structure of proteins, enzymes, nucleic acids, connective tissue and bone from molecular to microscopic levels. Relationship of chemical and physical structure of proteins to function including regulation of enzyme activity. Recombinant DNA technology including cloning, directed mutagenesis, DNA sequencing and expression of cloned genes. Development and use of recombinant proteins as therapeutic drugs. Fundamentals of therapeutic protein action. Site specific mutation of proteins. Protein-protein and protein-DNA interactions, receptor –ligand interactions, cell adhesion, cell migration, signal transduction, cell growth and differentiation. Post-translational processing and secretion of proteins. Gene cloning and expression in mammalian cells.

04-Bio-A4 Biomechanics

The musculoskeletal system; general characteristics and classification of tissues and joints. Elastic and viscoelastic mechanical characterization of biological tissues including bone, cartilage, ligament and tendon. Principles of viscoelastic and the rate sensitivity of biological materials. The stress-strain-time or constitutive equations for soft connective tissue components. Biomechanics and clinical problems in orthopaedics. Modelling and force analysis of musculoskeletal systems. Passive and active kinematics. Mechanical properties of biological and commonly used biomedical engineering materials.

04-Bio-A5 Enzyme and Microbial Kinetics

Basic principles of bioprocessing fundamentals, which includes: kinetics of enzymatic reactions and microbial growth, batch and continuous cell growth kinetics, products formation and nutrient utilization, bioreactor systems. Basic principles of biochemical engineering. Applied enzyme catalysis, immobilized enzyme technology, kinetics of substrate utilization, product formation and biomass production in cell culture, batch and continuous culture. Applications of biochemical engineering.

04-Bio-A6 Anatomy and Physiology

Description of the human systems. Skeletal system with anatomy of superior members, inferior members and rachis. Osteoarticular system: physiology of bones, osseous tissues, articular cartilage, tendons, ligaments and muscles. Respiratory system, circulatory system, digestive system, urinary system, nervous system, and reproductive system. Structure-function relationships in human body systems.

04-Bio-A7 Fluid Mechanics

Basics of momentum transfer and fluid flow; their application to the solution of engineering problems. Topics include: Engineering unit systems, dimensionless quantities; Basic concepts of fluid statics; Newton's law of viscosity; Steady and unsteady flow; Compressible and incompressible flow; Turbulent shear stress; Bernoulli's theorem, momentum transfer equations,

equation of continuity; Computational fluid dynamics principles; Newtonian and Non –Newtonian fluids; External and internal flow; Fluid flow in pipes; Friction factors; Pumps, compressors, turbines; Flow measurement devices.

04-Bio-A8 Biophysical Measurements

Biomedical sensors and their application to the measurement of blood pressure, cardiac output and respiratory function. The origin of biopotentials including membrane and action potentials. Measurement of the electrocardiogram, the electroencephalogram, and the electromyogram. Basic electrode, biochemical sensor and laser applications including cardiac pacemakers and defibrillators. The basic concepts underlying computed transmission and emission tomography, magnetic resonance and ultrasound imaging. The imaging methods should be understood in terms of how imaging information is generated, detected and processed and how different hardware configurations and other factors affect image quality.

04-Bio-A9 Bioreactor Design

Transport phenomena in biochemical engineering systems, design and analysis of bioreactors, mixing, aeration, sterilization, instrumentation and control in bioprocesses. Internal and external mass transfer in immobilized systems. Oxygen mass transfer parameters of a bioreactor and design of an aeration system. Scale up of Bioprocesses.

GROUP B

ELECTIVE EXAMINATIONS (THREE REQUIRED)

04-Bio-B1 Biochemical Separations

The fundamentals of downstream separation and purification processes such as membrane separation processes, protein separation and purification and other separation processes of economic importance to the fermentation industry. Cell Disruption. Solid Liquid Separation, filtration, centrifugation. Membrane separation. Isoelectric focussing. Adsorption. Chromatography principles, Crystallization.

04-Bio-B2 Prostheses and Orthoses

Introduction, historic, terminology and classification of prostheses and orthoses. Partial or total replacement of limb or joint. Introduction to biomechanics related to design of prostheses and orthoses: clinical and mechanical aspects, biomaterials, biocompatibility. General design objectives and criteria. Design and assessment standards.

04-Bio-B3 Biotransport Phenomena

Momentum, heat and mass transfer. Mass, linear momentum and energy balances. Differential analysis of laminar viscous flow. Differential analysis of heat conduction. Differential analysis of diffusion and convective transport. Biological examples of transport phenomena including: pharmacology and pharmacokinetics; absorption distribution, biotransformation, elimination, calculation of dosages; variability in drug response and adverse drug responses; drug delivery; microenvironment, transport and binding of small and large molecules; movement of cancer and immune cells; metastatic process, radiotherapy, chemotherapy, immunotherapy, hyperthermia, and photodynamic therapy of solid tumors. Numerical methods for computer simulation.

04-Bio-B4 Digital Image Processing

The extension of one dimensional sampling theory to two dimensions. Knowledge of the concepts of sampling geometry and sampling density. Two dimensional image transforms particularly the Fourier and Wavelet transforms. Important pixel operations for image enhancement particularly gray-scale modification and algebraic and geometric transforms. Convolution in two dimensions with particular application to image interpolation (upsampling). The spatial domain and frequency domain application of finite-extent point-spread filters for noise reduction, edge detection and image sharpening. Knowledge of the design and application of some common filters such as the Laplacian, the gradient and the Gaussian filters. Some knowledge of the concepts of image restoration from known degradations such as blur due to camera motion using some of the most common methods such as inverse and Wiener filtering and constrained deconvolution. The reconstruction of images from parallel and fan-beam projections as used in computed transmission tomography (CT).

04-Bio-B5 Cell and Tissue Engineering

Integration of relevant aspects of physiology, pathology, developmental biology, disease treatment and biomaterials to regenerative medicine in complex organ systems. Host response to tissue

engineered constructs including complement, coagulation, immunological responses. Engineered replacements of kidney, lung, vascular, skin. Chemical, electrical, mechanical, materials, pathological and surgical aspects of construct development. Integrative exploration of the use of three-dimensional polymeric scaffolds and drug delivery vehicles, and gene therapy and cellular engineering for functional repair of injured tissues. Cell selection.

04-Bio-B6 Bioinstrumentation

Principles of design and analysis of electric instrumentation for biological applications. Ideal and non-ideal operational amplifiers, signal conditioning filters, sampling theory, analog to digital and digital to analog converters, sample and hold circuitry and multichannel data acquisition including the constraints imposed by real-time processing. The acquisition and processing of diagnostic signals such as the electrocardiogram, the echocardiogram, the blood pressure and hemoglobin oxygen saturation signals. Some basic knowledge of statistics for assessing the signal to noise characteristics of measured data. Safety standards in the clinical setting for electrical and electronic equipment in both non-invasive and invasive applications.

04-Bio-B7 Robotics and Manufacturing Automation

An overview of robotics and manufacturing technology and principles. Topics include: Automatic production and assembly, PLCs, sensors, actuators and drives, mechanization of part handling, industrial robots, and machine vision systems. Emphasis will be on the planning, design and implementation of automation systems.

04-Bio-B8 Rehabilitation Engineering

Introduction to rehabilitation engineering; Wheeled mobility: W/C history, technology and standards, fundamentals of manual W/Cs propulsion biomechanics, powered W/Cs and control systems; Functional disabilities: types of neuromuscular impairments; Specialized seating: classification of seating technologies, biomechanical principles of seating support & pressure, CAD/CAM seating applications; Hearing aids and cochlear implants: sensory and hearing aided technologies; Alternative & Augmentative Communication: rational, technologies & access strategies, principles of access & communication optimization; Prosthetics and orthotics: engineering principles of lower limb prostheses; ADL Devices: rational, design principles and use for upper & lower limb dysfunction; Measurement tools in rehabilitation engineering.

04-Bio-B9 Artificial Intelligence and Expert Systems

AI-based decision making in biology and medicine using predicate calculus, structures and strategies for state space search, heuristic search and stochastic methods. Knowledge representation, reasoning and decision-making under uncertainty as well as case-based reasoning, decision trees. Rule-based and expert systems, inference mechanisms and knowledge engineering. Machine learning including supervised learning, self-organization, reinforcement learning and evolutionary computing. Intelligent biomedical information systems, intelligent devices and instruments such as interactive implants and replacements and measurement systems. Automated reasoning and data mining. Advanced methods for problem solving including natural language processing, planning and perception.

04-Bio-B10 Analytical Biochemistry

Relevant analytical techniques for characterization of biological systems and materials. Nuclear magnetic resonance. Fourier transform infra red analysis. SDS-PAGE and Western blotting. HPLC. Flow cytometry. DNA gel extraction and ligation. Plasmid DNA mini-preps and PCR. Affinity purification and electrophoresis. Surface analysis techniques including x-ray photoelectron spectroscopy, atomic force microscopy, interfacial tension and ellipsometry.

04-Bio-B11 Ergonomics (98-Ind-B5 Ergonomics)

Basic human abilities and characteristics, including vision and hearing. Psychomotor characteristics. Anthropometry: static and dynamic human body dimensions and muscle strength. Environmental factors, including illumination, atmospheric conditions, noise, and vibration. Ergonomic work design, including layout of equipment, manual work aids, design of seating, and person-machine interfaces: instruments, controls, and software. Repetitive Strain Injuries, also known as Cumulative Trauma Disorders.

04-Bio-B12 Applied Optics/Photonics

Basic optics of rays; reflection, refraction, and polarization. Lens systems and image formation. Principles of basic optical instruments such as magnifiers, microscopes and telescopes. Basics of light sources: lasers, light emitting diodes, thermal light sources, fluorescence, and photodetectors. Tissue optics and light-tissue interactions and dosimetry. Principles of fibre optics and light guides, endoscopic systems and applications. Biomedical applications of photonics such as phototherapy and photodiagnosis, tissue oximetry, optical spectroscopy and microscopy, fluorescence marking.