Nepal Engineering Council Registration Examination

Biomedical Engineering Syllabus (ABmE)

Chapters 1-2 focus on fundamental of human biology and biomaterials; chapters 3-7 are related to various tools, technologies, and instruments related to biomedical engineering; chapters 8-9 highlight on digital electronics and communication systems in biomedical engineering; and the last (10th) chapter is related to project planning, design and implementation.

1. HumanBiology (ABmE01)

1.1 Introduction to human body: Understanding of body design at structural-functional level: Cells, Tissues & Organization of the Body; Control & regulation of body function; Understanding of structure & function of different types of cells & tissues, Interpretation of the molecular cell biology to the development of body organs & system: Biomolecules: Proteins, carbohydrates, lipids, nucleic acid; Cell growth and division, apoptosis and oncogenic transformation; Cell to cell transport mechanisms; Cell signaling; Immunology: types of immunity, antigen and antibody, antigen-antibody reaction. (ABmE0101)

1.2. Blood, molecular biology and genetics: Blood: Composition of blood; erythrocytes (RBCs), leukocytes (WBCs) and platelets and their functions; Clotting factors; Hematopoiesis; Hematopoietic stem cell; Hemostasis, Components of coagulation cascades; Extrinsic, intrinsic and common pathway of coagulation cascades,DNA,RNA and Proteinsynthesis;Techniques of geneticengineering. (ABmE0102)

1.3 Nervous system and sensory organs: Understanding the microanatomy of Nerve cell (neurons), Arrangement of neurons. Types of neurons & their connections, Functions of nerve cell. Impulse generation. Basics of Neuromuscular transmission, Structure of Central Nervous system (CNS); Structural Details of Human Ear, Physiology of Ear; Structural Details of Human Eye, Physiology of Eye. (ABmE0103)

1.4 Cardiovascular system and respiratory system: Basics of Anatomy of heart & blood vessels; Coronary circulation: Blood circulation to and from the heart; Functions of the heart; Cardiac cycle, cardiac output & blood pressure; Conduction system of heart; Anatomical and physiological relationship of upper respiratory tract; Lungs & its topography. Pleura & pleural cavity; Lung functions; Mechanism of breathing, types of breathing & control of respiration; Understanding of Ventilation & Lung volumes, Gas transfer & diffusion. (ABmE0104)

1.5 Urinary system: Metabolic functions of urinary system, Topography of Kidneys; Microanatomy of kidney;Structure-function relationship of ureter,bladder &urethra; Controlof bladder function. (ABmE0105)

1.6 Biomechanics: Human joints: Classification and forces in joints (elbow, shoulder, hip, knee, spine, ankle, wrist), Mechanics of hard tissues: Bone growth and development, fracture mechanics, mechanical properties of cortical and cancellous bone; Mechanics of soft tissues: Mechanical properties of muscles, ligaments & tendons. Biofluid Mechanics: Basics of blood rheology. (ABmE0106)

2. Biomaterials (ABmE02)

2.1 Biomaterials: Introduction to Bio-materials and biocompatibility; Classes of materialsused in medicine, Methods of Surface characterization. (ABmE0201)

2.2 Metals and natural materials: Introduction, structure, chemistry, mechanical properties and applicationsof various metals relating to biomaterials, Different types of natural materials; Collagen: Structure, Physical modification, Chemical Modification; Proteoglycans and glycosaminoglycans. (ABmE0202)

2.3 Polymers, ceramics, glasses and composites: Introduction, Types of polymers used in medicine; Structure, chemistry and properties of ceramics and glasses used in medical devices; Types of bio-ceramics, composites. (ABmE0203)

2.4 Thin films, crafts and coatings: General Principles, Methods for modifying the surfaces of materials for enhancing biological interactions, The nature and production of plasma environment, High energy and high temperature plasma treatments. (ABmE0204)

2.5 Biologically functional materials: Biologically active molecules, Immobilization of biologically active molecules, Solid support for biomolecules, Applications, Immobilization methods. (ABmE0205)

2.6 Tissue device interactions: Inflammation, wound healing and foreign body response; Endothelialcells & ECM-Biomaterial interaction; Blood-biomaterials interaction Bacteria and biomaterials.
(ABmE0206)

3.Implantable Devices (ABmE03)

3.1 Cardiovascular implants: Heart valves: Mechanical and Bioprosthetic; Vasculargrafts: Artificial and biological; Stents, catheters and cannulas; Pacemakers; Inferior venacava filters; Intraaortic balloon pump; Ventricular assist device. (ABmE0301)

3.2Orthopaedicimplants: Biomaterials used in orthopaedic implants; Total hip Replacement; Total Knee Replacement. (ABmE0302)

3.3 Urology implants: Materials used in urology implants; Urethral catheters; Urology stents. (ABmE0303)

3.4 Plastic surgery implants: Materials used in plastic surgery implants; Types and procedures of breast implants; Gels and fillers in plastic surgery; Skin implants for burns, craniomaxillofacial reconstruction. (ABmE0304)

3.5 Ophthalmic implants: Types of Ophthalmic implants, Materials used in ophthalmic surgery implants. (ABmE0305)

3.6 Tissue engineering: Introduction; Basic procedure of tissue engineering. (ABmE0306)

4. Medical Imaging (ABME04)

4.1 X-ray Equipment: X-ray production and methods; X-ray tubes: Stationary and Rotating anode; X-ray control and indicating equipment; Filters and grids; Biological Effects of X-rays. (ABME0401)

4.2 Computed Tomography (CT): Introduction; Basic Principles of CT; Generation of CT; System Components (ABmE0402)

4.3 Magnetic Resonance Imaging (MRI): Fundamental Concepts; Principles and Parameters of MRI; Basic Principles of MR Imaging and Image formation; Contrast Enhanced MRI; Clinical Application. (ABmE0403)

4.4 Ultrasonography (USG): Physics of Ultrasound; Construction and Properties of Ultrasound Transducer, Ultrasonic Beam; Modes of Ultrasound Imaging; Doppler Ultrasound; Clinical Application; Biological Effects of Ultrasound. (ABmE0404)

4.5 Digital imaging:Introduction; Digital Radiography;CR, DR, PACS (Picture Archiving andCommunicating System). (ABME0405)

4.6 Basics of radioisotopesimaging: SPECT and PET, Types of Radioactivity, Radionuclide. (ABmE0406)

5. Biomedical Instrumentation- I (ABmE05)

5.1 Fundamental of medical instrumentation: Sources of Biomedical Signals; Performance Requirements of Medical Instrumentation Systems (Accuracy, precision, statistics of measurements);

Intelligent Medical Instrumentation Systems; General Constraints in Design of Medical Instrumentation; Signals and Electrodes: Bioelectric potential; Resting potential; Action potential; Propagation of action potential; Biological signals; Electrodes; Bio-potential electrodes; Microelectrodes; Skin surface electrodes, Physiological Transducers: Introduction, Classification of Transducers: Active andPassive; Displacement, Position and MotionTransducers; Pressure Transducers; Photoelectric Transducers, BiomedicalRecorders:Electrocardiograph (ECG);Electroencephalograph (EEG);Electromyograph(EMG). (ABmE0501)

5.2 Patient monitoring system: System Concept; Cardiac Monitor; Bedside Patient Monitoring Systems; Central Monitors; Measurement of Heart Rate; Measurement of Pulse Rate; Blood Pressure Measurement; Measurement of Temperature; Measurement of Respiration Rate;Arrhythmia and Ambulatory Monitoring Instruments: Cardiac Arrhythmias; Arrhythmia Monitor; QRS Detection Techniques; Exercise Stress Testing; Ambulatory Monitoring Instruments, Fetal Monitoring Instruments: Cardiotocograph; Methods of Monitoring Fetal Heart Rate; Monitoring Labor Activity; Recording System, PulseOximeter, Electromagnetic and Ultrasonic Blood Flowmeters. (ABmE0502)

5.3 Biomedical telemetry and telemedicine: Wireless Telemetry; Single Channel Telemetry Systems; Multi-patient Telemetry; Multi-channel Wireless Telemetry Systems; Implantable Telemetry System; Transmission of Analog Physiological Signals; Telemedicine.(ABmE0503)

5.4 Cardiac output measurement: Indicator Dilution Method; Dye Dilution Method; Thermal Dilution Techniques; Measurement of Continuous Cardiac Output Derived from Aortic Pressure Waveform; Impedance Technique; Ultrasound Method, Pulmonary FunctionMeasurement and Analyzers: Spirometry; Measurement of Volumes. (ABmE0504)

5.5 Clinical laboratory equipment:Biochemistry Analyzers; Colorimeters; Electrolyte Analyzers; Microscope; Centrifuge; ELISA reader and washer; Biosafety Cabinet; Autoclave, Blood Gas Analyzers, Blood Cell Counters: Methods of Cell Counting; Coulter Counters. (ABmE0505)

5.6 Audiometers: Basic Audiometer; Pure Tone Audiometer; Speech Audiometer; Audiometer System Bekesy (ABmE0506)

6. Biomedical Instrumentation- II (ABmE06)

6.1 Cardiac pacemakers: Need for Cardiac Pacemaker; External Pacemaker; Cardiac Defibrillators: Need for a Defibrillator; DC Defibrillator; Pacer – cardioverter- defibrillator. (ABmE0601)

6.2 Instruments for surgery: Principle of Surgical Diathermy; Surgical Diathermy Machine: Monopolar and Bi-polar; Safety Aspects in Electro-surgical Units, Laser Applications in Biomedical Field: Principle of Laser; Pulsed Ruby Laser; Nd-YAG Laser; Helium-Neon Laser; Argon Laser; CO2 Laser; Semiconductor Lasers;Laser Safety. (ABmE0602)

6.3 Physiotherapy and electrotherapy equipment: High Frequency Heat Therapy; Short-wave Diathermy; Microwave Diathermy; Ultrasonic Therapy Unit; Electrodiagnostic/ Therapeutic Apparatus; Pain Relief Through Electrical Stimulation. (ABmE0603)

6.4 Hemodialysis machines: Artificial Kidney; Dialyzers; Membranes for Hemodialysis; Hemodialysis machine, Lithotripters: Conventional Lithotripter Machine; ModernLithotripter Systems; Extra-corporeal Shock-wave Therapy. (ABmE0604)

6.5 Anesthesia machine, ventilators andinfusion system:Introduction andElectronics parts in Anesthesia Machine, Ventilators: Artificial Ventilators; Types of Ventilators; Ventilator Terms; Positive and Negative pressure ventilators, Basic modes, Biomedical Application, Drug Delivery Systems: Components of Drug Infusion Systems; Closed-loopControl in Infusion Systems; Examples of Typical Infusion Pumps and syringe pumps. (ABmE0605)

6.6 Patient safety: Electric shock hazards; Leakage currents; Electrical safety analyzer. (ABmE0606)

7. Electronic Devices, Circuits and Machines for BME (ABmE07)

7.1Integrated circuit technology and device models:Overview of dc and ac diode models, JFET models, bipolar transistor models, MOStransistor models. (ABmE0701)

7.2Amplifier:Classification, untuned and tuned power amplifiers, Operational Amplifier Circuits and differential amplifier, Operation amplifier-based relaxation oscillators, Oscillator Circuits and Filter Circuits, CMOS inverter relaxation oscillator. (ABmE0702)

7.3 AC circuit: Faraday's law of electromagnetic induction, R-L, R-C, R-L-C series circuits, parallel AC circuit, resonance in series and parallel R-L-C circuit; star/delta transformation; Generation of three phase AC emf waveform representation, use of j-operator star and delta connection of source and load, line voltage and line current, phase voltage and phase current, balanced three phase system, calculation of current and voltage, measurement of power, three phase four wire system.(ABmE0703)

7.4 Power supplies and voltage regulators: Half-wave and full-wave rectifiers, Capacitive filtering, LC Filters, RC Filters, Active Filters; Zener diodes, Zener diode voltage regulators, bandgap voltage references, constant current diodes, Voltage Frequency converter. (ABmE0704)

7.5 DC circuit and circuit analysis: Ohm's law, its application and limitation, electric circuit, circuit elements, introduction to voltage source and current source, series and parallel connection of resistors, series and parallel connection of source effect of their internal resistance on the circuit characteristics,Kirchhoff's laws-current law and voltage law, superposition theorem, Thevenin's theorem, Norton's theorem, matrix methods for electric circuit analysis.
(ABmE0705)

7.6 AC operation of magnetic circuit: hysteresis and eddy current losses; knowledge about different types of transformers, Basic knowledge of DC Motors and Generators. (ABmE0706)

8.Digital Electronics, Microprocessors and Signal Processing for BME (ABME08)

8.1Boolean algebra and logic gates: Basic gates: NOT, OR, AND, Derived gates: NOR, NAND,EX-OR, EX-NOR, Universal gates De-Morgan's laws,Boolean algebra: Theorems and Simplifications,Simplification of Logic functions using K-Map up to 4 variables. (ABmE0801)

8.2Combinational logic adder: Half adder, Full Adder, Subtractor: Half Subtractor, Full Subtractor, Encoder, Multiplexers,De-multiplexers. (ABmE0802)

8.3Sequential circuit flip flops: Graphic Symbol, Logic diagram, SR flip flop,D-flip flop,JK- flip flop,T-flip flop,Master Slave flip flop, Shift Registers,Serial in Serial Out (SISO) Serial In Parallel Out (SIPO),Parallel In Serial Out (PISO), Parallel In Parallel Out (PIPO).(ABmE0803)

8.4Introduction to memory and programmable logic: Static and Dynamic memory, Types of Memory: RAM, ROM, PROM, EPROM, EEPROM, Programmable logic: PAL and PLA.
(ABmE0804)

8.5Asynchronous interface: ASCII code, baud rate, start bit, stop bit, parity bit Synchronous interface, Physical communication standard. (ABME0805)

8.6Generalintroduction of various filters: LPF, HPF, BPF and BSF (notch filter) and application.
(ABmE0806)

9. Control and Communication Systemsfor BME (ABmE09)

9.1 System modeling: Differential equation and transfer function, matrix notation, modelling(ABME0901)

9.2 Mechanical components: mass, spring, damper. (ABmE0902)

9.3 Linearized approximations: Frequency domain characterization of systems, Bode amplitude and phase plots, Effects of gain and time constants on Bode diagrams, PID controllers.(ABmE0903)

9.4 Analog and digital communication sources: transmitters, transmission channels and

Receivers (ABME0904)

9.5Types and reasons for modulation:Amplitude Modulation (AM), Frequency Modulation (FM) and Phase Modulation (PM), Distortion, noise, and interference. (ABmE0905)

9.6 Nyquist sampling theory: sampling of analog signals, spectrum of a sampled signal, Sampling theorem for band-limited signals. (ABmE0906)

10. Project Planning, Design and Implementation (AALL10)

10.1 Engineering drawings and its concepts: Fundamentals of standard drawing sheets, dimensions, scale, line diagram, orthographic projection, isometric projection/view, pictorial views, and sectional drawing. (AALL1001)

10.2 Engineering Economics: understanding of project cash flow; discount rate, interest and time value of money; basic methodologies for engineering economics analysis (Discounted Payback Period, NPV, IRR & MARR); comparison of alternatives, depreciation system and taxation system in Nepal. (AALL1002)

10.3 Project planning and scheduling: project classifications; project life cycle phases; project planning process; project scheduling (bar chart, CPM, PERT); resources levelling and smoothing; monitoring/evaluation/controlling. (AALL1003)

10.4 Project management: Information system; project risk analysis and management; project financing, tender and its process, and contract management. (AALL1004)

10.5 Engineering professional practice: Environment and society; professional ethics; regulatory environment; contemporary issues/problems in engineering; occupational health and safety; roles/responsibilities of Nepal Engineers Association (NEA). (AALL1005)

10.6 Engineering Regulatory Body: Nepal Engineering Council (Acts & Regulations). (AALL1006)