Detailed Syllabus of Examination for the post of Assistant Engineer in Biomedical Engineering Animal Husbandry Department

Cat. No: 506/2023

Module1 (10 Marks)
Anatomy & Physiology: structural & functional organization of human body – cells, tissues, organs & systems –homeostasis –. Cell structure, types, organelles. transport across cell membranes - electrochemical gradient – Na+ -K+, Ca2+ pumps, transporters , Membrane Potential, Action Potential **Nervous System:** organization, Neurons – structure & types. Central nervous system, Limbic system – components & basic functions. Cerebellum, Brain Stem, Spinal cord – spinal and cranial nerves, spinal reflex. Peripheral nervous system, Autonomic nervous system, nerves and functions, Special senses – organs of vision, visual pathway, hearing & equilibrium, taste and smell –structure & mechanisms. **Muscular System:** structure of skeletal, cardiac and smooth muscles, mechanism of muscles contraction, muscle tone & energy utilization of muscle. Skeletal system: functions, classifications of bone, structure & composition of bone, bone growth, classification and type of joints. Endocrine system and functions, Integumentary system **Cardiovascular system**-heart- structure of heart, cardiac cycle, cardiac rhythm & rate – normal & abnormal, myocardial ischemia & infarction, atherosclerosis - Heart sounds Circulatory systems-Systemic circulation and pulmonary circulation, blood pressure, arterial pulse, composition of blood, function, blood groups, lymphatic systems. **Respiratory system**- structure and organization-mechanics of respiration, Gaseous exchange, lung volumes and capacities. Gas transport – % Hb saturation – oxygen – Hb dissociation curve. Urinary System- -kidneys-nephron-renal function, micturition, body fluids, acid-base balance.

Module 2 (10 Marks)
Electrochemistry – fundamental concepts of electro analysis, electrodes, electrolytes, Electrical Double Layer, The Half-Wave Potentials and Limiting Currents. Thermodynamics of electrochemical reactions, Standard Potentials, Characteristic Potentials.**-**Transfer of Ions, electrolytic cells, galvanic cells, salt bridge, anode and cathode properties. Electrolytes - basics, Ionic Transport, Ionic Solutions, Electrodes and Reaction mechanisms, Kinetics of Electrochemical Reactions –basic principles, Relationship Between the Current Density and Potential, Under Steady-State Conditions, Current–Potential Transients.-Working Electrodes –basics principles and applications, Electrode Materials, Electrode Geometry, Hydrodynamic Conditions, Chemically Modified Electrode. Reference Electrodes –types- basic principles, The Standard Hydrogen Electrodes, Electrodes of the Second Kind as Reference Electrodes, pH-Based Reference Electrodes, Inner Potential Standards, Solid-State Reference Electrodes, Pseudo Reference Electrodes. Mercury electrodes- Solid Electrodes, carbon electrodes, screen printed electrodes.
Excitable cells **-** Polarized state, Nernst potential, Goldman Hodgkin Katz equation .Synapses & Neuronal Integration, electrical & chemical synapses, excitatory & inhibitory synapses. Synaptic potentials. Post synaptic integration – types Neurotransmitters , Electrode-tissue interfaces - electrode-electrolyte and electrolyte- skin interfaces. Skin contact impedance. - **Properties and characteristics of bio signals** - ECG signal, Lead systems, Diagnostics values of ECG, Artifacts. Arrhythmias , AV conduction block, premature contractions, flutter, fibrillation. EEG**-** brain waves, sleep stages, Abnormal EEGs – epilepsy - 10-20 electrode system. Evoked potentials – visual, auditory & somatosensory EMG - myoelectric control system - ECG, EEG & EMG electrodes. Other bio potentials – ENG, ERG, EOG, EGG.

Module 3 (10 Marks)
Biomaterials -definition & properties. Classification –application. Characterization of materials - Mechanical, surface and electrical properties, viscoelasticity. Metallic implant materials, Ceramic implant, Bioactivity - Bioactive glass Polymeric implant materials , Physiochemical characteristics of biopolymers. Strength and strengthening mechanisms of metals, ceramics and polymers. Tailor made composites, Bio-

composites and nano bio-composites. Hard tissue implants, intramedullary and spinal fixation devices, Dental implants. Soft tissue replacement implants, Sutures, surgical tape and adhesives, wound dressings, Percutaneous and skin implants. Cardiovascular implants and Extracorporeal Devices Vascular implants. Biocompatibility. Factors affecting biocompatibility – Blood Compatibility – Factors affecting blood compatibility. Material response, Testing of implants, Materials, Design and selection of implant materials. **Bio-Fluid Mechanics**: Newton's laws, Stress, Strain, Elasticity, Hooke's-law, viscosity, Newtonian fluid. Non-Newtonian fluid, Viscoelastic fluids, vascular tree, velocity and Pressure of blood flow, Resistance against flow. **Flow Properties of Blood:** Physical, chemical and Rheological properties of blood. Apparent and Relative viscosity. Blood viscosity variation: Effect of shear rate, Hematocrit, Temperature, Protein content of blood. Casson's Equation, **Rheology of Blood in Microvessels**: Fahraeus – Lindqvist effect and inverse effect, distribution of suspended particles in a narrow rigid tube**.** Nature of red cells in tightly fitting tubes, hematocrit in very narrow tube. **Cardiac Mechanics:** Mechanical properties of blood vessels Blood flow: Laminar and Turbulent, Physics of cardiovascular diseases

Module 4 (10 Marks)

Therapeutic equipment- Cardiac pacemakers, external and implantable pacemakers, **Defibrillator,** Implantable defibrillator and automated external defibrillator (AED), Catheterization IABP, Stents. **Ventilators,** Flow sensors and FiO2 sensor. **Anaesthetic machines,** Gas blending and vaporizers, Anaesthesia delivery system, breathing circuit. **Surgical diathermy unit,** Neuro drills, Neuro navigation systems, Intra operative nerve monitors, Deep brain simulators. Laser surgery applications in ophthalmology, Ultrasonic therapy unit, Interferential current therapy, Transcutaneous electrical nerve stimulation (TENS). Transcranial magnetic stimulation, **Drug delivery systems**, **Dialysis machine, Endoscopy**, Cryo-surgery techniques. Operating microscope, arthroscopy, laser lithotripsy, Photo therapy, **Radio diagnosis and radio therapy** - Production **of X ray** - radiographic systems, X-ray tubes, mammography, CT -Rating charts of X-ray tubes Exposure switching - Primary & secondary – Comparison. Control of exposure time, Scattered radiation control in radiography , bucky grids Radiations units **-** Various components of **fluroscopic system** - Image intensifier - parts & working.TV chain for fluoroscopy- optical coupling. **Angiographic techniques in radiology** - Conventional angiography, basic principle. **Cardiac Catheterization,** DSA- Principle and clinical applications. Selective and Super-selective angiography, Coronary angiographic techniques , Cardiac Nuclear Imaging, Physical principles of radiotherapy. Types - Dosage data for clinical applications – kV & MV radiations –radiation sources (radionuclides) for brachytherapy.

Module 5 (10 Marks)

Digital Electronics - Number system: Binary, Octal, Hexadecimal, TTL: Basic working principle of TTL, CMOS, Boolean algebra, Combinational logic circuit & design, Karnaugh map, Shift registers - SISO, SIPO, PISO, PIPO, Synchronous sequential circuits using finite state machines. **Analog Electronics**: Bipolar Junction Transistors, Field-Effect Transistors, MOSFET, Operational Amplifiers, Realization of LPF, HPF, Notch filter, Linear-Digital ICs, Feedback Concepts, **Instruments**- Accuracy, precision, sensitivity, resolution, loading effect. Bridges for measurement: Wheatstone, Kelvin bridges; AC bridges-Maxwell, Hay and Wein bridges; Measurement of R,L, C and Q meter. Motors : Motor Components, DC Motors- Stepper Motor, Servo Motor, Brushless DC Motors, Hysteresis Motor, Reluctance Motor, Universal Motor, Electrostatic motor, Piezoelectric motor. **Medical Instrumentation circuits**: Analog Active Filters, two-Op Amp ECG amplifier, Instrumentation amplifier, Medical Isolation amplifiers, safety standards in medical electronic amplifiers , Phase sensitive rectifiers, phase detectors, VCO, Phase Locked Loops, **Digital Interfaces**: Aliasing and the Sampling Theorem -Digital-to-Analog Converters, DAC Designs(R–2R ladder),Static and Dynamic Characteristics of DACs, Hold Circuits. Analog- to-Digital Converters (Tracking Converters, The Successive Approximation ADC, integrating Converters, Flash Converters, Delta-Sigma converters). Quantization Noise. **Devices for Measurement and Recording** :Digital storage oscilloscopes. Method of measuring voltage, current, phase, frequency and period using CRO, DSO. Strip chart recorder, X-Y recorder, Plotter, liquid crystal display (LCD) ,Waveform analysing instruments- Distortion meter, Spectrum analyser, Digital spectrum analyser. **Microcontrollers**, Architecture of Intel 8051, Assembly language programming of 8051, PIC Microcontrollers, Addressing

modes, Instruction format, Introduction to PIC assembly programming, Arduino, Program structure, Interfacing sensors-LM35, PIR Sensors, motor control – PWM

Module 6 (10 Marks)
Active and Passive sensors - Resistive, Capacitive, Inductive sensors, Strain Gauge, Capacitive transducer, Inductive transducer, LVDT, thermistor, Thermocouple - characteristics. **Bio Sensors,** types, applications, characteristics, Enzymatic sensors: enzyme based bio sensor construction, enzyme immobilization techniques, Immobilization and Types of Immobilization, Immuno sensors, antigen antibody interaction, modes of antibody immobilization, electrochemical detection techniques, Electrochemical Biosensors: gas, ion and humidity sensors, applications of Nernst Equation in biosensor. Chemical Reactions, Thermodynamics of Chemical Interactions, biochemical electrodes, classification- Potentiometric, Amperometric, Conductimetric, Impedemetric, Ion Selective Electrodes, Electrochemical pH Sensors, Voltammetry, Stripping Analysis, Applications of Electrochemical Biosensors. Optical biosensors- light interactions with biomolecules, types of optical biosensors, optical waveguide based sensor & transducers, Propagation and sensitivity of optical waveguides, Optical Fiber based sensors, Interferometric optical Transducers, Plasmon band based sensors, fluorescence and phosphorescence concepts, fluorescence based biosensors. Nano biosensors: concepts & applications nanoparticle synthesis, construction of nano biosensors, sensing applications of Carbon Nanotubes, nanowires, nanorods, quantum dots. Nano materials for new bio sensing principles, optical nano bio sensors. Immobilization at the nano scale, DNA arrays, protein chips, theory of microfluidics, BioMEMS.

Module 7 (10 Marks)
ANALYTICAL & DIAGNOSTIC EQUIPMENTS - Beer-Lambert's Law, Colorimeters, Spectrophotometers - Filters-Monochromators -Detectors -UV & Visible, IR Spectrophotometer –Radiation Source -Monochromators & Detectors-, Electrolyte Analysers-Measurement methods - Ion selective electrode method (ISE) -Solid state ISE -Ion-Selective Optodes, Lab On a Chip (LOC) biochemical sensor, - glucometer-Point Of Care Test equipment(POCT) **Biochemistry Equipment:** Automated clinical analysers-Biochemistry analysers, Blood Culture Equipment, Radio immune assay (RIA) -Enzyme Linked Immuno Sorbent Assay (ELISA/CLIA), Immuno precipitation- Immuno fluorescence-Polymerase Chain Reaction (PCR)- RT-PCR instrumentation, Electrophoresis- Principles ,Chromatography – Gas- high-pressure liquid and paper chromatography, Flow Cytometry-Blood cell counters- Coulter Counters, Blood Gas Analysers. **Bioelectric Devices:** Electro cardiograph- Pre-amplifiers- Filters- Isolation circuits- RL driven circuit-protection circuits-Power amplifiers -Recorders, Phonocardiograph–Instrumentation, Cardiac stress testing, Patient monitoring systems -NIBP-PPG-Temperature, Arrhythmia monitors, Ambulatory recorders-Holter monitors, Electroencephalography – Instrumentation, Evoked potential measurement systems-applications, Sleep Studies-Polysomnography, Sleep apnoea monitors. **Impedance Techniques:** Bipolar and tetrapolar circuits-detection of physiological activities using impedance techniques -respiratory activity- Impedance Cardiography- Impedance Plethysmography, Pulse Oximeter Instrumentation, Cardiac output measurement- Fick method -Dilution Methods-Doppler method, Blood pressure monitors **Audiometers** – Pure tone - speech audiometers and impedance audiometry. **Respiratory measurements**: Spirometry – Pulmonary function measurements, **Blood flowmeters** - Electromagnetic – Ultrasonic Doppler blood flowmeters.

Module 8 (10 Marks)
Medical Imaging Techniques – Diagnostic Ultrasound Imaging-A-mode, B-mode and M-mode, Doppler Ultrasound, Spectral Ultrasound, colour imaging, Three-Dimensional Ultrasound, Elastography, **Magnetic resonance imaging, X-Ray Computed Tomography,** Multislice CT Scanners, CT Angiogram and DSA, **Radiology and Hybrid imaging,** Hybrid Imaging instrumentation MR-PET Instrumentation-Mutual interference between MR and PET, MR Compatible PET detector technology, MR-PET system architecture.

PET-CT, SPECT-CT. Radiation protection, **Infrared imaging** - thermographic image processing - clinical applications of thermography in rheumatology, neurology, oncology and physiotherapy, Tactile Imaging and Photoacoustic Imaging.

Module 9 (10 Marks)
Biomedical Signal and Image Processing - challenges in processing biosignals - Continuous time & Discrete time systems -Basic system properties - Causality, stability, Time invariance, linearity. Laplace transform - Region of convergence - The inverse Laplace transform - Properties of the Laplace transform. Signal representation, Aliasing-Sampling theorem. Classification of discrete signals Properties of. LTI system-convolution- correlation - difference equation representation of discrete systems Fourier Analysis: Fourier Analysis of discrete time signals - DFT-properties FFT algorithms. Spectrum analysis & Z Transform: parametric & non parametric methods. Z transform – Properties, Inverse Z transform, Digital filters: FIR, IIR filter design Applications of biomedical signal processing

Image quality and Information content: Characteristics of medical images from different modalities, artefacts in medical images, Digital image processing- digitization of image- sampling and quantization, representation of images. Image quality- contrast, Histogram stretch and equalization, Entropy, Signal to Noise ratio, Blur & Spread functions, resolution. **Image enhancement and restoration:** Image enhancement in the spatial domain- Gray level transformations, histogram processing, averaging, image subtraction, smoothing and sharpening, spatial filters. Image enhancement in the frequency domain- Fourier transform & spectral content, MTF, Filters- low pass, high pass, band pass and band stop filters, homomorphic filter. **Image restoration:** Noise reduction filters- Adaptive filters, Wiener filters, Inverse filters **Boundary detection and Image segmentation:** Boundary Representation- Chain Codes. Boundary Extraction-Connectivity, Contour Following, Edge Linking and Heuristic Graph Searching, Dynamic Programming, Hough Transform. **Edge Detection**-Gradient Operators, Compass Operators, Laplace Operators and Zero Crossings. **Image Segmentation** - Amplitude Thresholding or Window Slicing, Component Labelling, Boundary-based Approaches, Region-based Approaches and Clustering, Template Matching, Texture Segmentation **Feature extraction and interpolation:** Connected component labelling, Statistical classification- Parametric, non- parametric techniques- k-Nearest-neighbour (k-NN) classifier, unsupervised methods- k- means clustering &Hierarchical clustering. **Image Interpolation:** Classical and generalized Interpolation, **Hybrid image examination technique and deep learning models** Thresholding techniques, optimization techniques, Deep learning models.

Module10 (10 Marks)
ARTIFICIAL ORGANS AND IMPLANTS: Prosthesis - Types and materials. Engineering Design of artificial Heart & Circulatory Assist Devices: Prosthetic Heart Valves, Vascular grafts. Artificial heart-lung machine, Oxygenators, Artificial blood: Oxygen carrying plasma expanders; Blood substitutes. Artificial oxygen carriers; Hemoglobin based artificial blood. Artificial kidney, Artificial sphincters and catheters, Artificial pancreas, Artificial liver, urological Prosthetic Devices. Artificial skin, Cochlear implants, audiometry, air conduction and bone conduction hearing devices, masking. Hearing aids, Ocular implants, Joints: Types of human joints, joint replacement , Rehabilitation Engineering: Types of bone Impairments and disabilities, Prosthetic and Orthopedic devices, arthroplasty, total knee prosthesis, total hip prosthesis. Myo-electric hand and arm prosthesis. Gait study and spinal rehabilitation.

Bioinformatics & mobile computing in health care - Basics for Bioinformatics- Cells, DNA and Chromosome, the Central Dogma, Genes and the Genome, DNA Sequencing, Transcriptomics and DNA Microarrays, Proteomics and Mass Spectrometer, Basic Principles of Genetics-Mendel and Morgan's Legacy, Disease Gene Mapping in the Genomic Era. Basic building block of m-Health, Old Episodic model of health care.

NOTE: - It may be noted that apart from the topics detailed above, questions from other topics prescribed for the educational qualification of the post may also appear in the question paper. There is no undertaking that all the topics above may be covered in the question paper.