TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

Department of Electrical and Electronic Engineering

UNIVERSITY EXAMINATION FOR:

Bachelor of Science in Electrical and Electronic Engineering

EEE 4519: BIO-MEDICAL INSTRUMENTATION

END OF SEMESTER EXAMINATION

SERIES: JULY 2025

TIME: 2 HOURS

DATE: JULY 2025

Instructions to Candidates

You should have the following for this examination
-Answer Booklet, examination pass and student ID
This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.
Do not write on the question paper.

Question ONE (Compulsory 30 marks)

a) State and explain any Four sources of noise in human monitoring **[8 marks]**

b) A clinical staff member has attached a patient to an electroencephalograph (EEG) machine for a sleep study that continuously the patients EEG on computer screen and stores it in memory. This staff member accidentally used two different types of electrodes for the EEG led, and each electrode had different source impedance. One a relatively low impedance of 1500 Ω at EEG frequencies, while the other had a higher impedance of 4700 Ω. A ground electrode having an impedance of 2500 Ω was also used. The input impedance for of each differential input of the EEG machine to ground 10 M Ω, and the instrument had a CMRR of 80 dB. The power-line displacement current to the patient was measured at 400 nA.The amplitude of the patient's EEG was 12 μV.

(i) determine the common mode voltage seen on this patient

(ii) Comment whether the signal in (i) above will significantly interfere with the EEG signal.

(iii) determine the power line interference that will be seen on the patient's EEG

[5 marks]

c) Figure Q 1c an electrocardiograph (ECG) machine connected to the patient's body. Determine

(i) the 60 Hz interference voltage across the input terminals, if the displacement current I_d due to power line interference is 9 nA and difference in the skin electrode impedances of the two limb electrodes are 20 kV.

(ii) the common mode voltage at the input terminals given that the displacement current I_{db} through the patient's body is 0.2μA, the skin-electrode impedance Z_G at the leg electrode is 50 kV and the body impedance Z_b is 500Ω.

[5 marks]

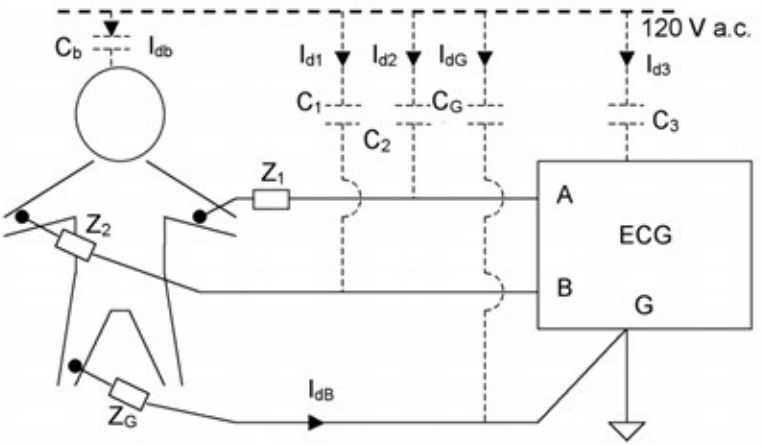

Figure Q1c

d) With the aid of a diagram explain the basic parts of a generalized medical instrumentation system

[12 marks]

Question TWO

a) Define the term microelectrode

[2 marks]

b) A metal micro electrode has a tip that can be modelled as being cylindrical. The metal itself is 1 μm in diameter and the tip region is 3mm long. The metal has a resistivity of 1.2 x 10^{-5} Ω-m and is coated over the circumference with an insulation material of 0.2μm thick. The insulation material has a relative dielectric constant of 1.67. Only the base of the cylinder is free from insulation. Determine the

(i) The resistance associated with the tip of this microelectrode.

(ii) Area of the surface of the electrode that contacts the electrolytic solution within the cell.

(iii) If the resistance associated with electrode-electrolyte interface is 10^3 Ω for 1cm^2, determine the resistance due to microelectrode contact with the electrolyte.

(iv) Determine the capacitance associated with the tip of the microelectrode when the capacitance at the interface of the electrode electrolytic solution are neglected.

(v) Draw the appropriate equivalent circuit for the tip portion of the microelectrode.

(vi) If the amplifier having a purely resistive input impedance of 10MΩ, is connected to the electrode, determine the frequencies at which distortions are expected.

[18 marks]

Question THREE

a) With the aid of a diagram explain the

(i) Construction and principle of operation of an electro cardio-graph (ECG.

(ii) production of the P, Q, R, S and T waves

[16 marks]

b) Defibrillators are devices that deliver electrical shocks to the heart in order to convert rapid irregular rhythms of the upper and lower heart chambers to normal rhythm. In order to rapidly deliver electrical shocks to the heart, a defibrillator charges a capacitor by applying a voltage across it, and then the capacitor discharges through the electrodes attached to the chest of the patient undergoing ventricular fibrillation. In a defibrillator design, a 64-μF capacitor is charged by bringing the potential difference across the terminals of the capacitor to 2,500V. Determine the;

(i) Energy stored in the capacitor

(ii) Charge stored on the capacitor

(iii) Average electrical current (in amperes) that flows through the patient's body if the entire stored charge is discharged in 10 ms.

[4 marks]

Question FOUR

a) With the aid of a diagram explain the sources of bio–medical signals in a human body

[16 marks]

b) An electrocardiograph has a broad frequency response so that its amplifier has a first order time constant of 16 s. The electrocardiograph amplifier has a broad dynamic range of input voltages, but any input voltage greater than ± 2mVwill be out of the range of its display and cut off. While according to the ECG of a patient, a transient occurs that has an amplitude of 10 mV, and this causes ECG to fall out of the range of the instrument display. If the ECG R wave has an amplitude of 1 mV. Determine how long it will take for the entire signal to be visible on the display.

[4 marks]

Question FIVE

a) Outline Four reasons why Magnetic resonance imaging (MRI) is quite recent diagnostic imaging that has aroused wide interest

[8 marks]

b) With the aid of diagrams describe the components of magnetic resonance imaging (MRI) system

[12 marks]