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: MARCH 2025

TIME: 2 HOURS

DATE: MARCH 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 briefly explain three types of electrodes used in patient monitoring systems

[6 marks]

b) Using silicon nitride (E = 385 GPa), a micro cantilever of a 200-μm length, 20 μm wide and 0.6 μm thick, is developed for use in a bacterial detection. Antibodies specific to those bacteria are immobilized only at the tip. If a deflection of 10 mm is observed, assume that each bacterium weighs 53 ng. determine how many bacteria should attach to the cantilever

[6 marks]

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

[13 marks]

d) (i) In an ECG measurement using the setup in Figure Q1d, 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, find the 60 Hz interference voltage across the input terminals of the ECG machine.

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

[5 marks]

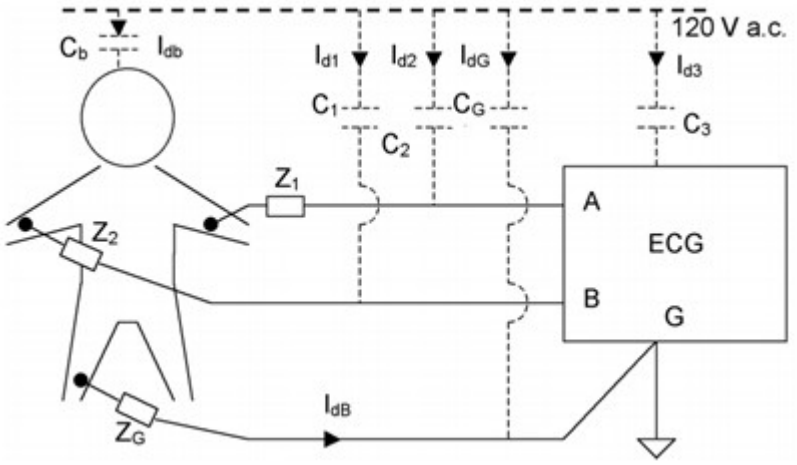

Figure Q1d

Question TWO

a) Explain the working principle of the right led derived circuit of Figure Q2a

[11 marks]

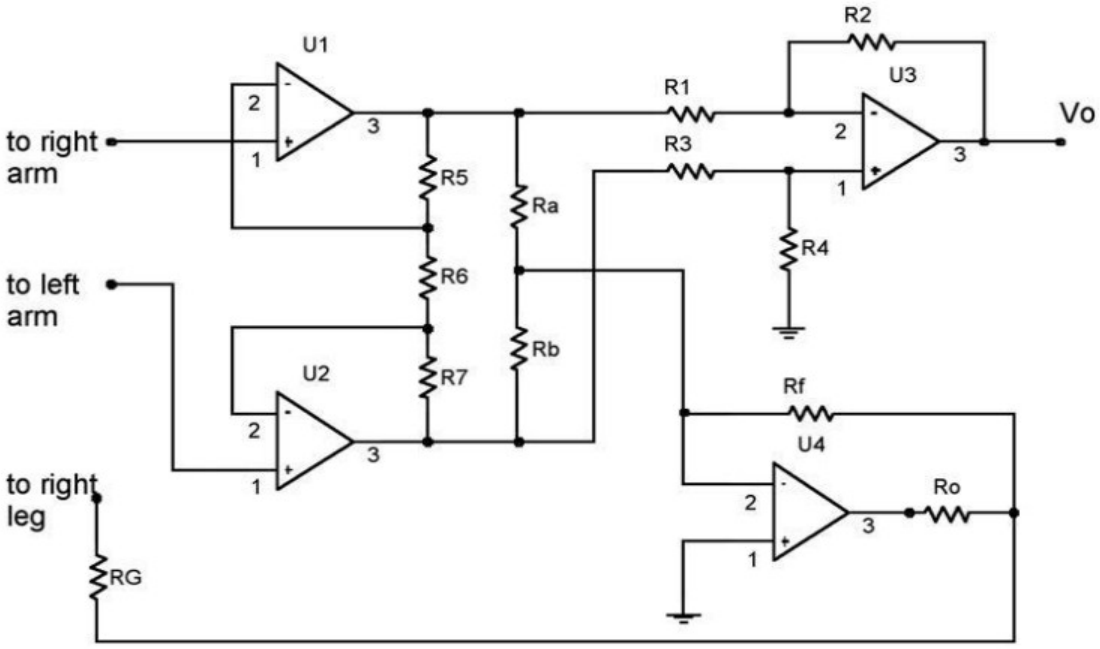

Figure Q2a

b) An Instrumentation Amplifier with input impedances of 5 MW between each input terminal to ground is used as the first stage of an ECG machine. If the difference in the skin-electrode impedance is 20 kW and the common mode voltage induced from power lines on the patient's body is 10 mV, determine the magnitude of the 60-Hz interference appearing across the input terminals of the Instrumentation Amplifier.

[3 marks]

c) For the RLD circuit in Figure Q2a, using the values in (b) (i.e., I_{db} = 0.2 mA, RG = 50 kW,

(i) If R_f = 5 MW and R_a = 25 kW, determine the common mode voltage V_{cm} on the patient's body.

(ii) Using this new V_{cm} value from above, calculate the magnitude of the 60-Hz interference appearing across the input terminals of the Instrumentation Amplifier in (b)

[6 marks]

Question THREE

a) With the aid of a diagram explain the

(i) construction and principle of operation of and electrocardiograph (ECG)

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

[16 marks]

b) Outline any FOUR variables that represent a patient's vital signs that are commonly measured using an ECGA group of researchers are trying to develop an electrochemical biosensor with a requirement of detecting a constant current of 50 mA for 1 hour. If the valency of the analyte is +2, determine the minimum number of moles of analyte required to be present.

[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) Describe the advantages of using depth-of-anesthesia monitoring using EEGs.

[4 marks]

Question FIVE

a) (i) Outline the reasons why silver – silver chloride electrodes are preferred to pick up signals from a biological object

ii.) Explain the process of producing silver- silver chloride electrodes

[11 marks]

b) In a filtration of the urea from blood using a countercurrent flow, a dialysate exchanger with an area of 210 cm^2. The mass transfer coefficient K for the exchanger is 0.2 cm/min. If the dialysate flow rate is 400 mL/min, the blood flow rate is 200 mL/min and the urea concentration in the blood at the start of dialysis is 150 mg/cm^3; then determine;

(i) The concentration of the urea in the dialysate outlet and in the blood outlet after a short transient during which the dialyzer reaches steady state.

(ii) The clearance at the start of dialysis,

(iii) The time it will take to bring the urea concentration in the blood to 10%of its initial value if the body fluid volume is 10L.

[9 marks]