University of Ghana

BSc. Engineering

First semester examinations: 2015/2016

Department of Biomedical Engineering

BMEN 303: Bioinstrumentation (3 credits)

INSTRUCTION:

Answer Three Questions in all (question 1 and any other two questions)

Time Allowed: 2 hrs 30 mins

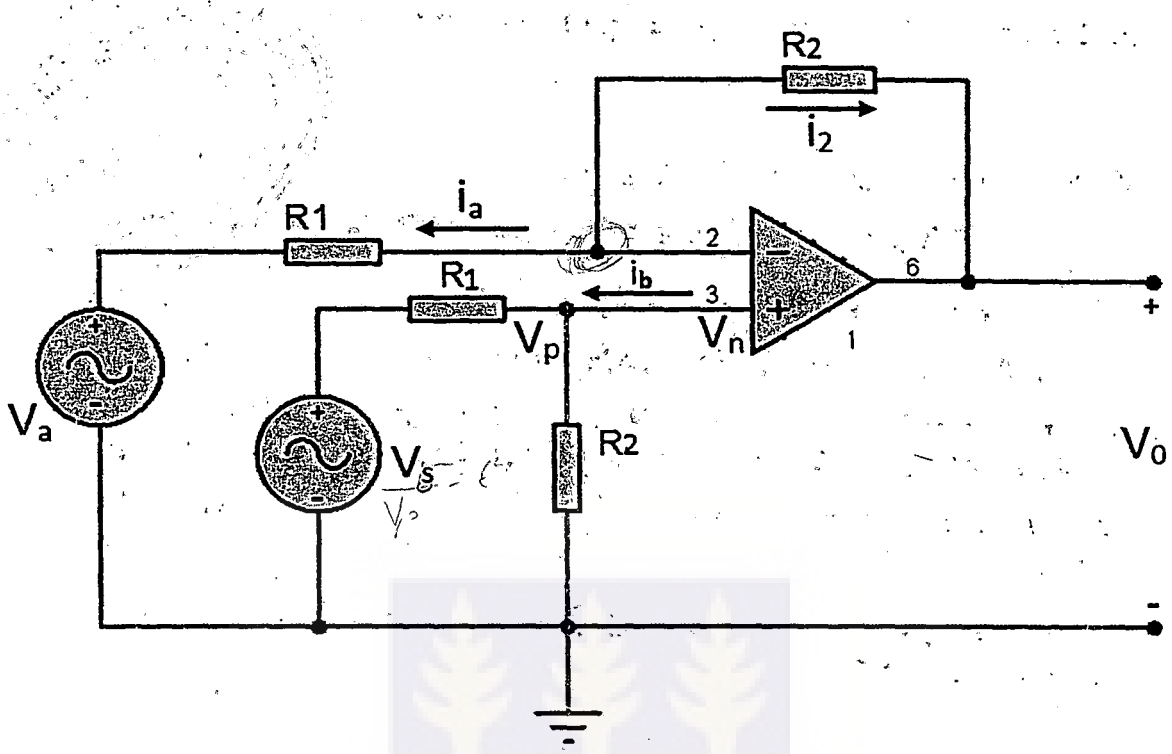
1a. Draw a well labelled diagram of an instrumentation amplifier and write down the expression for the output voltage V_o (10 marks)

b. Give three reasons why Instrumentation amplifiers (IA) are used in biomedical applications. (6 marks)

c. Show that the overall gain of the circuit below is

$$V_o = \frac{R_2(V_b - V_a)}{R_1}$$

(9 marks)



d. Sketch the circuit diagram of a non-inverting follower and calculate the voltage gain if R_1 = 2.2 kΩ and R_2 = 10 kΩ. (6 marks)

e. State two applications of the unity gain non-inverting follower. (4 marks)

f. Calculate the membrane potential of a cell at 27 °C if the concentration of sodium ions in the cytoplasm and the extracellular fluid are 13 mM and 110 Mm, respectively. Take Boltzmann's constant k to be 1.38 x 10^{-23} m^2 kgs^{-2} K^{-1} and the charge q on an electron to be 1.6 x 10^{-19} C.

(6 marks)

2a. What is biopotential electrode? Give three reasons that made the Ag/AgCl electrode the most popular biopotential. (8 marks)

b. State the practical problems clinicians face when making biopotential measurements and state two ways how these problems are resolved. (8 marks)

c. Silver and aluminum electrodes are placed in an electrolyte solution. Calculate the current that will flow through the electrode if the equivalent resistance of the solution is 2 kΩ. The Half-cell potentials for Silver and aluminum are 0.799 and -1.706 V respectively. (6 marks)

d. Explain why amplifiers used in biomedical applications have very high input impedance.

(3 marks)

e. What is motion artifact? Explain its effect on bio potential measurement. How is it reduced or eliminated? (5 marks)

3a. i. Explain the terms **impedance** and **a pole** in a filter design. (4 marks)

ii. By means of diagram only show how a simple passive RC low pass filter can be made. (6 marks)

iii. Under what conditions would you use a low pass filter? (4 marks).

b. Sketch and label the frequency response curve of a one pole low pass filter. (6 marks)

c A low pass filter circuit of a resistor of 47 kΩ in series with a capacitor of 47 nF is connected across a 10 V sinusoidal supply. Sketch the circuit diagram and calculate the output voltage (V_{out}) at frequency of 100 Hz and a gain of 10. (10 marks)

4a. Draw a well labeled block diagram of a generalized instrumentation system and explain the function of each component. (10 marks)

b. State five problems in signal detection in living systems. (5 marks)

c. Sketch sample waveforms for the following biopotentials; ECG, EEG, EMG (6 marks)

i. State the most suitable electrode used in each case. (3 marks)

ii. The frequency range for each bipotential. (3 marks)

iii. Explain action potential of a cell. (3 marks)