UNIVERSITY OF GHANA

BSC. ENGINEERING FIRST SEMESTER EXAMINATIONS: 2018/2019
DEPARTMENT OF BIOMEDICAL ENGINEERING
BMEN 303: BIOINSTRUMENTATION (3 Credits)

INSTRUCTIONS:

ANSWER ALL QUESTIONS IN SECTION A AND ANY TWO QUESTIONS IN SECTION B

TIME ALLOWED: TWO AND HALF HOURS

SECTION A (50 MARKS)

1. List **three** keys to a successful engineering design of a bio instrument (3 marks)

2. Draw and label a block diagram of bioinstrumentation system and explain briefly the function of each component. (10 marks)

3. In bio potential measurement, the most critical point is the contact between electrodes and biological tissue. Both the electrode offset potential and the electrode/tissue impedance are subject to changes due to relative movements of electrode and Tissue. Thus, two interference signals are generated as motion artifacts and motion induced changes of voltage drop.

   Mention the three measures / remedies you would take to minimize motion artifact. (6 marks)

4. You are hired to design an instrumentation device for Biomedical application, where very low frequency biopotentials are not to be measured, it would therefore be desirable to block these signals during the design.

   a. At what stage in the process would you block these signals? (2 marks)

   b. Draw and label the component in your device that would address the problem [name the component]. (5 marks)

5. Which of the configurations of the OP-amplifier in Figure 1 is operating in common mode. Give reason for your choice. (3 marks)

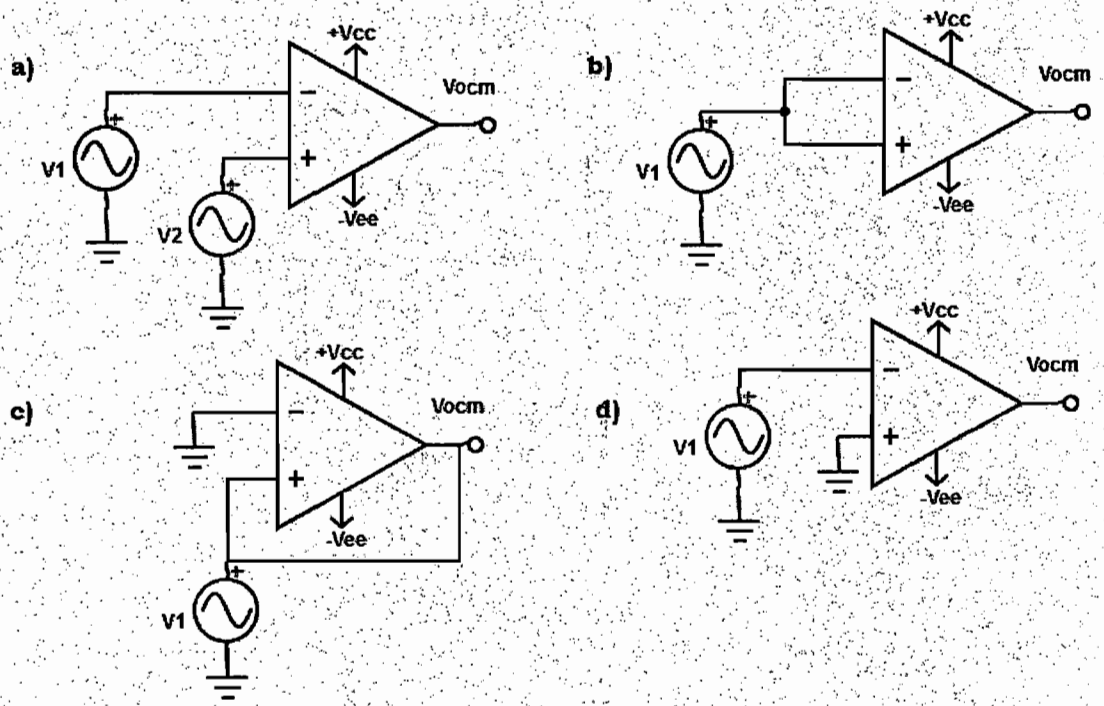

Figure 1: Operational Amplifier Circuits

6. Calculate the common mode gain for the operational amplifier in **Figure 2**. (6 marks)

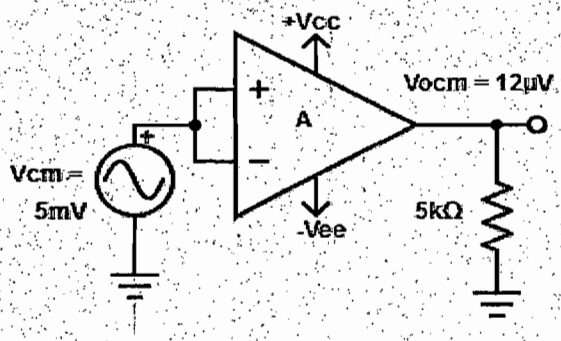

Figure 2: Operational Amplifier

7. What are ECG leads? Name the different types of leads in the 12-lead system. (5 marks)

8. Find the rhythm of the ECG in Fig. 3 below and interpret it. (6 marks)

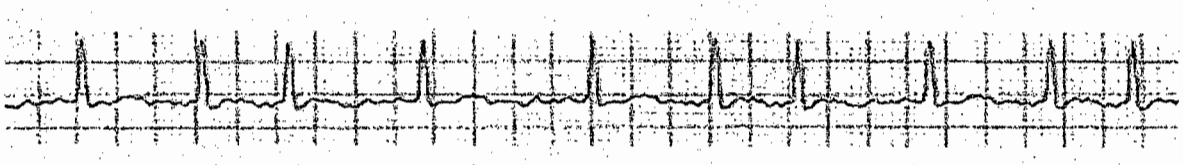

Fig. 3: ECG signal

9. Name two electrodes used in measuring the following Bio signals.

   a. ECG

   b. EEG

   c. EMG (6 marks)

SECTION B - **ANSWER TWO QUESTIONS FROM THIS SECTION**

12. The circuit shown Figure 4 is operating in the sinusoidal steady state with

$$v_s(t) = 35\ cos\ 1000t.$$

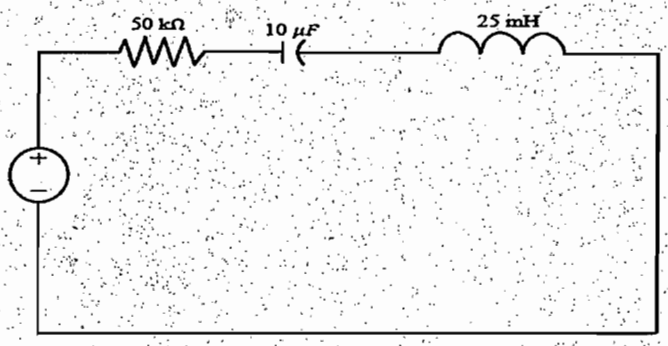

Figure 4: The electric circuit in steady state

a. Transform the circuit into the phasor domain (4 marks)

b. Solve for the phasor current **I** (5 marks)

c. Solve for the phasor voltage across each element (8 marks)

d. Construct the waveforms corresponding to the phasors found in (b) and (c) (8 marks)

13. a. Describe the auscultation method of measuring blood pressure. (7 marks)

b. Mention **two** possible sources of error in this method and the precautions that you would take to avoid them. (5 marks)

c. What is the rhythm and the interpretation of the ECG below in fig 5? (7 marks)

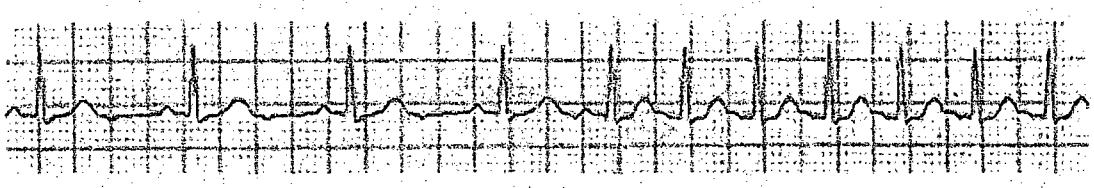

Fig.5: ECG signal

d. An ECG signal has 1 mV peak to peak amplitude and electrode noise of 1 μV. Calculate the **signal –to- noise ratio (SNR)** in decibels. (6 marks)

14. A first order active high pass filter has a pass band gain of 2 and a cut-off corner frequency of 1 kHz. If the input capacitor has a value of 10 nF,

a. Calculate the value of the resistor at this cutoff frequency (6 marks)

b. What is the relationship between the gain resistors in the feedback network (5 marks)

c. Design this filter circuit using the results in a and b (10 marks)

d. Sketch the frequency response curve of your design (4 marks)

15. a. What is meant by slew rate? (2 marks)

b. An operational amplifier has a slew rate of 2 V/μs. If the peak output is 12 V. What is the power bandwidth? (4 marks)

c. A 100 pF capacitor has maximum charging current of 150 μA. Calculate the slew rate. (5 marks)

d. Draw and label the Ideal voltage transfer curve for an operational amplifier. (4 marks)

e. The circuit in Figure 6 below consists of two noninverting amplifiers cascaded, (meaning that the output of the first amplifier becomes the input for the second amplifier)

Find

i. **Vo,** the output of the cascaded circuit (5 marks)
ii. The current **I** through the 10 kΩ resistor. (5 marks)

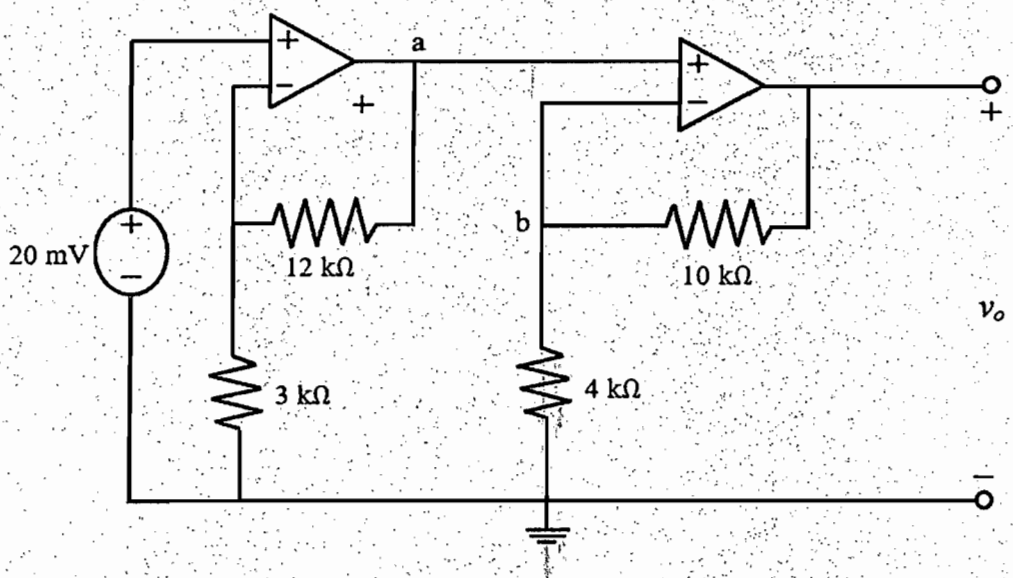

Figure 6: Cascaded Operational Amplifier Circuit