MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE), BACHELOR OF EDUCATION (SPECIAL NEEDS) AND BACHELOR OF SCIENCE IN APPLIED PHYSICS AND TECHNOLOGY

SPH 442: INSTRUMENTATION SYSTEMS

DATE: **TIME:**

INSTRUCTIONS

1) The paper consists of five questions.
2) Question ONE is compulsory and carries 30 marks.
3) Choose any other TWO questions from the other questions. Each carries 20 marks.

QUESTION ONE (30 marks)

(a) Differentiate between the following types of instruments

i. a transducer and a transmitter. (4 marks)

ii. a secondary and absolute instruments. (4 marks)

(b) State the three basic functions of sensors and transducers. (3 marks)

(c) Describe the first three elements in a measurement system (6 marks)

(d) An operational amplifier circuit is required to produce an output that ranges from 0 to −5 V when the input goes from 0 to 100 mV. Calculate the gain factor in the feedback arm over input resistance.

(4 marks)

(e) Explain with aid of diagram an application of potentiometer in designing a transducer for converting pressure to voltage. (5 marks)

(f) Briefly describe the following types of error in measuring instruments.

i. Application error (2 marks)

ii. Dynamic error (2 marks)

QUESTION TWO (20 marks)

(a) Define a measurement system (2 marks)

(b) Describe the following static characteristics of instruments

i. Linearity (2 marks)

ii. Resolution (2 marks)

(c) Redraw the inverting amplifier circuit in Figure 1 as a non-inverting amplifier with a voltage gain of 470 and calculate the value of R_R. (5 marks)

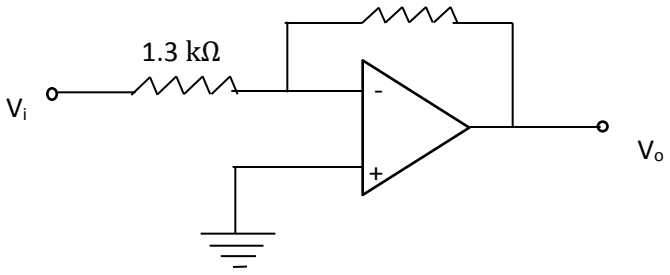

Figure 1

(d) Explain the mode of operation of a null-type voltage measuring instrument. (5 marks)

(e) A tungsten/5% rhenium–tungsten/26% rhenium thermocouple has an output e.m.f. as shown in the following table when its hot (measuring) junction is at the temperatures shown. Determine the sensitivity of measurement for the thermocouple in mV/°C. (4 marks)

mV	4.37	8.74	13.11	17.48
ºC	250	500	750	1000

QUESTION THREE (20 marks)

(a) Define the following terms in instruments

i. Precision. (2 marks)

ii. Range (2 marks)

(b) Explain the mode of operation of a deflection type instrument. (6 marks)

(c) Explain three specifications of an ideal op-amp (6 marks)

(d) Determine the value of the output voltage for the signal conditioning circuit shown in Figure 2. (4 marks)

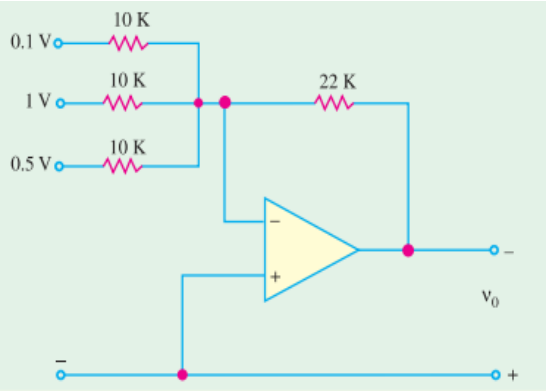

Figure 2

QUESTION FOUR (20 marks)

(a) Briefly describe the following types of instruments and state an example in each case

i. active instruments (3 marks)

ii. passive instruments (3 marks)

(b) Explain how a strain gauge sensor can be used to sense a small change in strain. The output from the strain gauge circuit is to be compared with a reference electrical signal. (4 marks)

(c) Distinguish between a low-pass filter and a high pass filter. Use simple circuits and plots for emphasis. (5 marks)

(d) Explain the principle of working of op-amp as a differential amplifier. (5 marks)

QUESTION FIVE (20 marks)

(a) Describe the following signal conditioning processes

i. Filtering (3 marks)

ii. Attenuation (3 marks)

(b) Design a circuit that has just one operational amplifier and which is able to add three voltages so that $V_o = -10V_1 – 5V_2 + 2V_3$. (6 marks)

(c) With aid of a diagram explain how a digital binary signal 1101_2 can be converted into analog signal using an R-2R resistor ladder network DAC. (8 marks)