



MACHAKOS UNIVERSITY

University Examinations 2023/2024

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES
FOURTH YEAR FIRST SEMESTER EXAMINATION FOR
BACHELOR OF SCIENCE IN APPLIED PHYSICS AND TECHNOLOGY
BACHELOR OF EDUCATION (SCIENCE)
SPH 442: INSTRUMENTATION SYSTEMS

DATE:

TIME:

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

- a) Briefly describe the main components of an Analogue to Digital Converter. (4 marks)
- b) Briefly describe the following errors in measurement instruments.
- i. Application error (2 marks)
 - ii. Dynamic error (2 marks)
- c) 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
°C	250	500	750	1000

- d) For the circuit shown in Figure 1
- i) Identify the circuit's name and its function (2 marks)
 - ii) If $R = 180\ \Omega$ calculate the value of V_3 . (4 marks)

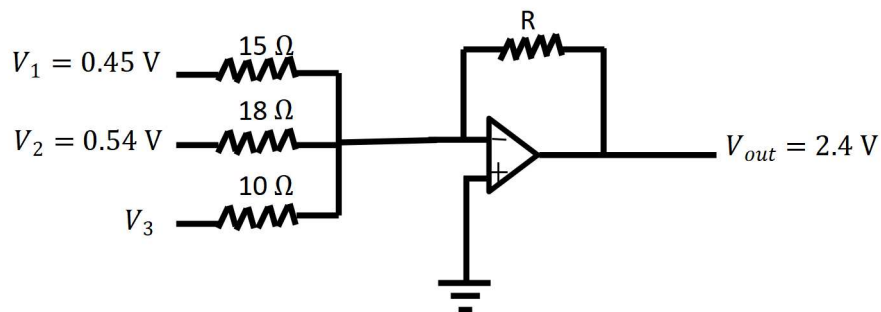


Figure 1

- e) List the three application areas for measurement systems. (3 marks)
- f) Distinguish between a null-type and a deflection type instruments. (4 marks)
- g) Describe with aid of a diagram how fluid pressure can be measured using a strain gauge and a diaphragm. (5 marks)

SECTION B (ANSWER ANY TWO QUESTIONS)

QUESTION TWO (20 MARKS)

- a) Define an active instrument and describe how a Petrol-tank level indicator works. (4 marks)
- b) Explain how a feedback control system can be used to monitor and control temperature in a room (5 marks)
- c) Explain the concept used in R-2R ladder network in DACs and explain how a binary word 1011_2 is converted into an analog equivalent. (5 marks)
- d) Explain the function and configuration of an op-amp as
 - (i) A comparator (3 marks)
 - (ii) A differential amplifier (3 marks)

QUESTION THREE (20 MARKS)

- a) What is the importance of voltage references in an ADC design? (3 marks)
- b) Explain with aid of a relevant example the process of binary weighted conversion used by successive approximation ADCs (8 bits). (5 marks)
- c) Explain four factors governing the choice of a measuring instrument for a given application? (4 marks)
- d) Explain the four open loop specifications of an operational amplifier. (8 marks)

QUESTION FOUR (20 MARKS)

- a) Define a measurement system and state one example. (3 marks)
- b) Describe a high pass filter in signal conditioning and use a circuit diagram to explain how it works. (4 marks)
- c) Draw a simple differential amplifier circuit and show mathematical how the differential inputs are obtained. (6 marks)

- d) Explain what happens if an integrator circuit is connected to a constant input signal. (3 marks)
- e) Explain the type of signal processing element that might be used to transform an input of a resistance change into a voltage. (4 marks)

QUESTION FIVE (20 MARKS)

- a) List and explain the functional elements of a measurement system. (6 marks)
- b) Explain how an RTD provides an output representative of the measured temperature. (4 marks)
- c) Define a passive instrument and describe how a passive pressure gauge works. (4 marks)
- d) For the differentiator circuit shown in Figure 2.

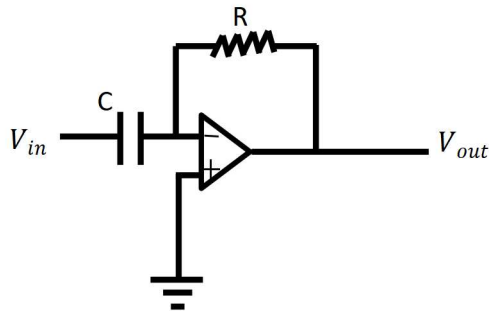


Figure 2

- i. Show that the output voltage V_{out} is given by $V_{out} = -RC \frac{dV_{in}}{dt}$ (4 marks)
- ii. Sketch the output waveform for a triangular input waveform (2 marks)