2507/205
MEASUREMENT TECHNOLOGY
June/July 2020
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING (AVIONICS OPTION)

MODULE II

MEASUREMENT TECHNOLOGY

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Drawing instruments;
Non-programmable scientific calculator.
*This paper consists of **EIGHT** questions.*
*Answer any **FIVE** of the **EIGHT** questions in the answer booklet provided.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.
Candidates should answer the questions in English.

This paper consists of 6 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

1. (a) (i) Define the following terms as used in measuring instruments:

I. reproducibility;
II. sensitivity;
III. hysteresis.

(ii) A change of 8 Ω in the unknown arm of a wheatstone bridge produces a deflection of 4 mm in the galvanometer. Determine the:

I. sensitivity;
II. deflection factor. (7 marks)

(b) With the aid of a labelled diagram, explain the principle of operation of a potentiometric accelerometer. (7 marks)

(c) An accelerometer has a seismic mass of 0.06 kg and a spring constant of 4×10^3 N/M. Maximum mass displacement is ±0.04 M. Determine the:

(i) natural frequency;
(ii) maximum acceleration;
(iii) frequency in hertz. (6 marks)

2. (a) (i) State any **three** advantages of pressure spring thermometers over resistance thermometers.

(ii) With the aid of a diagram, explain the principle of operations of a liquid expansion type pressure spring thermometer. (10 marks)

(b) With the aid of a circuit diagram, explain the principle of operation of a hot wire anemometer used to measure fluid flow. (6 marks)

(c) A temperature of 1065°C is measured from a piece of metal emitting radiant energy and the emissivity is assumed as 0.82. The true emissivity was found to be 0.75. Determine the error in the temperature measurement. (4 marks)

3. (a) (i) State any **three** methods of determining the coefficient of viscosity.

(ii) A sphere of diameter 1.6 mm and mass density of 7800 kg/m² sinks 200 mm in 21.3 seconds in an oil of density 960 kg/m³. Determine the coefficient of viscosity of the oil in poise. (7 marks)

(b) With the aid of a diagram, explain the operation of a twisted bourdon tube pressure gauge. (5 marks)

(c) Figure 1 shows a differential manometer connected at two points A and B at the same level in a pipe containing an oil of specific gravity 0.8. It shows a difference in level of mercury as 100 mm. Determine the pressure difference (H) at the two points.

(8 marks)

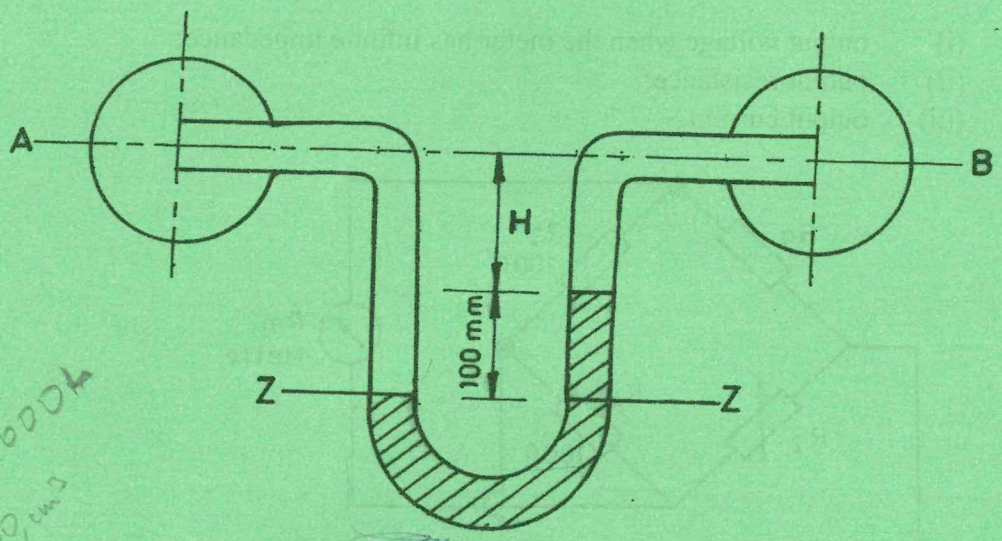

Fig. 1

4. (a) Describe the following optical sources listed below:

(i) incandescent source;
(ii) fluorescence source.

(6 marks)

(b) A molybdenum surface with a work function of 4.3 eV produces photo electrons when irradiated by a mercury light having a wavelength of 0.2537 μm. The electron mass (e/m) ratio is 0.176×10^{12} C/kg. Determine the:

(i) energy imparted;
(ii) velocity of electrons.

(4 marks)

(c) Figure 2 shows a wheatstone bridge arrangement to measure the pressure applied to a strain gauge (Rg). A galvanometer of resistance 50 Ω is used to detect the output from the bridge. Unstrained resistance of the strain gauge is 120 Ω and the gauge factor is 2. If a strain of 400 μ M/M is applied, determine the:

(i) output voltage when the meter has infinite impedance;
(ii) output resistance;
(iii) output current. (7 marks)

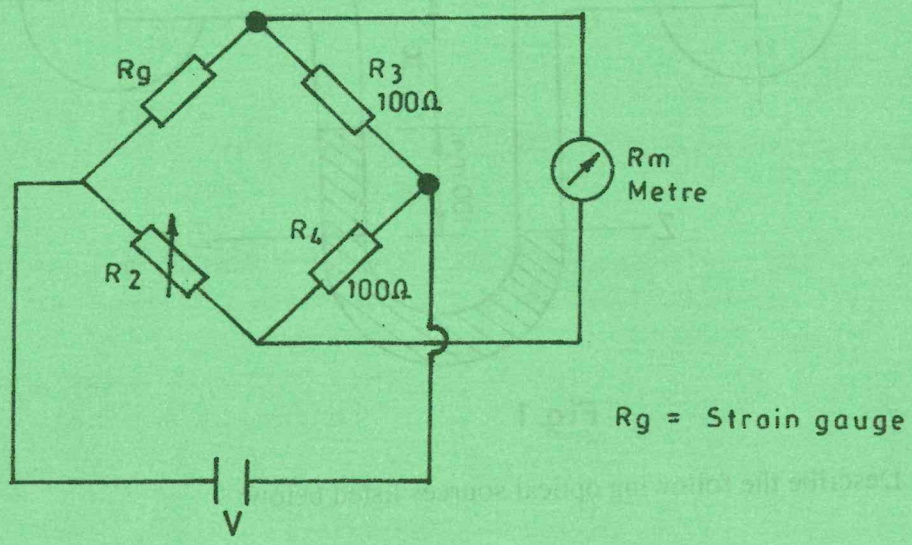

Fig.2

(d) Table 1 shows different transducers used in measurements. Complete the table by inserting the mode of operation for each transducer. (3 marks)

Table 1

Transducer	Mode of operation
Venturi tube	Bernoullis
Bimettalic strip	Conductivity
Manometer	Pressure

5. (a) State the principle of operation of the following infra-red detector:

(i) thermal detectors;
(ii) photon detectors. (2 marks)

(b) (i) State any **three** areas of application of thermistors.
(ii) When measuring temperature of 800°C with a thermocoupe at reference temperance of 0°C, the emf generated is 33.3 V. The resistance of the meter coil R_m is 50 Ω and a current of 0.1 mA gives full scale deflection. The resistance of junctions and leads, R_e is 12 Ω. Determine the:

I. resistance of series resistance if a temperature of 800°C is to give full scale deflection;

II. approximate error due to rise of 1 Ω in R_e;
III. approximate error due to rise of 10°C in the copper coil of the meter;

(Take the resistance temperature coefficient of coil as 0.00426/°C)

(12 marks)

(c) With the aid of a diagram, explain how capacitive dielectric variation is used to measure liquid level. (6 marks)

6. (a) (i) State **three** advantages of pneumatic over hydraulic system in measurements.
(ii) Draw a labelled diagram of a flapper and nozzle amplifier. (6 marks)

(b) With the aid of a labelled schematic diagram, explain the operation of force balance transmitter. (6 marks)

(c) (i) State **three** merits of resistance potentiometers with respect to displacement measurements.
(ii) Figure 3 shows the potentiomenter arrangement to measure displacement x. The total resistance is 2 kΩ and the supply voltage is 10 V. The meter resistance is 5 kΩ. Determine the loading error for slider positions corresponding to $xi/xt = 0, 0.25, 0.5, 0.75$. (8 marks)

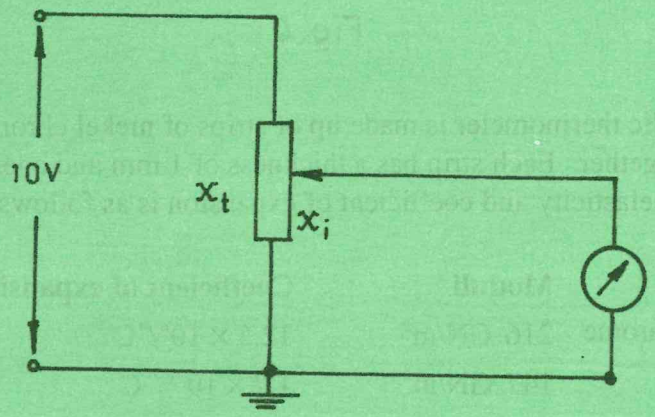

Fig.3

7. (a) (i) State **three** advantages of ultrasonic transmission waves.
(ii) Draw a schematic diagram of an ultrasonic link and explain its operation. (10 marks)

(b) With the aid of a schematic diagram, explain the operation of a DC tachogenerator. (6 marks)

(c) An inductive pick off operating from a 120 tooth wheel is used to measure angular speed of a shaft. The gating period is 10^4 μS and a reading of 0030 is obtained on a four digit display. Determine the speed of shaft in rps. (4 marks)

8. (a) (i) Define vacuum pressure.

(ii) Figure 4 shows a diagram of a Pirani's gauge used for measurement of vacuum pressure. Explain its operation. (6 marks)

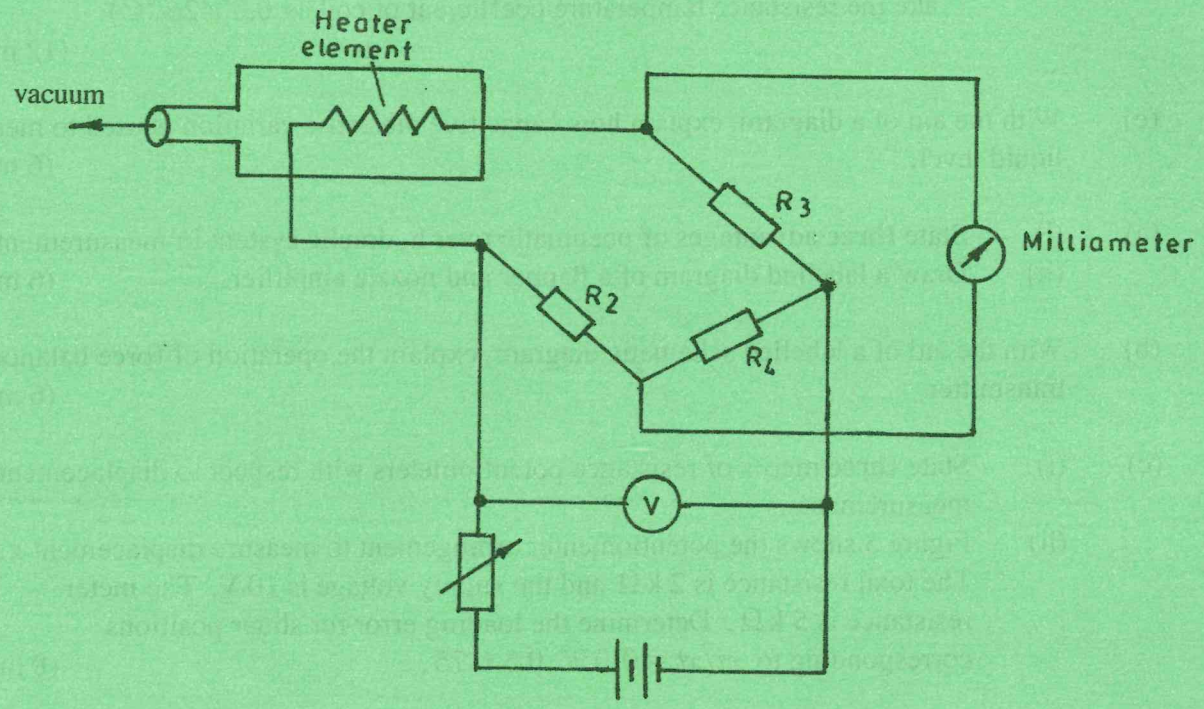

Fig. 4

(b) A bimetallic thermometer is made up of strips of nickel chromium alloy and invar bonded together. Each strip has a thickness of 1 mm and a length of 50 mm. The moduli of elasticity and coefficient of expansion is as follows:

	Moduli	**Coefficient of expansion**
Nickel chrome	216 GN/m^2	12.5×10^{6}/°C
Invar	147 GN/m^2	1.7×10^{-6}/°C

Taking the ambient temperature as 25°C, determine the radius of curvature when the strip is subjected to a temperature of 200°C. (7 marks)

(c) A piezo-electric crystal having dimensions of 5 mm x 1.5 mm and a voltage sensitivity of 0.055 V − m/N is used to measure force. Determine the force if the voltage developed is 100 V. (4 marks)

(d) State any **three** applications of spectral measurement system. (3 marks)

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