2507/205
MEASUREMENT TECHNOLOGY
June/July 2023
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 indicated.
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.

    Turn over

1.　(a)　Define each of the following characteristics of instruments:

　　　　(i)　　sensitivity;

　　　　(ii)　　reproducibility;

　　　　(iii)　hysteresis.

　　　　　　　　　　　　　　　　　　　　　　　　　　　　(3 marks)

　　(b)　(i)　　State **three** causes of instrumental errors.

　　　　(ii)　　A resistance is determined by voltmeter - ammeter method. The voltmeter reads 100 V with a probable error of ± 12 V and ammeter reads 10 A with probable error of ± 2 A.

　　　　　　　Determine the probable error in the computed value of resistance.

　　　　　　　　　　　　　　　　　　　　　　　　　　　　(9 marks)

　　(c)　(i)　　Figure 1 shows a circuit diagram of a d.c network. Using Thevenin's theorem, determine the:

　　　　　　(I)　　voltage between points P and Q;

　　　　　　(II)　　output impedance Z_0.

　　　　(ii)　　From I and II, draw the Thevenins equivalent circuit and determine the actual value of current.
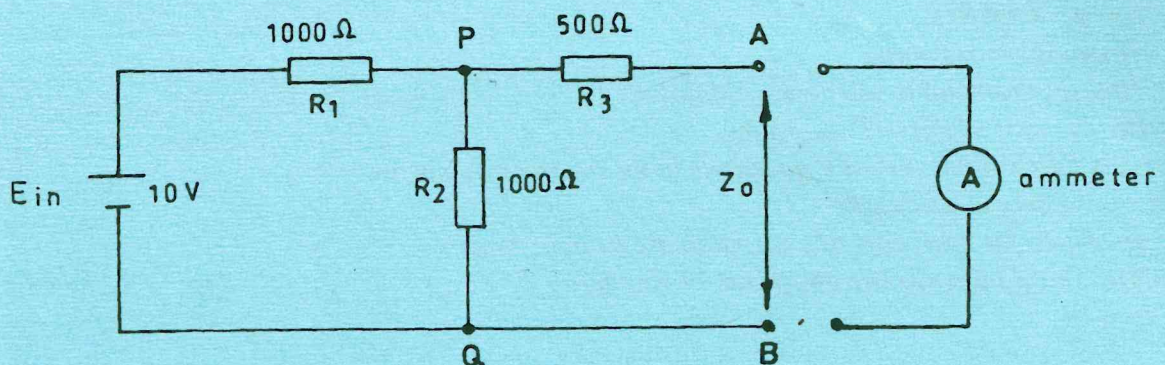　　　　　　　　　　　　　　　　　　　　　　　　　　　　(8 marks)

Fig.1

2. (a) With the aid of a schematic diagram of a potentiometric acceleromer, explain how vibrations is measured. (7 marks)

    (b) An accelerometer has an output response of 14 mV per g where $g = 9.81 \text{ ms}^{-2}$. It is used with an integrator having time constant of 1 second where the output velocity signal is scaled at 0.25 V/ms^{-1}. Determine the:

        (i) sensitivity of the accelerometer;

        (ii) gain of the set-up.
                                                                        (6 marks)

    (c) (i) State **two** merits of photoelectric tachometer.

        (ii) Draw a schematic diagram of a photoelectric tachometer and explain its operation.
                                                                        (7 marks)

3. (a) (i) State **three** quantities in flow measurements.

        (ii) Distinguish between inferential and positive displacement meters.
                                                                        (7 marks)

    (b) (i) With the aid of a diagram, explain the operation of pitot tube in flow measurements.

        (ii) A pitot tube is used for measurement of flow of water having a density of 1000 kg/m³. Determine the velocity at the head of pitot tube when a differential pressure of 10 KN/m² is measured between its two outlets. (8 marks)

    (c) Figure 2 shows a pipe which increases in diameter size. Using Bernoullis continuity equation, determine the pressure P_2. (5 marks)
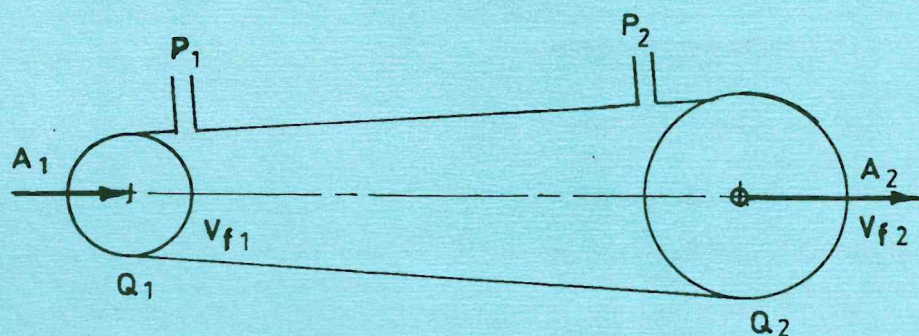

Fig.2

(Take $Z_1 = Z_2$, $P_1 = 100\text{N/m}^2$, $A_1 = 1\text{m}^2$, $A_2 = 2\text{m}^2$, $Q = 20\text{m}^3/\text{s}$)

4. (a) (i) State **three** principles used in measuring pressure with a manometer.
   (ii) Figure 3 shows a diagram of a manometer arranged to measure pressure. Derive the expression for the length S of the inclined tube.

(8 marks)
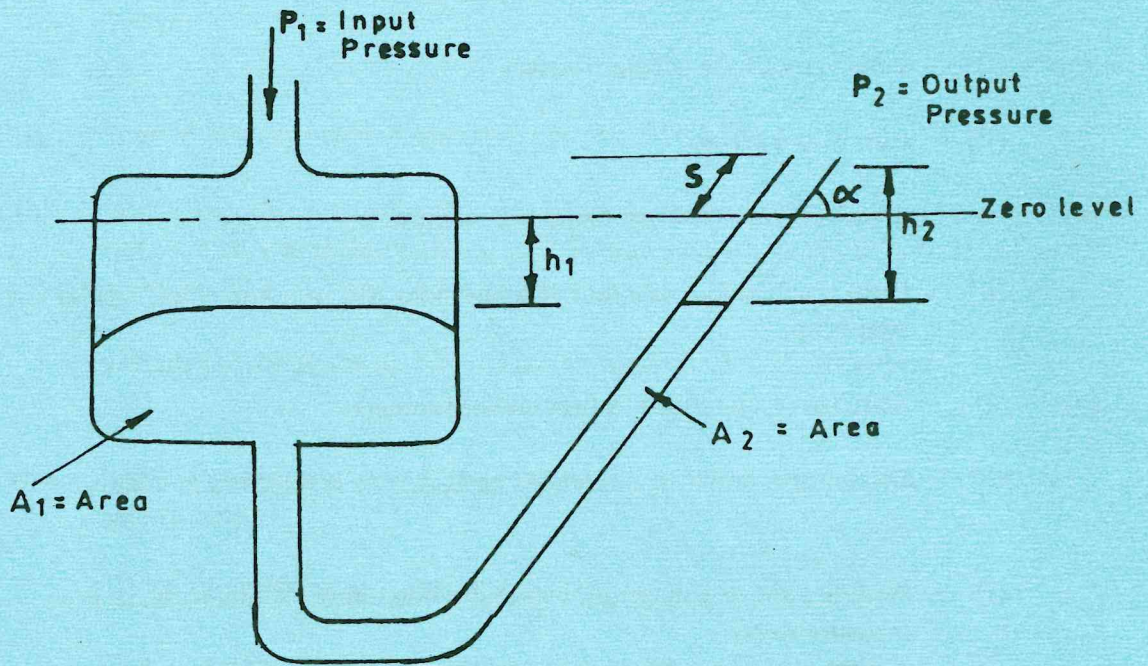
Fig. 3

(b) Outline **three** effects of increase of temperature on the accuracy of manometers.

(3 marks)

(c) Define the following terms:

(i) gauge pressure;

(ii) absolute pressure.

(2 marks)

(d) With aid of a diagram, explain the operation of a slack diaphragm pressure gauge.

(7 marks)

5. (a) With the aid of a diagram, explain liquid level measurement using a float.

(7 marks)

(b) In the measurement of level of liquid in a tank, a pressure gauge indicated $68.67 \ KN/m^2$. If relative density of liquid is two, determine the height of the liquid in the tank.
   (Take $g = 9.81 \ m/s$)

(3 marks)

(c) State **three** advantages of bimetallic strip thermometer over other types in the measurement of temperature. (3 marks)

(d) A bimetallic thermometer is made of strips of nickel chromium alloy and invar bounded together at $25°C$. Each strip has a thickness of 1 mm and a length of 50 mm. The modulus of elasticity of nickel chrome alloy and invar are 216 GN/m^2 and 147 GN/m^2, and their coefficients of expansion are $12.5 \times 10^{-6}/°C$ and $1.7 \times 10^{-6}/°C$ respectively. Determine the radius of curvature when the strip is subjected to a temperature of $200°C$. (7 marks)

6. (a) State **three** advantages of pneumatic systems over hydraulic systems. (3 marks)

(b) With aid of a labelled diagram, explain the operation of a pneumatic relay. (7 marks)

(c) Distinguish between batch weighing and continuous weighing. (2 marks)

(d) The strain gauge used in a load cell has an electrical resistance of 130 Ω and a gauge factor of 2.5. The strain gauge is bonded to a steel with an elastic limit stress of 420 MN/m^2 and a modulus of elasticity of 220 GN/m^2.

Determine the change in resistance:

(i) due to a change in stress of $\frac{1}{10}$ of the elastic range;

(ii) when the coefficient of linear expansion of gauge metal and steel are $12 \times 10^{-6}/°C$ and $16 \times 10^{-6}/°C$ respectively.

(8 marks)

7. (a) Define the following terms as used in viscosity measurements:

(i) co-efficient of dynamic viscosity;

(ii) kinematic viscosity.

(2 marks)

(b) A shaft of length 76 mm has a diameter of 75 mm and rotates inside a bearing of diameter 75.07 mm. The annular space between the shaft and the bearing is filled with oil having a coefficient of viscosity 0.096 k/m˙s. Determine the power used to overcome viscous resistance in the bearing at a speed of 1400 rev/min.

(7 marks)

(c) Explain the capacitive method of measuring humidity. (4 marks)

(d) (i) State **three** merits of ultrasonic measurements;

(ii) Draw a labelled diagram of a ultrasonic link.

(7 marks)

8.   (a)   List **four** parts of a laser used in optical measurements.   (4 marks)

     (b)   With the aid of a diagram, explain the operation of a thermopile as an optical detector.
                                                                                          (7 marks)

     (c)   A photodiode has a capacitance of 2 pF and effective area of 0.2×10^{-6} m^2. If a load
           resistance of 10 KΩ is connected across the output of the photodiode and the irradiance
           is 250 W/m^2.

           Determine the:

           (i)   incident power;

           (ii)   cut-off frequency.
                                                                                          (4 marks)

     (d)   (i)   State **two** applications of X-ray fluorescence in industry.

           (ii)   Draw a labelled schematic diagram of ionization chamber X-ray detector.
                                                                                          (5 marks)

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