2507/205
MEASUREMENT TECHNOLOGY
June/July 2019
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.
Answer any FIVE questions of the EIGHT questions in the answer booklet provided.
All questions carry equal marks.
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.

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Turn over

1. (a) State **three** merits of using a venturimeter in flow measurements. (3 marks)

   (b) A venturimeter whose diameters are 40 cm and 20 cm respectively is provided in a vertical pipeline carrying oil of specific gravity 0.9.
   The flow is upward stream. The difference in elevations of the throat and entrance section of the venturi is 30 cm.
   The pressure difference in manometer is 25 cm of mercury. The specific gravity of mercury is 13.6 and the discharge coefficient, C_d is 0.98. Taking g as 9.81 m/s^2, determine the:

   (i) area of inlet section;
   (ii) area at throat section;
   (iii) head difference in water column;
   (iv) discharge of oil through the venturi;
   (v) pressure difference between inlet and throat section. (10 marks)

   (c) (i) Define atmospheric pressure.
   (ii) With the aid of a diagram, describe absolute pressure measurement using bellows. (7 marks)

2. (a) With the aid of a block diagram, describe the operation of a compact disk optical measurement system. (8 marks)

   (b) A disk mounted on the shaft of a machine has 13 pattern points. The number of flashes projected on the disc by a stroboscope is 5000 in a minute. The disc has a single image of 13 points if the machine is stationary. Determine the:
   (i) speed of the machine if disc appears stationary;
   (ii) speed of the disc if it rotates at 10 rpm in the forward direction;
   (iii) speed of the machine if it rotates at 12 rpm in the reverse direction.
   (6 marks)

   (c) An accelerometer has a seismic mass of 0.75 kg. Maximum mass displacement is ±0.03 m and angular speed is 193.649 rad/s.
   Determine the:

   (i) spring constant, K;
   (ii) maximum acceleration, a_m;
   (iii) natural frequency, f_o. (6 marks)

3. (a) State **three** merits of using resistive methods of level measurements. (3 marks)

   (b) With the aid of a labelled diagram, describe liquid level measurement using ultrasonic method. (6 marks)

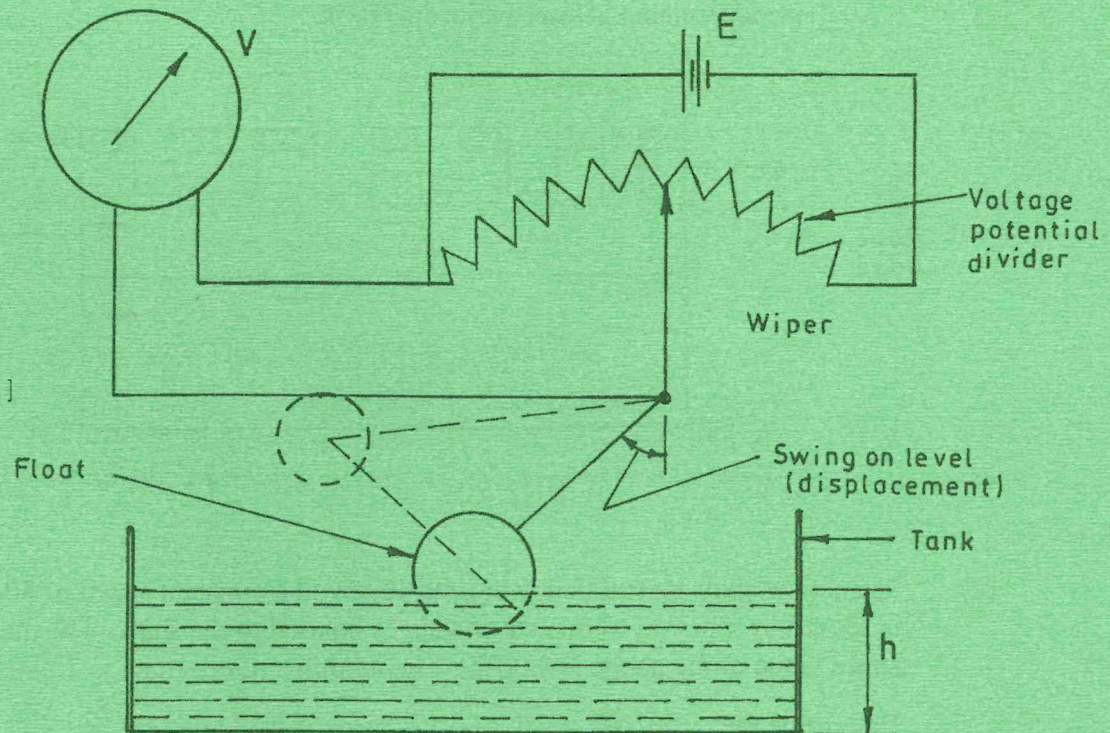(c)   Figure 1 shows a diagram of a float method of liquid level measurement. Describe its operation.   (5 marks)

Fig. 1

(d)   (i)   A piezoelectric crystal having dimensions 10 mm x 10 mm x 1.0 mm and a voltage sensitivity of 0.06 V - m/N is used for force measurement. When a force is applied to the larger surface of the crystal, the voltage developed is 100 V. Determine the:

(I)   applied pressure;
(II)   force.

(ii)   State **two** quantities to be measured in vibrating systems.   (6 marks)

4.   (a)   State **two** demerits of U-tube manometer when used for pressure measurement.
(2 marks)

(b)   With the aid of a diagram, describe temperature measurements using a thermopile.
(6 marks)

(c) (i) Distinguish between absolute humidity and relative humidity.

   (ii) Figure 2 shows a diagram of aluminium oxide hygrometer used in humidity
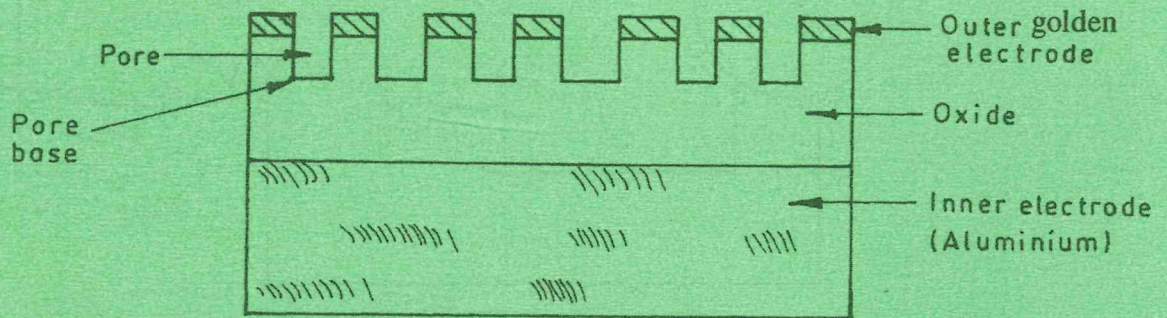   measurements. Describe its operation.   (6 marks)

Fig. 2

(d) A machine shaft transmits power upto 40 kW at a constant speed of 30 rps. The torque
     is sensed by a pair of torque strain gauges bonded to the shaft. The maximum
     strain value of the gauge is 0.0015. The modulus of elasticity is 200×10^9 N/m².

     Determine the:

     (i)   angular speed;
     (ii)   torque;
     (iii) maximum direct stress.   (6 marks)

5. (a) State **three** applications of pneumatic differential transmitters.   (3 marks)

    (b) With the aid of a labelled diagram, describe the operation of a hydraulic load cell used in
         industrial weighing.   (7 marks)

    (c) A flat circular diaphragm used for pressure measurement has a diameter of 30 mm.
         The Young's Modulus, E for the diaphragm material is 200 G Pa and Poissons ratio
         is 0.28. Maximum stress is 300 MN/m² and pressure is 300 kN/m².

         Determine the:

         (i)   thickness of the diaphragm;
         (ii) deflection at the centre for a pressure of 200 kN/m².   (6 marks)

    (d) A linear resistance potentiometer is 60 mm and is uniformly wound with a wire
         having a resistance of 8,000 Ω. The slider is at the middle of the potentiometer.
         Resistance measured by wheatstone = 3000 Ω.

         Determine the:

         (i)   the resistance at its normal position;
         (ii)   resistance of potentiometer per unit length.   (4 marks)

6. (a) (i) Sketch the output characteristics of a linear Variable Differential Transformer for the core displacement in opposite directions.

(ii) An output of 4 mA appears across the terminals of an LVDT when the core moves through a distance of 0.8 mm. The output of the LVDT is connected to a 10 A ammeter through an amplifier whose amplification factor is 200. The millimeter scale has 100 divisions and can be read to 1/10 of a division.

Determine the:

(I) sensitivity of the LVDT;
(II) sensitivity of the instrument system;
(III) least current that can be measured;
(IV) resolution. (9 marks)

(b) With the aid of a labelled diagram, describe the operation of a photovoltaic cell as used in radiation detection and measurements. (7 marks)

(c) The effective area of a photo diode is 0.4×10^{-6} m^2 and the irradiance is 280 W/m^2. The load resistance is 20 kΩ and the capacitance of the diode is 4 pF.

Determine the:

(i) incident power;
(ii) cut off frequency. (4 marks)

7. (a) Define each of the following as used in measurements:

(i) precision;
(ii) dead time. (2 marks)

(b) With the aid of a labelled diagram, explain the principle of operation of an optical fibre transmission medium. (6 marks)

(c) An optical fibre has refractive indices of 1.47 and 1.46. Determine the:

(i) minimum angle at which the ray will strike the core-cladding interface to be guided in the core;
(ii) maximum propagation angle;
(iii) numerical aperture. (6 marks)

(d) When measuring viscosity of a liquid using falling - piston viscometer, show that the dynamic η, is given by the expression

$$\eta = \frac{K}{V}$$

Where K = Constant = Mass X acceleration due to gravity X Distance between piston and wall,
V = terminal velocity of the piston. (6 marks)

8. (a) (i) State **three** properties of X-rays.

(ii) With the aid of a labelled diagram, describe the generation of X-rays.

(11 marks)

(b) An electromagnetic flowmeter is used to measure the average flow rate of an effluent in a pipe of 60 mm diameter. The flux density in the liquid has a peak value of 0.4 Wb/m². The output from the flowmeter electrodes is taken to an amplifier of gain 1000 and the impedance between electrodes is 300 kΩ. The input impedance of the meter is 250 MΩ. The peak-to-peak open circuit voltage at the amplifier output is 0.3 V.

Determine the:

(i) peak open circuit voltage from the amplifier, under loaded conditions;
(ii) average flow rate;
(iii) peak-to-peak voltage under loaded conditions. (9 marks)

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