

2507/205

MEASUREMENT TECHNOLOGY

Oct./Nov. 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.

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 7 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) Explain each of the following static characteristics of instruments:
- (i) accuracy;
 - (ii) repeatability. (4 marks)
- (b) The reading on a voltmeter is 111.5 V. The true value of the voltage is 112.6 V. Determine the:
- (i) static error;
 - (ii) error correction for this instrument. (4 marks)
- (c) With the aid of a circuit diagram, show that the maximum power delivered to a resistive load R_L from a voltage source, E_0 is given by:
- $$\frac{E_0^2}{4R_L} \quad (11 \text{ marks})$$
- (d) State **one** cause of measurement errors in instruments. (1 mark)
2. (a) (i) State **three** activities carried out in routine maintenance on Tachometers.
- (ii) Explain the purpose for the perforated holes on the pitot tube used in speed measurements. (5 marks)
- (b) A piezo-electric accelerometer uses two discs so connected such that charges produced are added up. The diameter of the disc is 6 mm and the thickness of each disc is 0.65 mm. Young's modulus of the disc material is $1.08 \times 10^5 \text{ N/m}^2$. The dielectric constant of the crystal material is 10^{-10} F/cm , the mass is 2.2 g and the piezo-electric constant is $2 \times 10^{-10} \text{ C/N}$. The capacitance of the disc is $0.3 \times 10^{-10} \text{ F}$. Determine the:
- (i) total stiffness;
 - (ii) natural frequency;
 - (iii) charge sensitivity;
 - (iv) voltage sensitivity. (8 marks)
- (c) A capacitive transducer has a capacitance of 20 pF when it has a plate separation of 0.2 mm. During displacement measurement, the capacitance is changed by a value of $\pm 2 \text{ pF}$. Determine the value of displacement. (7 marks)
3. (a) State **four** factors considered when selecting flow measurements methods. (4 marks)

- (b) Figure 1 shows a nutating disc flow meter. Describe its operation. (8 marks)

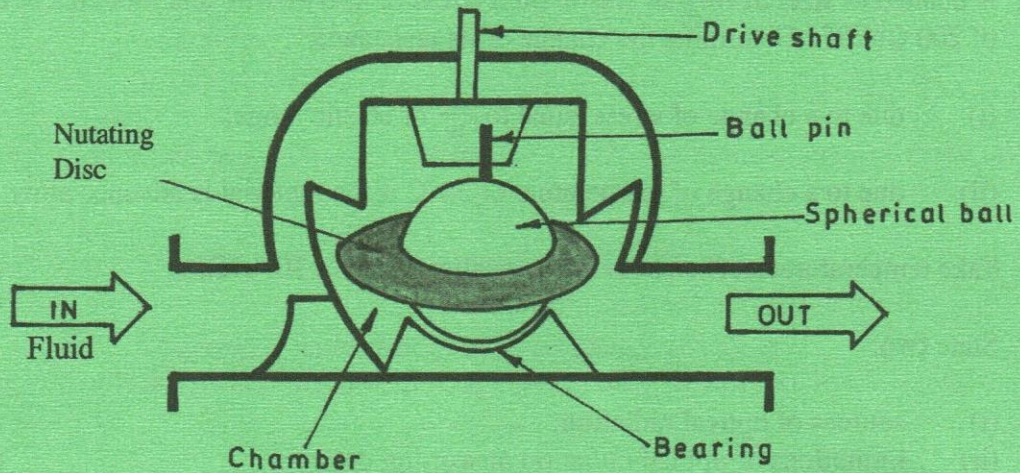


Fig.1

- (c) An orifice meter with orifice diameter of 20 cm is inserted into a pipe of 35 cm diameter. The pressure on the upstream and downstream of orifice meter is 16.5 N/cm^2 and 10.5 N/cm^2 respectively. Take discharge coefficient as 0.6. Determine the:

- pressure head;
- discharge of the orifice. (8 marks)

4. (a) State two merits of thermo couples when used in temperature measurements. (2 marks)

- (b) A thermocouple circuit gives an emf of 15 mV when measuring a temperature of 615°C with reference temperature at 0°C . A current of 0.15 mA gives full scale deflection. The resistance of the meter coil is 42Ω . The resistance of the junction and the leads is 14Ω . The coefficient of resistance is $0.00426 / ^\circ\text{C}$. Determine the:

- resistance of the series resistor if a temperature of 615°C is to give full scale deflection;
- approximate error due to rise in temperature of 0.8Ω in the junction resistance;
- approximate error due to rise in temperature of 7.5°C in the copper coil of the meter. (8 marks)

- (c) With the aid of a diagram, describe the operation of a load cell using a strain gauge. (5 marks)

- (d) A single electrical-resistance strain - gauge of resistance $100\ \Omega$ and a gauge factor of 2 is bonded to steel having an elastic limit stress of $450\ \text{MN/m}^2$ and modulus of elasticity of $200\ \text{GN/m}^2$. Determine the change of its resistance:
- due to a change of stress equal to $\frac{1}{10}$ of elastic range;
 - due to a change of temperature of 30°C if the material is advance alloy.

Take temperature coefficient of advance alloy as $20 \times 10^{-6}/^\circ\text{C}$. (5 marks)

5. (a) State two:
- sources of optical radiation;
 - limitations of optical radiation measuring devices. (4 marks)
- (b) (i) State two areas of application of photovoltaic cells.
- (ii) A photovoltaic cell produces a voltage of $0.44\ \text{V}$ on open circuit when illuminated by $12\ \text{W/m}^2$ radiant incidence. When a load of $110\ \Omega$ is connected to the cell, a current of $2.3\ \text{mA}$ is delivered at that intensity. Determine the:
- internal resistance of the cell;
 - open circuit voltage for a radiance incidence of $35\ \text{W/m}^2$ when the calibration voltage is the same for both cases. (8 marks)
- (c) Figure 2 shows a block diagram of a compact disc system. State the functions of the following blocks:

- servomotor;
- photo detector. (4 marks)

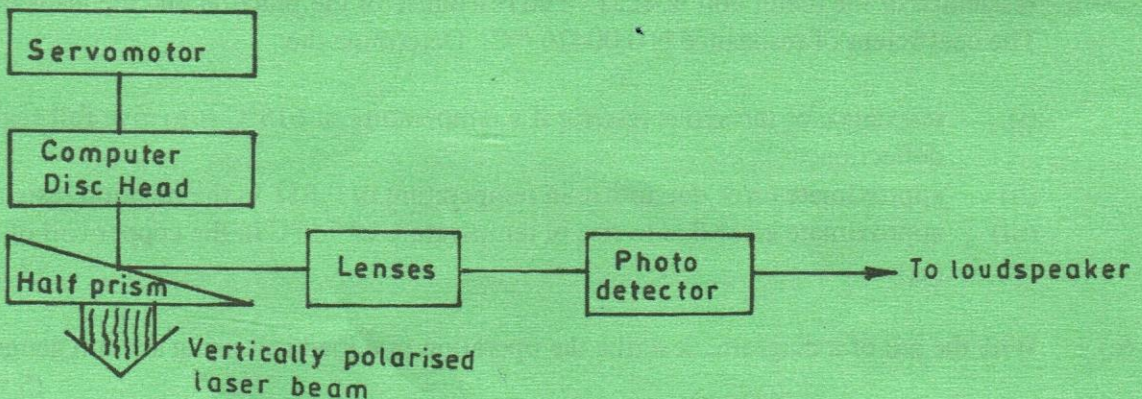


Fig. 2

(d) Draw the refractive index profiles for each of the following optic fibre cables:

(i) step index;

(ii) graded index.

(4 marks)

6. (a) With the aid of a labelled diagram, describe AC tachometer used in speed measurement.

(6 marks)

(b) Figure 3 shows a diagram of a U-tube manometer.

(i) Describe its operation in pressure measurements.

(ii) Derive an equation showing the pressure head at point A.

(6 marks)

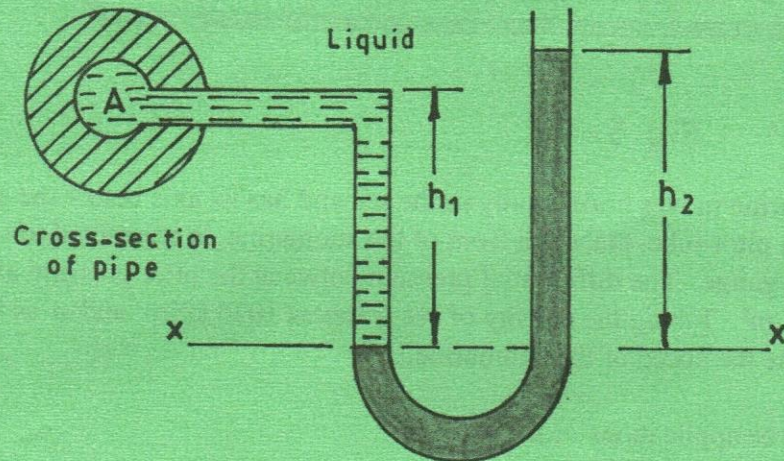


Fig.3

(c) (i) Figure 4 shows an inclined tube manometer. Derive an equation to show the pressure difference of the instrument.

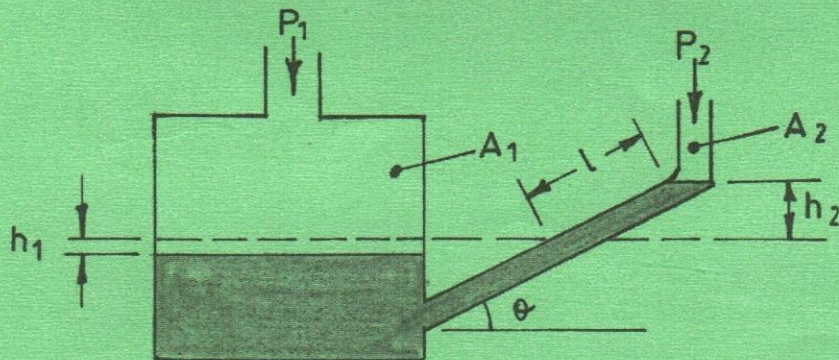


Fig. 4

(ii) State two characteristics of liquid used in U-tube manometer.

(8 marks)

7. (a) Describe the doppler effect as used in ultrasonic measurements. (4 marks)
- (b) Figure 5 shows a doppler flowmeter. Show that the doppler frequency difference $f'' - f'$ is proportional to fluid velocity. (10 marks)

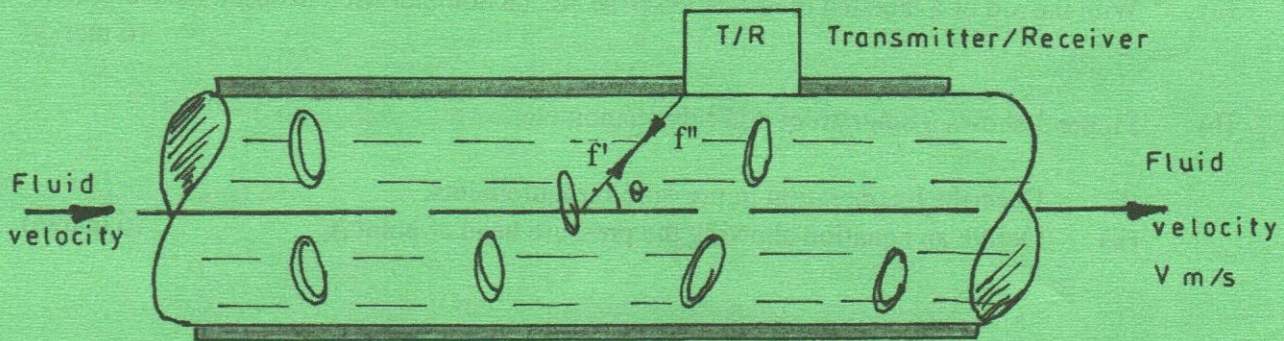


Fig. 5

- (c) A submarine moves horizontally in the sea and has its axis below the surface of the water. A pitot-tube, placed in front of the submarine, is connected to a differential pressure gauge. The differential pressure between the pitot pressure and static pressure is 25 kN/m^2 . Taking the density of sea water as 1026 kg/m^3 and g as 9.81 m/s^2 , determine the speed of the submarine. (6 marks)

8. (a) State **three** applications of x-rays. (3 marks)
- (b) (i) Define humidity.
- (ii) With the aid of a labelled diagram, describe the construction and operation of a resistive hygrometer. (10 marks)

(c) Figure 6 shows x-ray fluorescence spectroscopy instrument. Describe its operation. (7 marks)

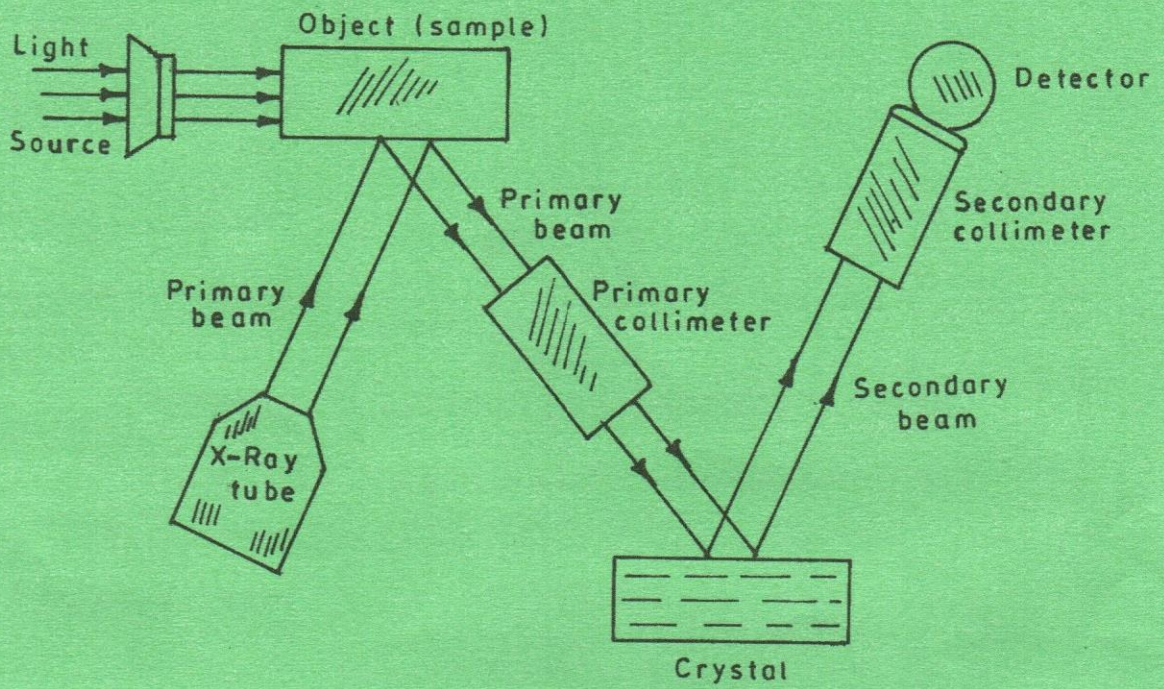


Fig. 6

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