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2602/102
PHYSICAL SCIENCE, MECHANICAL SCIENCE
AND ELECTRICAL ENGINEERING PRINCIPLES
Oct./Nov. 2017
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING
(POWER OPTION)
(TELECOMMUNICATION OPTION)
(INSTRUMENTATION OPTION)

MODULE I

PHYSICAL SCIENCE, MECHANICAL SCIENCE AND ELECTRICAL ENGINEERING PRINCIPLES

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Drawing instruments.
*This paper consists of **EIGHT** questions in **THREE** sections; **A** and **B** and **C**.*
*Answer **ONE** question from section **A**, **ONE** question from section **B** and **THREE** questions from section **C**.*
Maximum marks for each part of a question are indicated.
Candidates should answer the questions in English.
Take: $\mu_0 = 4\pi \times 10^{-2}$ H/m

This paper consists of 8 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

SECTION A: PHYSICAL SCIENCE

*Answer **ONE** question from this section.*

1. (a) (i) Define background radiations as used in radioactivity.

(ii) State **four** sources of background radiations. (3 marks)

(b) Outline **two** safety measures observed when handling radioactive materials. (2 marks)

(c) A hydrocarbon of relative molecular mass 84, burns completely in excess oxygen to form 5.28 g of carbon (IV) oxide gas and 2.16 g of steam. Determine its:

(i) empirical formula;

(ii) molecular formula.

Take R.A.M of C = 12, O = 16 and H = 1. (8 marks)

(d) (i) Explain the term 'resonance' in relation to vibrating objects.

(ii) Describe the energy changes in the LC circuit in figure 1. (7 marks)

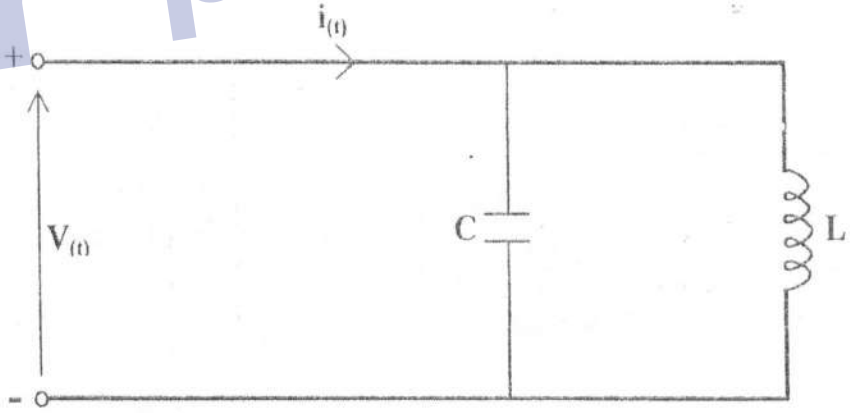

Fig. 1

2. (a) (i) Arrange the following ions in order of their position in the electrochemical series:

(I) Lead, Zinc, Copper;
(II) Hydroxide, Sulphate, Chloride.

(ii) Differentiate between endothermic reaction and exothermic reaction, giving one example in each case. (6 marks)

(b) Show the relationship between velocity, frequency and wavelength. (3 marks)

(c) (i) Define ultrasound as used in acoustics.

(ii) An echo sounder transmits sound wave to the bottom of a hydroelectric power dam and receives its echo after 1.2 seconds. The speed of sound in the water is 1500 m/s. Determine the depth of water in the dam. (4 marks)

(d) (i) State **two**:

(I) forms of heat transfer;
(II) temperature scales.

(ii) 3000 g of water at 21° C was frozen to 0° C. Determine the heat lost. Take specific heat capacity of water as 4200 J kg^{-1} K^{-1}, and specific latent heat of fusion of ice as 336 kJ/kg. (7 marks)

SECTION B: MECHANICAL SCIENCE

*Answer **ONE** question from this section.*

3. (a) (i) State **two** forms of mechanical energy.

(ii) A machine exerts a force of 240 N to move an object at a constant speed through a distance of 600 cm in 2 minutes. Determine its power. (4 marks)

(b) (i) Name **four** types of coupling devices used in mechanical power transmission.

(ii) Explain how centrifugal governor controls the speed of an engine. (4 marks)

(c) Figure 2 shows a system of co-planer forces acting concurrently in different directions. The resultant force is zero. Determine force F and angle α. (8 marks)

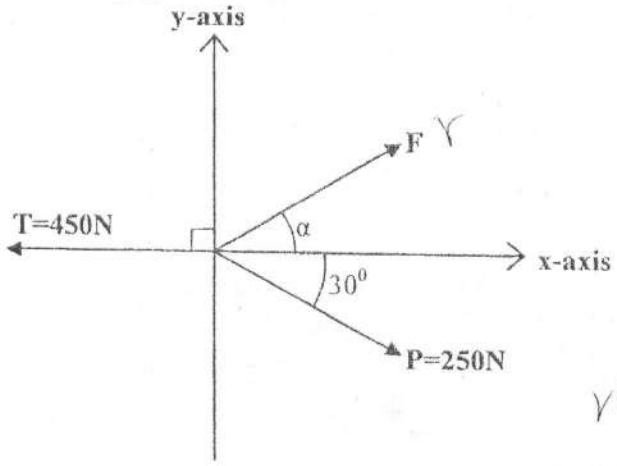

Fig. 2

(d) (i) Define the following terms as used in thermodynamics:

(I) phase;
(II) cycle.

(ii) Differentiate between 'pure' and 'working' thermodynamic substances. (4 marks)

4. (a) (i) Define the following terms as applied to engineering materials:

(I) hardness;
(II) fatigue.

(ii) A tensile force of 12 N acts on an aluminium wire of length 2 m and diameter 2.5 mm. The wire is stretched by 0.3 mm. Determine the:

(I) stress;
(II) strain in the wire. (6 marks)

(b) With the aid of a graph of uniform angular velocity against time, describe angular acceleration of a rotating object. (3 marks)

(c) A stationary object of mass 500 g is hit by a force, F lasting a period of 1.2 seconds. The object takes off at a velocity of 36 m/s. Determine the:

(i) change in momentum;

(ii) mgnitude of the force F. (4 marks)

(d) (i) State **four** causes of pressure drop in oil pipeline.

(ii) Figure 3 shows venturi meter used to measure flow rate of oil in a horizontal pipe. The density of oil is 900 kg/m^3. The difference in oil-pressure in the wide and narrow sections is 110 N/m^2. Determine the volume flow rate. (7 marks)

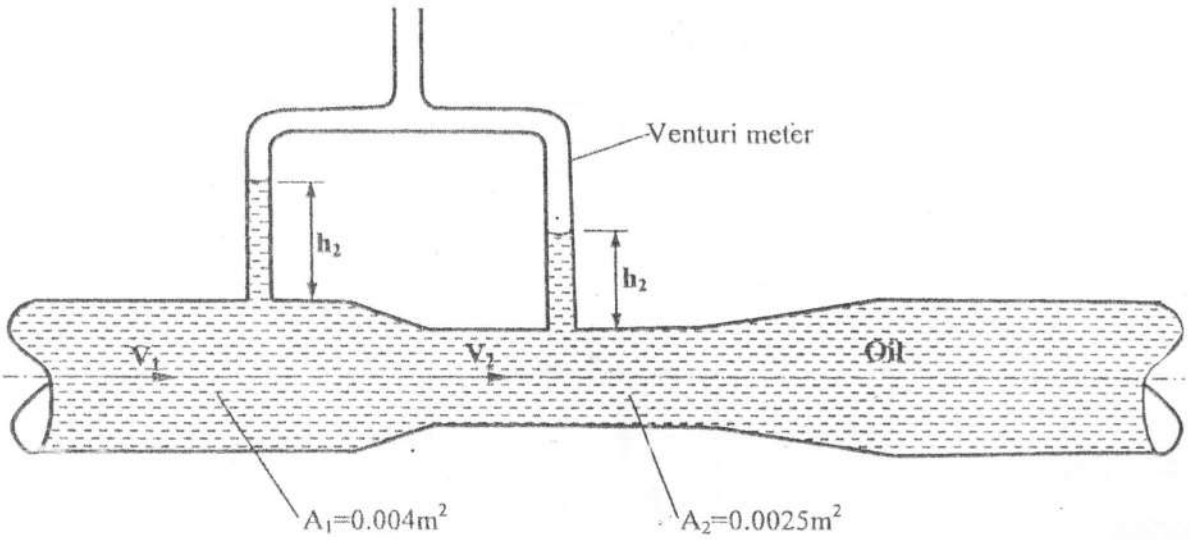

Fig. 3

SECTION C: ELECTRICAL ENGINEERING PRINCIPLES

*Answer **THREE** questions from this section.*

5. (a) (i) State the SI units associated with the following electrical quantities and classify each as either basic or derived unit:

(I) conductance;
(II) current.

(ii) An electromagnet exerts a force of 12 N and moves a soft iron armature through a distance of 1.5 cm in 40 ms. Determine its power. (5 marks)

(b) State two advantages and two disadvantages of alkaline cells over lead-acid cells. (4 marks)

(c) Explain:

(i) The process of charging a secondary cell;
(ii) **Two** precautions observed during battery charging. (6 marks)

(d) Figure 4 shows a series-parallel arrangement of cells supplying a load current of 0.1 A. Each cell has an emf of 1.25 V and internal resistance of 0.1 Ω. Determine the:

(i) emf and internal resistance of the battery formed;
(ii) load resistance. (5 marks)

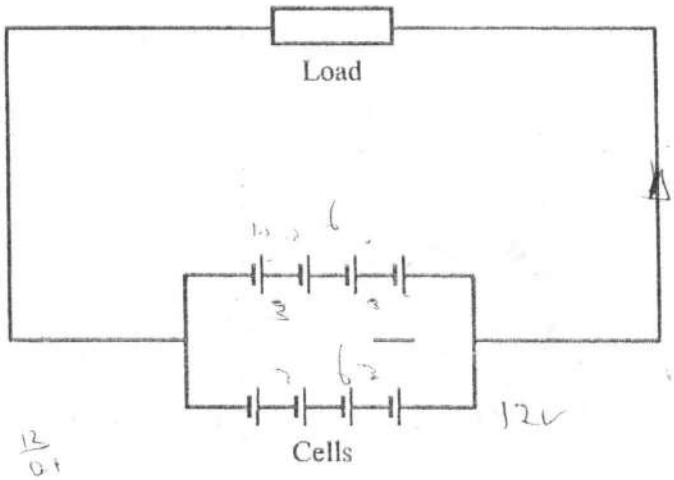

Fig. 4

6. (a) Differentiate between linear scale and non-linear scale as used in electrical instruments. (2 marks)

(b) (i) Explain the principle of operation of a moving-coil instrument.

(ii) State **one** advantage of moving-iron instruments over moving-coil instruments. (3 marks)

(c) With the aid of labelled diagram, describe the operation of repulsion type moving-iron instrument. (7 marks)

(d) (i) State Kirchoff's laws.

(ii) Figure 5 shows an electric circuit. Determine the:

(I) current through 6 Ω resistor;
(II) voltage across 2 Ω resistor. (8 marks)

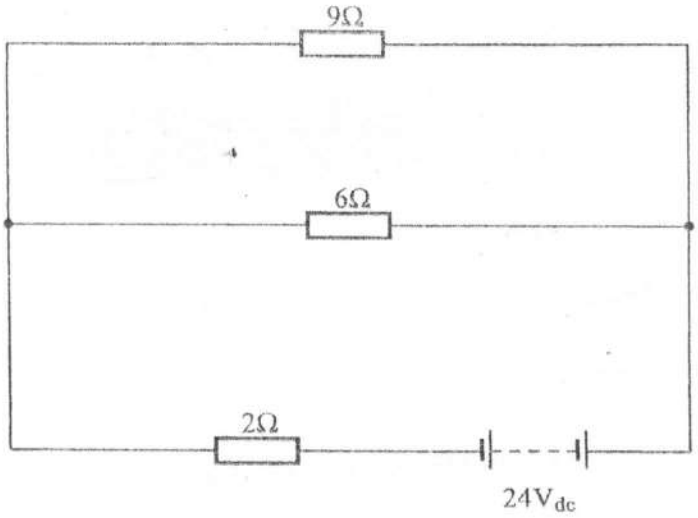

Fig. 5

7. (a) State **one** application of:

(i) ceramic capacitor;

(ii) variable air capacitor;

(iii) electrolytic capacitor. (3 marks)

(b) Two 12 μF capacitors are connected in series. The voltage across the combination is 19.5 V. Determine the energy stored in each capacitor. (4 marks)

(c) (i) Explain the term 'hysteresis' as applied in magnetic materials.

(ii) With the aid of a diagram, describe the hysteresis loop for magnetic materials. (9 marks)

(d) Describe how the following occurs in magnetically coupled circuits:

(i) self inductance;

(ii) mutual inductance. (4 marks)

8. (a) Define the following terms as used in a.c supply:

(i) period;

(ii) frequency. (2 marks)

(b) An alternating voltage is given by the expression $V = 239 \sin (100\pi - 0.25)$ volts. Determine the:

(i) peak to peak voltage;

(ii) rms voltage;

(iii) frequency;

(iv) phase angle. (8 marks)

(c) Explain the purpose of laminating a transformer core. (2 marks)

(d) A 5 kVA single-phase transformer has a turns ration of 46:1 and is fed from as 11 kV, 50 Hz supply. Neglecting losses, determine the:

(i) secondary voltage on open circuit;

(ii) full-load secondary current;

(iii) minimum load resistance;

(iv) full-load primary current. (8 marks)

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