2601/102
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2603/102
PHYSICAL SCIENCE, MECHANICAL SCIENCE AND ELECTRICAL ENGINEERING PRINCIPLES
March/April 2024
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;
Non-programmable scientific calculator;
Drawing instruments.
*This paper consists of **EIGHT** questions in **THREE** sections; **A**, **B** and **C**.*
*Answer **ONE** question from section **A**, **ONE** question from section **B** and **THREE** questions from section **C**.*
All questions carry equal marks.
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.
Take: gravitational force, g = 9.81 N/kg.

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.

Turn over

SECTION A: PHYSICAL SCIENCE

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

1. (a) (i) State **three** properties of gamma rays.

(ii) A radioactive substance ${}^{A}_{B}X$ decays by emitting two alpha particles and three beta particles. Write the nuclear equation for the decay. (7 marks)

(b) An electromagnetic wave has a frequency of 2 MHz. Determine its wavelength. Take speed of light $C = 3 \times 10^{8}$. (3 marks)

(c) With the aid of labelled diagram, describe the electromagnetic spectrum. (4 marks)

(d) With the aid of a labelled diagram, describe the process of electrolysis in lead-acid cell. (6 marks)

2. (a) (i) State **three** characteristics of progressive waves.

(ii) Draw a labelled diagram of a stationary wave. (6 marks)

(b) (i) Define 'Simple Harmonic Motion'.

(ii) A spiral spring extends by 7 cm from resting position when loaded with a 40 g mass. If the mass is allowed to vertically oscillate freely, determine the periodic time of oscillation. (6 marks)

(c) A 65 kg of pure water at 21° C is contained in an enclosed copper can of mass 3.5 kg. A 1.4 KW immersion heater is used to raise the temperature of water to boiling point. Determine the:

(i) energy absorbed by the water;
(ii) energy absorbed by the copper can;
(iii) heating time.

Take: specific heat capacity of water = 4, 200 J/kg °C.
specific heat capacity of copper = 389 J/kg °C.

(8 marks)

SECTION B: MECHANICAL SCIENCE

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

3. (a) (i) State the 'principle of conservation of energy'.

(ii) Table 1 shows examples of energy conversions. Copy and complete the table.

Table 1 (5 marks)

Conversion mechanism	Energy conversion
Generator	Mechanical to electrical energy
Steam engine	
Burning fuels	
Solar cells	

(b) Water is pumped to an overhead tank through a vertical distance of 7 m. If the work done is 360 kJ, determine the:

(i) force applied;
(ii) mass of the water pumped. (5 marks)

(c) Figure 1 shows two co-planar forces acting at a point P.

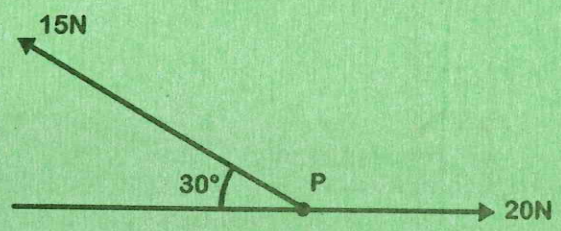


Fig. 1

Using triangle of forces method, determine the:

(i) resultant of the forces;
(ii) direction of the resultant force. (5 marks)

(d) (i) Define angular acceleration.
(ii) A motor shaft speed increases uniformly from stationary position to 1,200 rpm in 10 s. Determine the:

I. angular velocity;
II. angular acceleration. (5 marks)

4. (a) (i) Differentiate between elasticity and plasticity as used in materials.

(ii) Sketch a graph of force applied against extension for a material that has reached its elastic limit. (5 marks)

(b) A wire of length L metres and diameter d meters extends by x meters when a tensile force of F newton is applied. Derive the expression for the modulus of elasticity, E of the wire in terms of L,F,x and d. (4 marks)

(c) A body of mass 260 kg being lifted by a crane falls freely from a height of 12 m above the ground. Determine the:

(i) maximum potential energy possessed by the body.

(ii) momentum with which the body hits the ground. (7 marks)

(d) (i) Define 'atmospheric pressure'.
(ii) Figure 2 shows a U-tube manometer. Determine the fluid pressure. (4 marks)

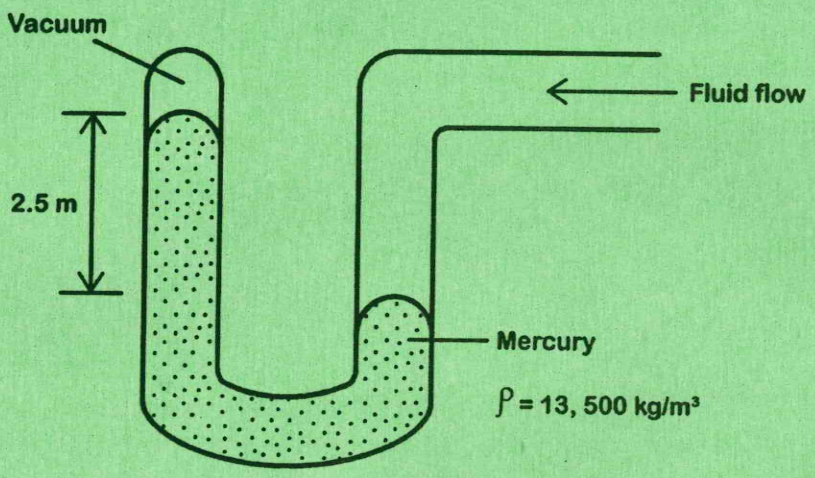


Fig. 2

SECTION C: ELECTRICAL ENGINEERING PRINCIPLES

*Answer **THREE** questions in this section.*

5. (a) State Kirchoffs laws. (4 marks)

(b) Figure 3 shows an electric circuit.

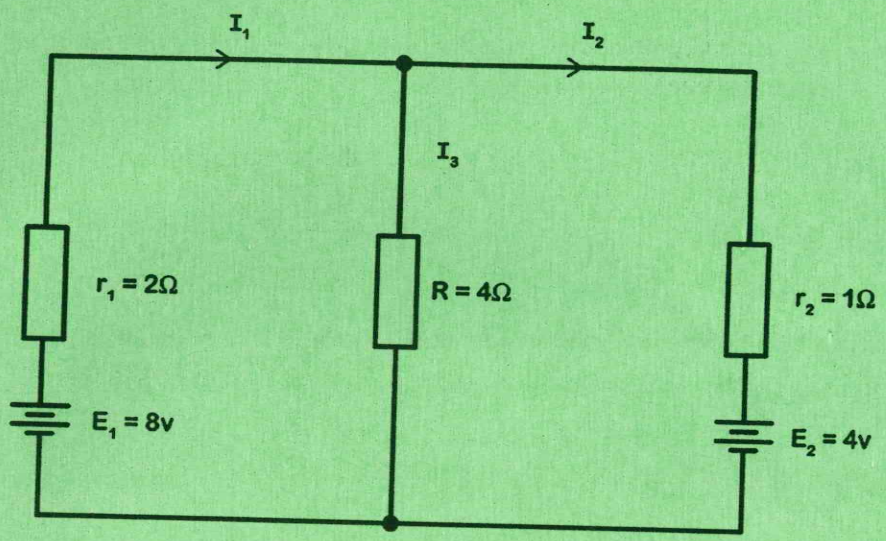


Fig. 3

Using Kirchoffs laws, determine currents I_1, I_2 and I_3. (8 marks)

(c) Distinguish between an ammeter and a voltmeter. (4 marks)

(d) Draw a labelled schematic diagram of a wattmeter connected to a load. (4 marks)

6. (a) (i) State Lenzs' law.

(ii) A conductor moves with a velocity of 10 m/s at 90° to a magnetic field produced by two square faced poles of side length 2 cm. If the flux leaving a pole face is $4\mu wb$. Determine the magnitude of induced Emf. (4 marks)

(b) Figure 4 shows two pole faces of a magnet with a conductor placed between them.

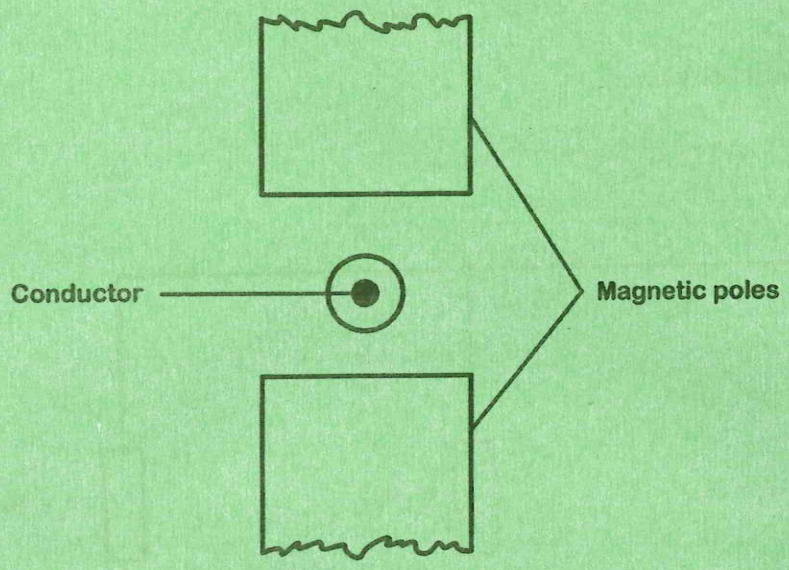


Fig. 4

Copy the figure and use the right hand grip rule to show:

(i) lines of flux;
(ii) polarity of poles of magnets;
(iii) force on the conductor. (4 marks)

(c) (i) Define 'magnetomotive force'.
(ii) A magnetising force of 4000 A/m is applied to a circular magnetic circuit of mean diameter 30 cm by passing circuit through it. If the magnetic circuit is made up of 350 turns, determine the current flowing in the circuit. (6 marks)

(d) (i) Describe 'local action' with reference to batteries.
(ii) Outline **four** charging methods of secondary cells. (6 marks)

7. (a) (i) Define 'farad'.
(ii) A parallel plate capacitor has 19 interleaved plates of cross-sectional area 5000 mm^2 separated by mica sheets 0.4 mm thick. If relative permittivity of mica is 5, determine the capacitance of the capacitor. (5 marks)

(b) With the aid of a circuit diagram, derive the expression of total capacitance of two capacitors C_1 and C_2 connected in series. (5 marks)

(c) Three capacitors 2 μF, 3 μ F and 5 μF are connected in parallel across a supply voltage of 10 V d.c. Determine the:

(i) total capacitance;
(ii) total charge;
(iii) charge on 3 μ F capacitor. (5 marks)

(d) Draw a labelled diagram of attraction type moving iron instrument. (5 marks)

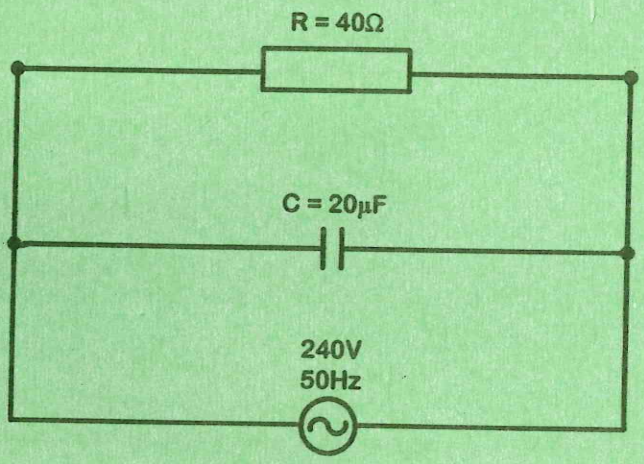
8. (a) Explain each of the following with reference to A.C circuits:

(i) periodic time;
(ii) instantaneous value. (4 marks)

(b) An alternating voltage is given by 242.8 sin 314 t volts. Determine the:

(i) r.m.s voltage;
(ii) frequency;
(iii) instantaneous value of voltage when t = 2 ms. (6 marks)

(c) Figure 5 shows an R -C circuit.



Determine the:

(i) branch currents;
(ii) supply currents;
(iii) circuit impedance. (6 marks)

(d) Draw the circuit diagram of the open circuit test of single phase transformer. (4 marks)

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