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2602/102
PHYSICAL SCIENCE, MECHANICAL SCIENCE AND ELECTRICAL ENGINEERING PRINCIPLES
Oct./Nov. 2021
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

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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: $\mu_0 = 4\pi \times 10^{-7}\ H/M$
$\varepsilon = 8.85 \times 10^{-12}\ F/M$
Speed of light = $3.0 \times 10^{8}\ m/s$
Planks constant, $h = 6.63 \times 10^{-34} J$

This paper consists of 10 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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SECTION A: PHYSICAL SCIENCE

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

1. (a) Distinguish between the following:

   (i) convection and radiation;

   (ii) isothermal and adiabatic changes in gases.

   (iii) A perfectly lagged vessel contains 20 litres of water at 90°C. If 5 litres of water at 20 °C is now added to the vessel, determine the final temperature of the mixture. Neglect heat losses.

   (8 marks)

   (b) (i) Describe the energy changes which occur in a simple pendulum.

   (ii) A plane progressive wave is described by the equation $y = 1.4\pi \sin 2(\pi x + 3t)$ where x and y are in metres and t is in seconds. Determine for the wave:

   (I) amplitude;
   (II) period;
   (III) velocity.

   (8 marks)

   (c) Explain the following as applied to vibrations:

   (i) damping;
   (ii) resonance.

   (4 marks)

2. (a) (i) State **two**:

   (I) hazards of x-rays;
   (II) uses of radioisotopes.

   (ii) Describe the **two** modes of radioactive decay. (8 marks)

   (b) (i) Distinguish between:

   (I) acids and bases;
   (II) conductance and conductivity of a substance.

   (ii) State the pH ranges for acids and bases.

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(iii) Name **two** functional groups found in organic compounds.

(7 marks)

(c) A sample of a hydrocarbon fuel was found to contain 1.71 kg of carbon and 0.287 kg of hydrogen. Determine the empirical formula for the fuel. The the atomic masses as:

Hydrogen = 1 and carbon = 12.

(5 marks)

SECTION B: MECHANICAL SCIENCE

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

3. (a) (i) State the law of conservation of linear momentum.

(ii) A hoisting motor starts from rest and accelerates uniformly for 10 seconds. It then continues at uniform angular velocity for 30 minutes, then retards to rest in a further 5 seconds. The total number of motor revolutions was 450.
Sketch the angular velocity - time graph for the motion and hence determine the:

(I) maximum rotational speed attained by the motor;

(II) number of motor revolutions made in the first 5 seconds.

(8 marks)

(b) (i) Distinguish between stress and strain as applied to engineering materials.

(ii) Table 1 shows the data obtained from a tensile test on a metal specimen:

Table 1

Load (kN)	0	10	17	25	30	34	37.5	38.5	36
Extension (mm)	0	0.05	0.08	0.11	0.14	0.2	0.4	0.6	0.9

(I) Draw the load-extension graph.

(II) If the specimen diameter is 7.3 mm and the gauge length is 42 mm, determine the modulus of elasticity of the metal. (12 marks)

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4. (a) State the following:

(i) Principle of transmission of fluid pressure.

(ii) Second law of thermodynamics.

(4 marks)

(b) (i) Distinguish between couple and torque.

(ii) Determine the magnitude of the resultant force of the system of forces shown in **Figure 1**.

(8 marks)

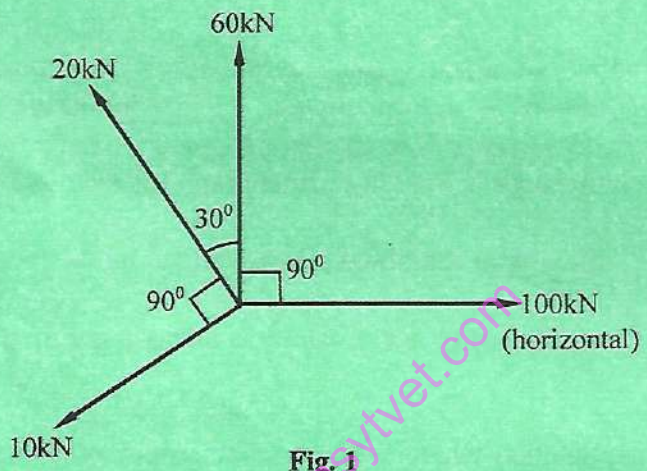

Fig. 1

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(c) (i) Explain the following characteristics of mechanical governors:

(I) sensitivity;
(II) stability.

(ii) With the aid of a labelled diagram, describe the operation of a centrifugal governor.

(8 marks)

SECTION C: ELECTRICAL ENGINEERING PRINCIPLES

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

5. (a) State:

(i) Kirchoff's voltage law;
(ii) Faraday's second law of electrolysis;
(iii) three factors affecting the resistance of an electrical conductor wire.

(7 marks)

(b) **Figure 2** shows an electrical circuit. Show that the total resistance of the circuit (R_t) can be given by the expression;

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

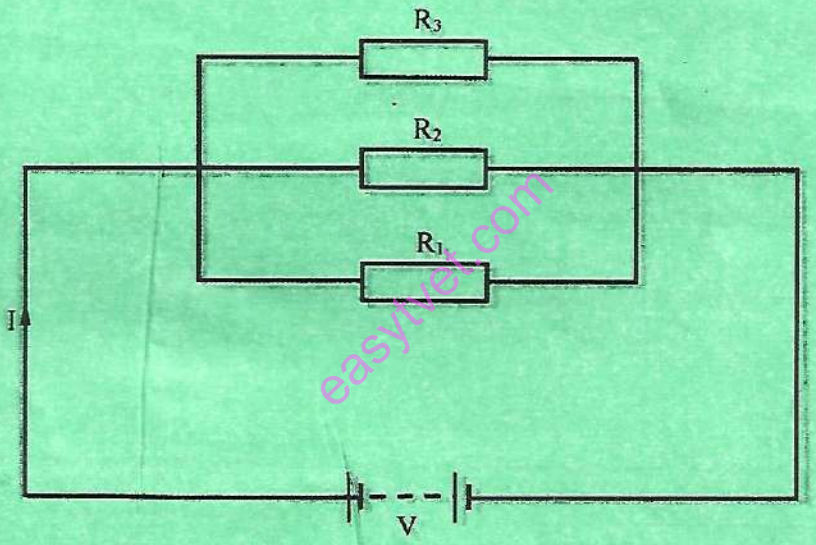

Fig. 2

(4 marks)

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(c) Use superposition theorem to determine the value of current in the 8 Ω resistor of **Figure 3**. (9 marks)

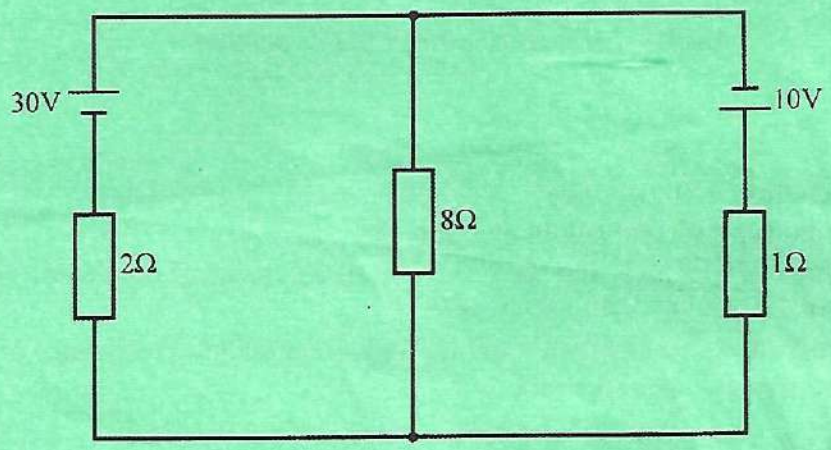

Fig. 3

6. (a) State:

(i) **two** types of damping applied to electrical indicating instruments.

(ii) **three** merits of an auto-transformer.

(5 marks)

(b) Table 2 shows the comparison between moving-coil and moving iron measuring instruments. Copy and complete the table.

Table 2

Instrument characteristics	**Moving-coil**	**Moving-iron**
Suitable for measuring		d.c and a.c currents and voltages
Scale		Non-linear
Method of control	Hair springs	
Method of damping	Eddy current damping	
Frequency limits	— —	20 - 200 Hz

(4 marks)

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(c) A moving coil instruments has a full scale deflection of 20 mA and a resistance of 25 Ω. Determine the value of the resistor to be used as a:

(i) shunt to enable the instrument to be used as a 0 - 20 A ammeter.

(ii) multiplier to enable the instrument to be used as a 0 - 20 V voltmeter.

(8 marks)

(d) Three capacitors of capacitances $6\mu F, 6\mu F$ and $12\mu F$ are connected in series across a 100 V d.c supply. Determine the:

(i) total equipment circuit capacitance.

(ii) charge on each capacitor.

(3 marks)

7. (a) Define each of the following as applied in magnetic circuits, stating the SI unit for each:

(i) magnetic flux density;
(ii) reluctance;
(iii) permeance.

(6 marks)

(b) With the aid of a labelled circuit diagram, describe the no-load test on a single-phase transformer. (7 marks)

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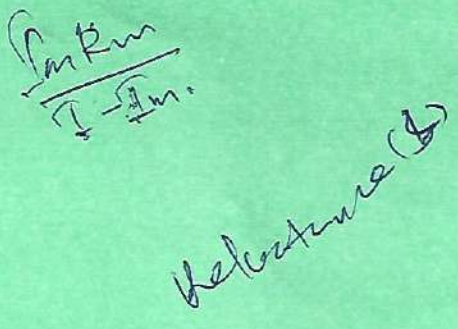

(c) **Figure 4** shows a magnetic circuit. The silicon-iron magnetic circuit has a uniform cross-sectional area of 3 cm^2. The magnetization curve for silicon-iron can be obtained from the graph in **Figure 5**. Assuming no leakage or fringing, determine the current in the coil required to produce a flux of 0.45 mWb in the air-gap. (7 marks)

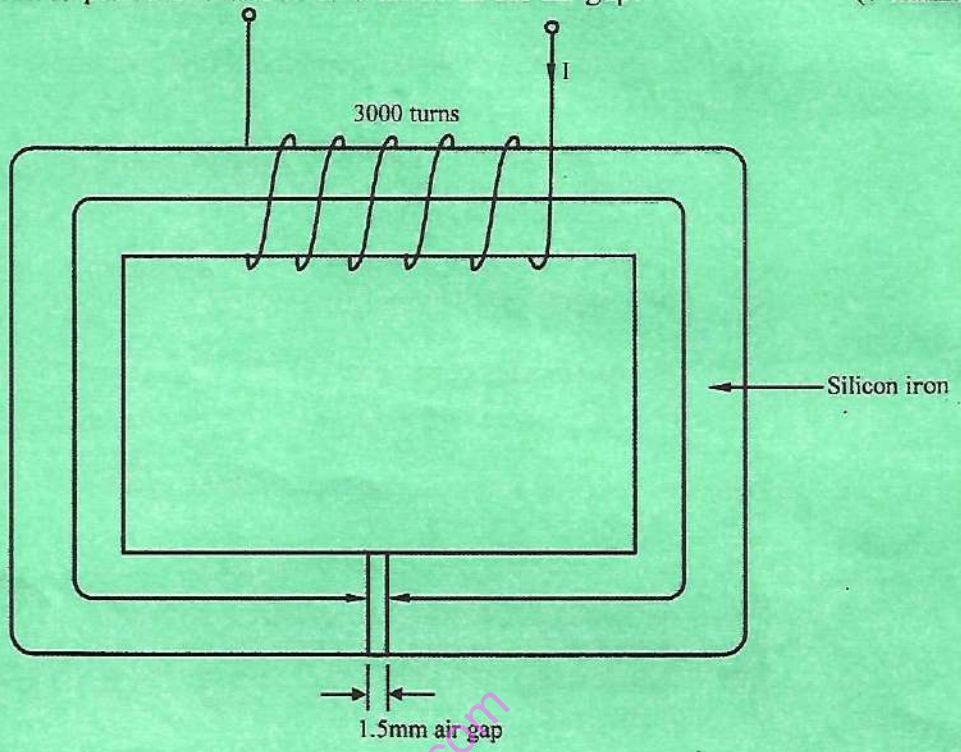

Fig. 4

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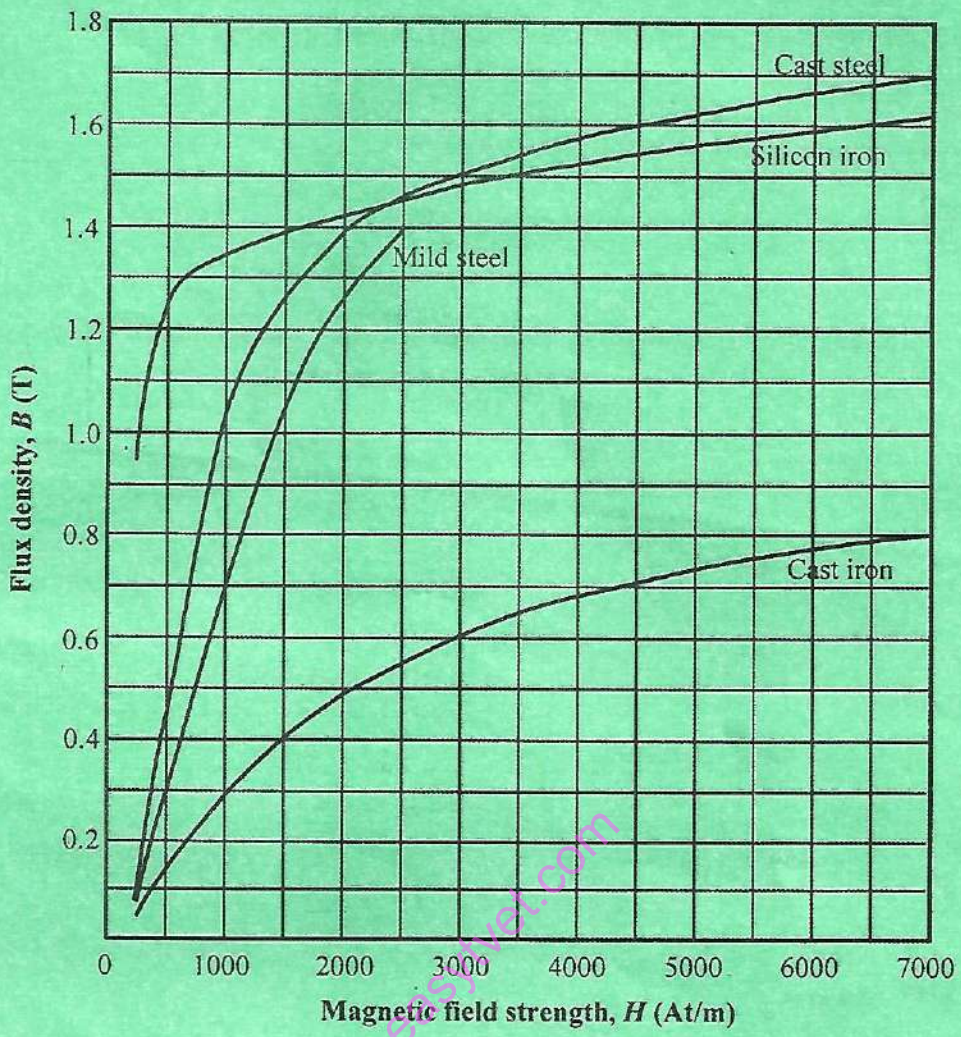

Fig. 5: ***B-H curves for four materials***

8. (a) (i) Define each of the following as applied in alternating current quantities:

(I) frequency;
(II) peak to peak value.

(ii) State **three** electrical equipment where electromagnets are used.

(5 marks)

(b) An alternating voltage given by $V = 100 \sin 240t$ volts is applied across a coil of resistance 32 Ω and inductance 100 mH. Determine the:

(i) circuit impedance;
(ii) current flowing in the circuit;
(iii) circuit power factor;
(iv) power dissipated by the coil.

(8 marks)

(c) With the aid of a labelled diagram, describe the construction of a dry-type leclanché cell. (7 marks)

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