2601/102
2602/102
2603/102
PHYSICAL SCIENCE, MECHANICAL SCIENCE
AND ELECTRICAL ENGINEERING PRINCIPLES
June/July 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

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Non-programmable scientific calculator.
*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** in the answer booklet provided.*
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.

Take $\mu_0 = 4\pi \times 10^{-7}\,\text{H/m}, \varepsilon_0 = 8.854 \times 10^{-12}\,\text{F/m}$
Speed of light, $C = 3.0 \times 10^8 m/s$
Plank's constant, $h = 6.63 \times 10^{-34} J$

This paper consists of 9 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

SECTION A: PHYSICAL SCIENCE

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

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

(ii) Describe the production of X-rays in an X-ray tube. (7 marks)

(b) An object moving with a simple harmonic motion has an amplitude of 0.02 m and a frequency of 20 Hz. Determine the maximum acceleration. (4 marks)

(c) The atomic notation of element is $^{18}_{40}X$. Draw the electronic configuration of the atom. (3 marks)

(d) Sodium sulphate is formed by reacting 25 cm³ of dilute sulphuric acid solution with 40 cm³ of 0.4 M sodium hydroxide solution. The chemical reaction equation is given by:

$$H_2SO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow NaSO_{4(aq)} + 2H_2O_{(l)}$$

Determine the:

(i) moles of sodium hydroxide;

(ii) moles of sulphuric acid;

(iii) molarity of sulphuric acid. (6 marks)

2. (a) State the effect of each of the following on the speed of sound:

(i) density of the medium;

(ii) temperature of the medium. (2 marks)

(b) A plane progressive wave is governed by the expression $y = 0.08\sin(36t - 9x)$ metres.

Determine the:

(i) amplitude;

(ii) wavelength;

(iii) frequency;

(iv) speed of the wave. (7 marks)

(c) (i) Define each of the following:

(I) heat capacity;
(II) latent heat.

(ii) Explain each of the following with respect to heat:

(I) absolute scale;
(II) black body radiation.

(6 marks)

(d) With the aid of energy level diagram, describe exothermic reaction with respect to thermo-chemistry. (5 marks)

SECTION B: MECHANICAL SCIENCE

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

3. (a) (i) Define power as used in mechanics.

(ii) A load is raised to a height of 160 m in 20 seconds expending 80 kJ of energy. Determine the:

(I) power;
(II) force.

(5 marks)

(b) (i) Explain equilibrium with respect to coplanar forces.

(ii) Figure 1 shows a system of coplanar forces.

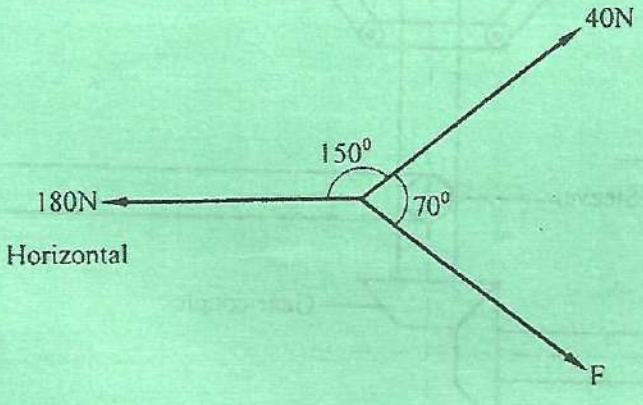

Fig. 1

If the forces are in equilibrium, determine the value of force, F. (6 marks)

(c) (i) State **two** demerits of Pitot-static tube flow meter.

(ii) Draw a labelled cross-sectional view of a Pitot-static tube flow meter fitted in the pipeline.

(6 marks)

(d) Outline the destructive tensile test for a material. (3 marks)

4. (a) (i) Explain plasticity of a material.

(ii) Draw a labelled Hooke's Law curve for an elastic material. (6 marks)

(b) (i) State **two** forces acting on a body moving at a constant speed in a circular path.

(ii) The speed of a motor shaft increases uniformly from zero to 280 revolutions per minute in 4 seconds. Determine the final:

(I) angular velocity;

(II) angular acceleration. (8 marks)

(c) Figure 2 shows an engine speed governor.

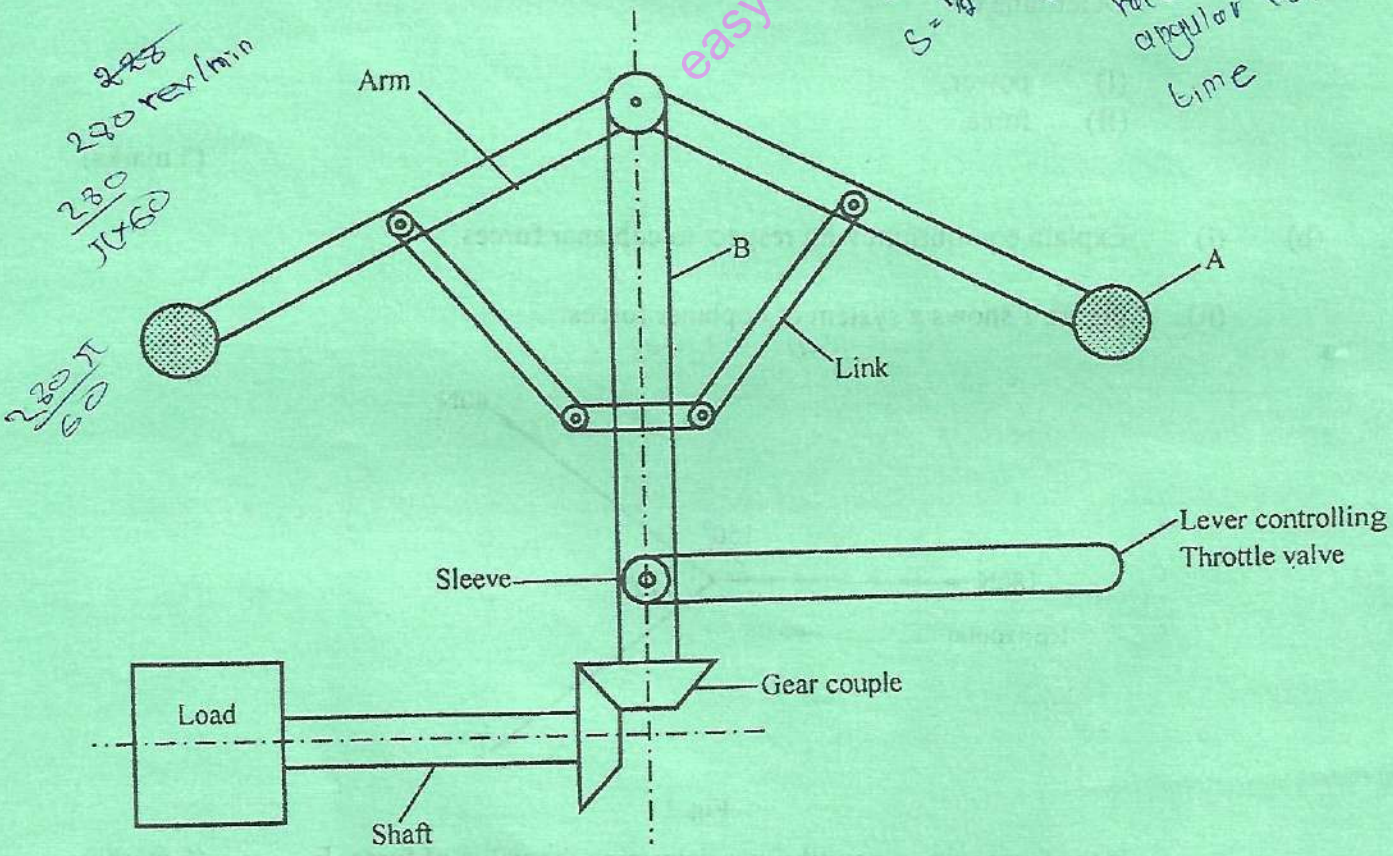

Fig. 2

(i) Identify the type of the governor.

(ii) Name the parts labelled A and B.

(iii) Explain how the governor controls engine speed when the load on the engine reduces.

(6 marks)

SECTION C: ELECTRICAL ENGINEERING PRINCIPLES

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

5. (a) Define each of the following electrical quantities:

(i) potential difference;
(ii) current.

(2 marks)

(b) A 18 Watt electric light bulb is supplied by a 12 V solar battery rated 700 Ah. Determine the:

(i) current flowing through the bulb;

(ii) resistance of the bulb element;

(iii) supply duration.

(6 marks)

(c) (i) **Figure 3** shows construction diagram of Lead-acid cell. Name the parts labelled A, B, C and D.

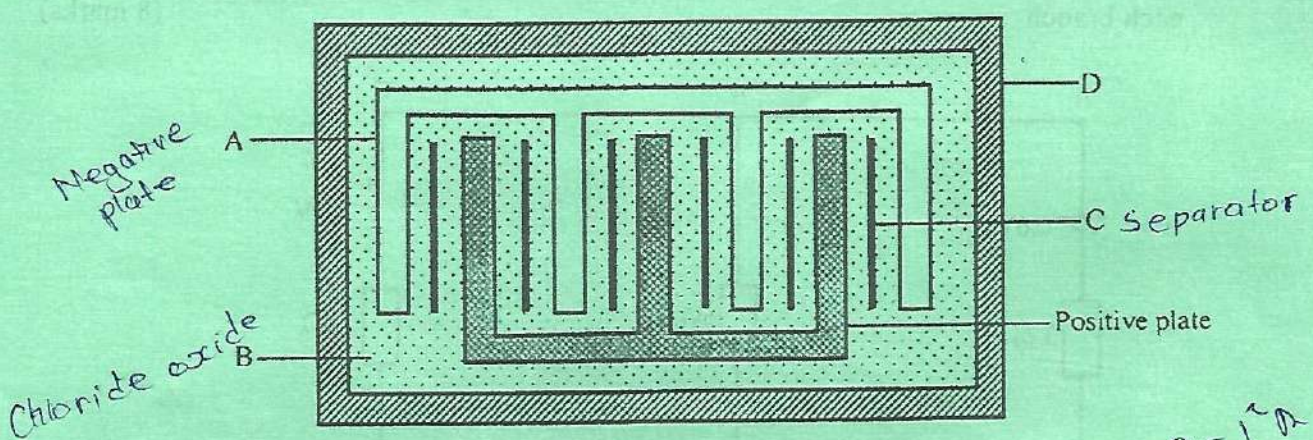

Fig. 3

(ii) Explain each of the following as used in electric cells:

(I) local action;
(II) polarization.

(8 marks)

(d) Four cells generating an e.m.f of 2.2 V and having internal resistance of 0.9 Ω each are connected in parallel. Determine the:

(i) total internal resistance;

(ii) voltage across the cells terminals when supplying a current of 0.6 A.

(4 marks)

6. (a) (i) State two safety practices observed when using electrical measuring instruments.

(ii) Draw a labelled circuit diagram showing wattmeter connection to a single phase supply.

(5 marks)

(b) (i) Explain temperature coefficient of resistance of a material.

(ii) A conductor has a resistance of 30 Ω at 50°C. The temperature coefficient of resistance of the conductor is 0.0038/°C at 0°C. Determine its resistance at 0°C.

(5 marks)

(c) State the superposition theorem with reference to d.c circuits. (2 marks)

(d) **Figure 4** shows a d.c circuit. Using superposition theorem, determine the current in each branch. (8 marks)

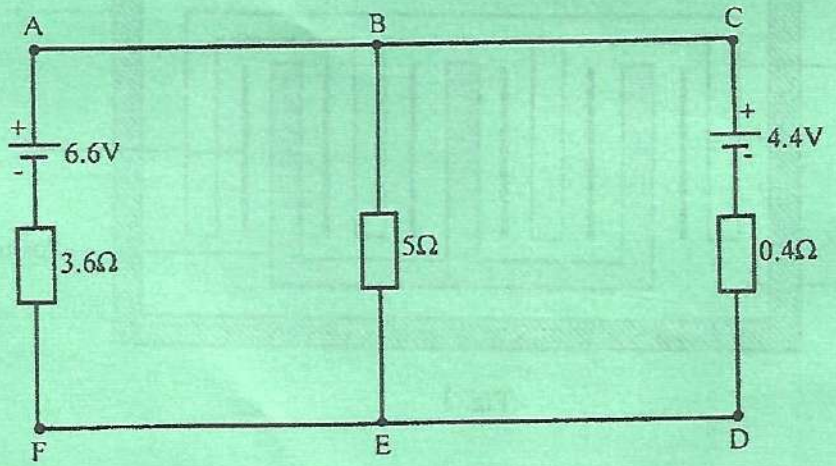

Fig. 4

7. (a) (i) State **three** advantages of digital measuring instruments over analogue measuring instruments.

(ii) A wattmeter of current coil resistance 0.02 Ω is connected in series to a 2 Ω load. If the current flowing through the current coil is 12 A, determine the wattmeter reading.

(6 marks)

(b) **Figure 5** shows a magnetic circuit.

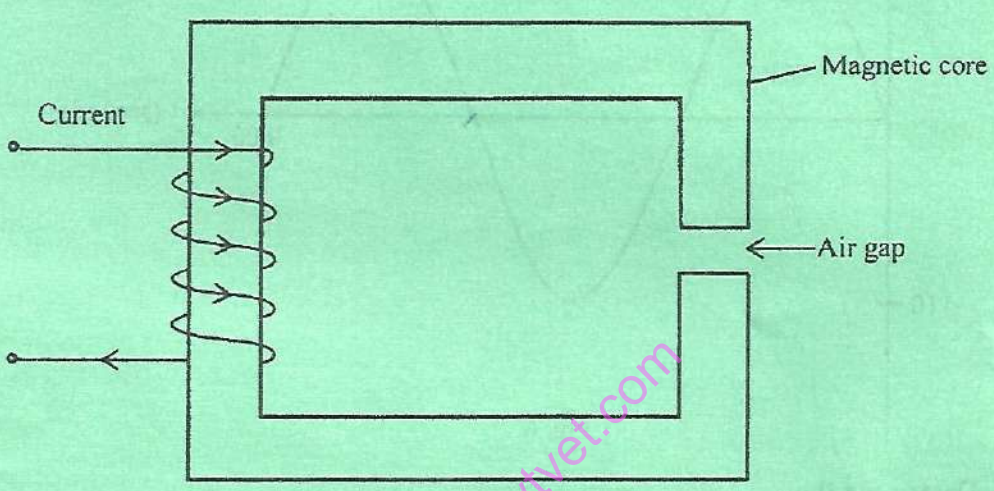

Fig. 5.

Draw the given circuit and show the following:

(i) useful flux;
(ii) leakage flux;
(ii) fringing flux.

(6 marks)

(c) (i) State Faraday's laws of electromagnetic induction.

(ii) A flux of 30 mWb links with a coil of 1600 turns when a current of 1.5 A flow in the coil. The current falls to zero in 200 ms. Determine the:

(I) inductance of the coil;
(II) average e.m.f induced in the coil.

(8 marks)

$\phi = BA$
$\phi = 30mWb$
$N = 1.5\ A$

8. (a) List any two parts of a.c generators. (2 marks)

- Bruch
- Bearing

(b) **Figure 6** shows a.c waveform.

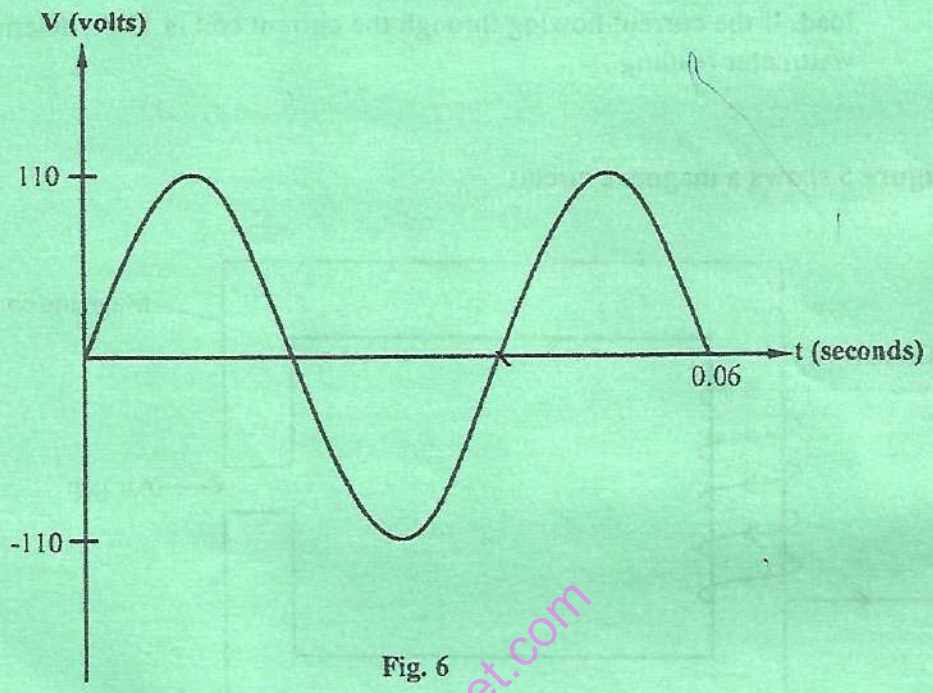

Fig. 6

Determine the:

(i) periodic time;

(ii) frequency;

(iii) average value of voltage;

(iv) r.m.s value of voltage.

(6 marks)

(c) (i) State **two** transformer losses.

- Hesterisis loss
- Copper loss

(ii) Show that efficiency of a transformer is given by:

$$\text{Efficiency} = 1 - \frac{\text{losses}}{\text{input power}}$$

(4 marks)

(d) **Figure 7** shows a capacitor circuit.

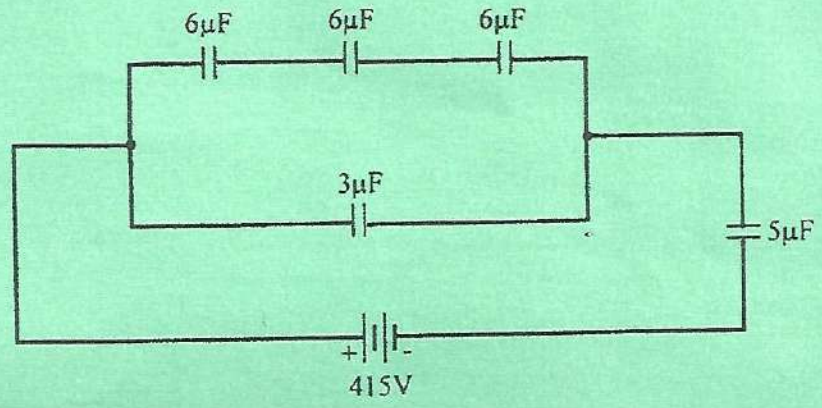

Fig. 7

Determine the:

(i) equivalent circuit capacitance;

(ii) voltage across each 6 μF capacitor. (8 marks)

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