2601/102
2602/102
2603/102
PHYSICAL SCIENCE, MECHANICAL SCIENCE AND ELECTRICAL ENGINEERING PRINCIPLES
June/July 2022
Time: 3 Hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRICAL AND ELECTRONICS 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:
drawing instruments;
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.*
All questions carry equal marks.
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.

Take,

$\mu_o = 4\pi \times 10^{-7}$ H/M;
$\varepsilon_o = 8.85 \times 10^{-12}$ F/M
Speed of light C, $= 3.0 \times 10^{8}$ m/s
plants constant, $h = 6.63 \times 10^{-34}$ J
acceleration due to gravity, g = 9.81 m/s²

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) Define half life of a radioisotope.

(ii) Name **two** appliances used for detecting nuclear radiations.

(iii) A museum artifact contains a radioisotope of half life 1500 years. If the activity of the isotope in the artifact is 30%, determine the age of the artifact.

(iv) State **two** engineering applications of x-rays.

(9 marks)

(b) (i) Distinguish between transverse and longitudinal waves and give **one** example of each.

(ii) With the aid of a sketch, explain the occurrence of diffraction in light waves.

(iii) A radio wave has a frequency of 64 mHz. Determine its wavelength.
Take speed of light = 3×10^8 m/s

(7 marks)

(c) An engine piston moves with a simple harmonic motion. At a piston displacement of 10 cm from its centre of oscillation, its acceleration is 500 m/s^2. Determine the frequency of the piston motion in Hz. (4 marks)

2. (a) (i) State the Dalton's law of partial pressures.

(ii) Distinguish between isobaric and isochoric changes in gases.

(iii) An electric kettle rated 2 kW is used to heat 1.5 litres of water from 22°C to 100 °C. The specific heat capacity of water is 4.18 kJ/kg °C and the heat capacity of the kettle is 5 kJ/ °C. Neglecting heat losses, determine the time taken to heat the water. (9 marks)

(b) (i) With the aid of a sketch, explain the term electrolysis.

(ii) State **two** engineering applications of electrolysis.

(iii) Distinguish between electron affinity and electro-negativity of a substance.

(7 marks)

(c) (i) Explain the term isomerism.

(ii) State **two** uses of hydrocarbons.

(4 marks)

SECTION B: MECHANICAL SCIENCE

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

3. (a) (i) Define the following terms and state their S.I units:

(I) moment;
(II) power.

(ii) A hoist raises 1.2 tonnes of concrete vertically through a distance of 20 metres in 40 seconds. If the efficiency of the hoist is 92%, determine the:

(I) work done;
(II) power developed;
(III) energy consumption while raising the concrete.

(9 marks)

(b) (i) State **two** effects of vibration on rotating machinery.

(ii) With the aid of sketches, describe how the following couplings transmit power from an electric motor to a load:

(I) belt drive;
(II) clutch drive.

(6 marks)

(c) A shaft accelerates from rest to a speed of 2400 rev/min in 10 seconds. Determine the:

(i) angular acceleration;
(ii) number of shaft revolutions during the period.

(5 marks)

4. (a) (i) Explain the function of a speed governor.

(ii) Name **two** types of centrifugal speed governors.

(4 marks)

(b) (i) With the aid of sketches, distinguish between laminar and turbulent flow of a fluid.

(ii) A horizontal tapering water pipe has a diameter of 10 cm at one end and 20 cm at its other end. If the velocity of water at the 10 cm diameter end is 2.5 m/s, determine the:

(I) water flow rate through the pipe in litres/ minute;
(II) velocity at the 20 cm diameter end.

(10 marks)

(c) Draw a labelled line diagram of a steam power plant. (6 marks)

SECTION C: ELECTRICAL ENGINEERING PRINCIPLES

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

5. (a) With reference to alternating quantities, define the following terms:

(i) period;

(iii) amplitude;

(ii) root mean square value.

(3 marks)

(b) The instantaneous value of voltage in an a.c circuit at any time t seconds is given by $v = 339\sin\left(100\pi t + \frac{\pi}{6}\right)$ volts.

Determine the:

(i) amplitude;

(ii) periodic time;

(iii) time when the voltage first reaches 200 V;

(iv) time when the voltage reaches a maximum first time.

(8 marks)

(c) Sketch the voltage and current waveforms when a voltage $v = v_m \sin \omega t$ is applied to a circuit which is:

(i) purely inductive;
(ii) purely capacitive.

(6 marks)

(d) A battery of e.m.f 20 V and internal resistance 0.2 Ω supplies a load taking a current of 10A. Determine the:

(i) potential difference at the battery terminals;

(ii) resistance of the load.

(3 marks)

6. (a) State each of the following:

(i) superposition theorem as applied to electric circuits;

(ii) Faraday's first law of electrolysis.

(4 marks)

(b) **Table 1** shows the comparison between lead-acid cell and Nickel-iron cell.

Table 1

Particulars	Lead-acid cell	Nickel-iron cell
Positive plate		
Negative plate		
Electrolyte		
Internal resistance	Comparatively low	Comparatively higher
Efficiency		
Life	gives nearly 1250 charges and discharges	five years at least
Average e.m.f		

Copy and complete the table. (5 marks)

(c) (i) **Figure 1** shows an electrical circuit. Use Kirchoff's laws to determine the currents in each of the resistors. (11 marks)

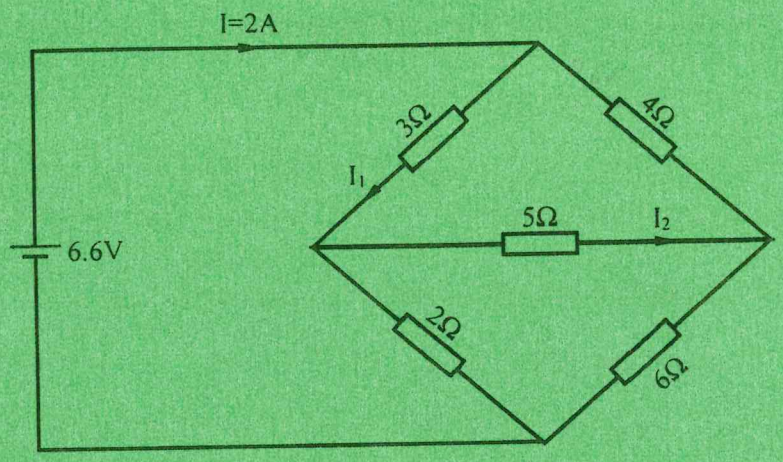

Fig. 1

7. (a) State the **two** Faraday's laws of electromagnetic induction. (4 marks)

(b) Explain why:

(i) the short-circuit test on a transformer give the copper losses only and not iron-losses;

(ii) the short-circuit test on a transformer is performed on high voltage side. (4 marks)

(c) Show that the root mean square value of induced e.m.f (E_1) in the primary winding of single phase transformer is given by:

$E_1 = 4.44 f_1 N_1 \phi_m$ volts.

where f_1 = frequency of the primary voltage

ϕ_m = maximum flux in the transformer core.

N_1 = number of turns in the primary winding. (7 marks)

(d) A flux of 40 mWb links with a 1500 turn coil when a current of 5A is passing through the coil. Determine the:

(i) inductance of the coil;

(ii) energy stored in the magnetic field;

(iii) average e.m.f induced if the current is reduced to zero in 0.20 seconds. (5 marks)

8. (a) State **three**:

(i) merits of permanent - magnet moving - coil (PMMC) type electrical measuring instrument.

(ii) types of capacitors.

(6 marks)

(b) With reference to electrical indicating instruments, explain the following:

(i) deflecting torque;

(ii) controlling torque;

(iii) damping torque.

(6 marks)

(c) A parallel - plate capacitor, having plates 100 cm^2 area, has three dielectrics 1 mm each and of relative permittivities 3, 4 and 6 respectively. If a peak voltage of 2000 V is applied to the plates, determine the:

(i) capacitance;

(ii) potential gradient across each dielectric.

(8 marks)

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