2602/102
2603/102
PHYSICAL SCIENCE, MECHANICAL
SCIENCE AND ELECTRICAL
ENGINEERING PRINCIPLES
June/July 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
drawing instruments;
non-programmable scientific calculator.
*This paper consists of **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.

This paper consists of 5 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 Faraday's laws of electrolysis.

(ii) A calorimeter of heat capacity 80 JK^{-1} contains water of mass 0.1 kg and a coil of 5 ohms totally immersed in the water. The coil is connected in parallel with a copper voltameter having copper electrodes and a resistance of 7 ohms. When the arrangement is connected as a circuit, 0.66 grammes of copper is deposited in 40 minutes. Determine the temperature rise of the calorimeter in the same time.

Take: Specific heat capacity of water = 4200 J/kgK

Mass of copper deposited per coulomb = 3.3×10^{-7} kg/C.

(10 marks)

(b) 1 m^3 of air, initially at 110 kN/m^2 and 15° C, is compressed according to the law $PV^{1.3}$ = constant, in a cylinder to a final pressure of 1.4 MN/m^2.
Taking R for air = 287 J/kgK and Cp = 1005 J/kgK, determine the:

(i) volume and temperature of the air at the end of the compression;
(ii) workdone in compressing the air;
(iii) change in internal energy;
(iv) heat exchange through the cylinder walls, stating the direction of heat flow.

(10 marks)

2. (a) (i) Distinguish between transverse and longitudinal waves and state one example of each.

(ii) Illustrate the following types of damped vibrations:

(I) critically damped;
(II) under damped;
(III) over damped.

(6 marks)

(b) The displacement y of a plane progressive wave is given by $y = 10 - 4\sin(200\pi t - 0.5\pi x)$ where 'x' and 'y' are in metres and 't' in seconds.
Determine the:

(i) amplitude;
(ii) wave length;
(iii) velocity;
(iv) phase difference between two points one metre apart.

(6 marks)

(c) A particle moves with simple harmonic motion between two points, one metre apart. The frequency of the oscillation is 4 Hz. Determine the:

(i) periodic time for the oscillation;
(ii) maximum velocity of the particle;
(iii) acceleration of the particle when it is 300 mm from one end of the motion.

(8 marks)

SECTION B: MECHANICAL SCIENCE

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

3. (a) State Newtons second law of motion. (2 marks)

(b) A piece of metal weighing 30 g is thrown from a sling at a velocity of 20 m/s. It is brought to rest in 0.05 seconds after it hits and penetrates a sand bag. . Determine the:

(i) depth of the penetration in metres;
(ii) average retarding force of the sand in Newtons.

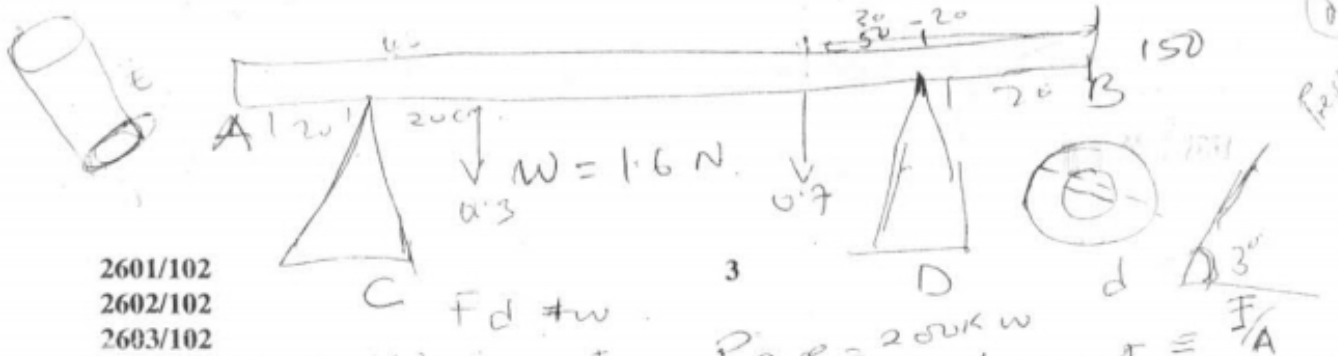
(10 marks)

(c) With the aid of a labelled diagram, explain the measurement of fluid pressure using a manometer. (8 marks)

4. (a) State the principle of moments. (2 marks)

(b) A beam AB measures 150 cm and weighs 1.6 N. It is placed on two supports C and D such that they are 20 cm from each end of the beam. A 0.3 N weight hangs on the beam 40 cm from C and a 0.7 N weight hangs similarly 50 cm from D. Sketch and determine the reactions at the supports. (11 marks)

(c) A hollow steel shaft transmits 200 kW of power at 150 rev/min. The total angle of twist in a length of 5 m of the shaft is 3°. Determine the inner and outer diameters of the shaft if the permissible shear stress is 60 MPa. (Take G = 80 GPa) (7 marks)



SECTION C: ENGINEERING PRINCIPLES

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

5. (a) State Kirchhoff's:

(i) voltage law;
(ii) current law.

(4 marks)

(b) With the aid of a circuit diagram, derive an expression for the total resistance for three resistors connected in parallel. (6 marks)

(c) Figure 1 shows a bridge network. Use Kirchhoff's laws to determine the:

(i) branch currents;
(ii) power dissipated by 5Ω resistor.

(10 marks)

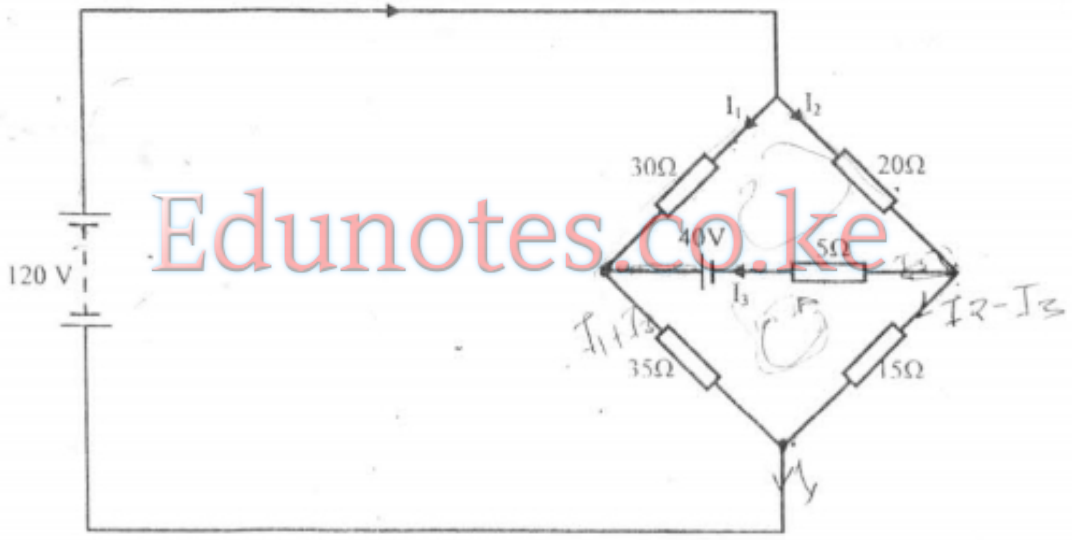


Fig. 1

6. (a) Define the following terms as used in electrostatics:

(i) electric field intensity;
(ii) relative permittivity.

(4 marks)

(b) State the factors that determine the capacitance of a capacitor. (3 marks)

(c) (i) Two capacitor plates measuring 6 cm by 4 cm are 7 mm apart. This space is filled by 2 mm glass dielectric and 5 mm paper dielectric materials. The relative permittivities of glass and paper are 6 and 2.5 respectively. If the applied voltage is 500 V across the capacitor plates, determine the:

(I) capacitance of the capacitor;
(II) potential difference across each dielectric.

(ii) Draw a circuit diagram that will enable a d.c. ammeter to measure a.c. voltage.
(13 marks)

7. (a) Define the term reluctance as used in magnetism. (2 marks)

(b) A circular magnetic ring has a diameter of 4.2 cm. An air gap of 2 mm has been cut off. The ring has a cross-sectional area of 6 cm^2 and a relative permeability of 500. If a coil of 6000 turns is wound on the ring and a currnt of 750 mA flows through it, determine the:

(i) total reluctance;
(ii) magnetomotive force drop in the air gap;
(iii) flux density in the magnetic material.
(10 marks)

(c) Two alternating quantities are represented by $V_1 = 2\,Sin\,\omega t$ and $V_2 = 3\,Sin\left(\omega t + \frac{\pi}{12}\right)$.

(i) Draw graphs for V_1, V_2 and resultant V_r on the same graph.
(ii) Write an expression of V_r in the form $V_r = A\,Sin(\omega t + m)$.
(8 marks)

8. (a) A coil has a resistance of 12 ohms and inductance of 70 mH. It is connected in parallel with a capacitor of 80 μF. If the supply voltage is 240 V, 50 Hz, determine the:

(i) supply current;
(ii) power factor of the circuit;
(iii) true power of the circuit.
(10 marks)

(b) (i) Explain the three losses that occur in a transformer and state how they are minimised.

(ii) A 20 ohms resistor is connected across the secondary winding of a single phase transformer. If the secondary voltage is 150 V and the primary current is 5 A, determine the primary voltage and turns ratio. (Neglect the losses)
(10 marks)

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