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PHYSICAL SCIENCE, MECHANICAL
SCIENCE AND ELECTRICAL
ENGINEERING PRINCIPLES

June/July 2017

Time: 3 Hours

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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,

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/M};$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ F/M}.$$

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.

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 = $3.3 \times 10^{-7} \text{ kg/C}$.
- (10 marks)

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

- (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:

- periodic time for the oscillation;
- maximum velocity of the particle;
- 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:

- depth of the penetration in metres;
- 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)

- (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)

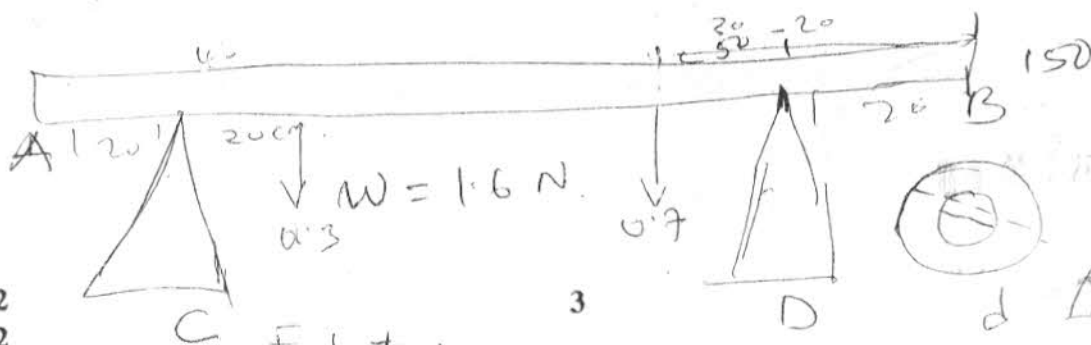
- (c) A hollow steel shaft transmits 200 kW of power at 150 rev/min. The total angle of twist in a length of 5 m of the shaft is 3° . Determine the inner and outer diameters of the shaft if the permissible shear stress is 60 MPa. (Take $G = 80$ GPa) (7 marks)

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$$P_{\text{she}} = 200 \text{ kW}$$

$$f = 150 \text{ rev/min}$$

$$L = 5 \text{ m}$$

$$\theta = 3^\circ$$

$$\tau = 60 \text{ MPa}$$

$$\tau = \frac{F}{A}$$

Turn over

$$P = FV$$

SECTION C: ENGINEERING PRINCIPLES

Answer **THREE** questions from this section.

- 5/ (a) State Kirchhoff's:
- (i) voltage law;
 - (ii) current law.
- (b) With the aid of a circuit diagram, derive an expression for the total resistance for three resistors connected in parallel.
- (c) Figure 1 shows a bridge network. Use Kirchhoff's laws to determine the:
- (i) branch currents;
 - (ii) power dissipated by 5Ω resistor.

(4 marks)

(6 marks)

(10 marks)

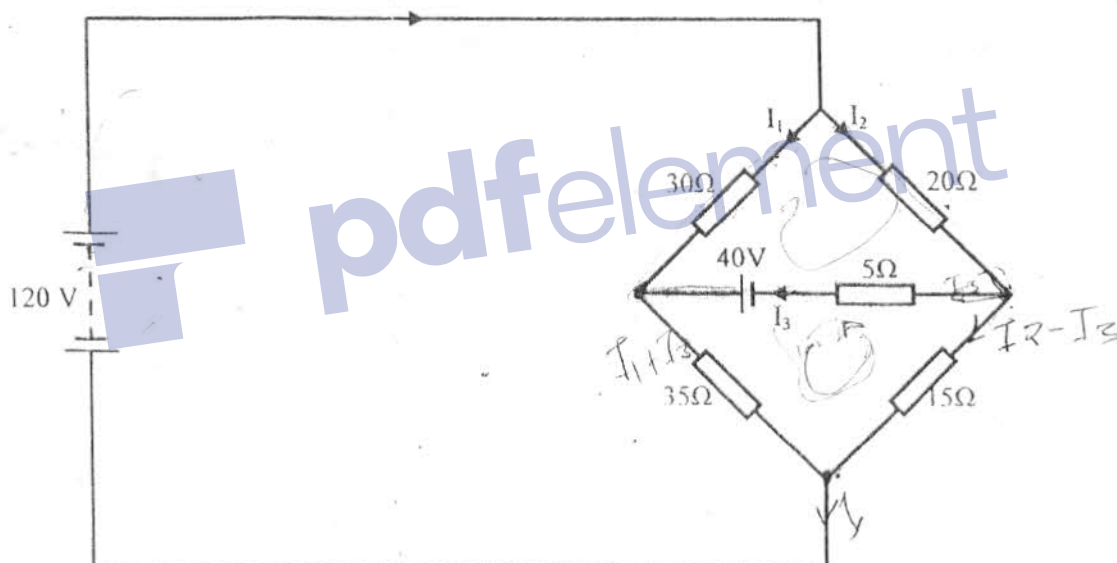


Fig. 1

6. (a) Define the following terms as used in electrostatics:
- (i) electric field intensity;
 - (ii) relative permittivity.
- (b) State the factors that determine the capacitance of a capacitor.

(4 marks)

(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)

- (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 cm² and a relative permeability of 500. If a coil of 6000 turns is wound on the ring and a current 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.

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

- (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 μ F. 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.

- (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)

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P S

2:1

2 N_P

1 m² = 100 000 cm²

$$\frac{1 N_s}{2 N_P} = \frac{V_{SP}}{V_P} = V_S$$

$$\frac{N_P}{N_S} = \frac{V_P}{V_S}$$

$$\frac{N_P}{N_S} = \frac{V_P}{V_S}$$