

2601/102

2602/102

2603/102

PHYSICAL SCIENCE, MECHANICAL SCIENCE  
AND ELECTRICAL ENGINEERING PRINCIPLES

Oct./Nov. 2018

Time: 3 hours



THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRICAL AND ELECTRONICS ENGINEERING  
(POWER OPTION)  
(TELECOMMUNICATION OPTION)  
(INSTRUMENTATION OPTION)

PHYSICAL SCIENCE, MECHANICAL SCIENCE  
AND ELECTRICAL ENGINEERING PRINCIPLES

3 hours

INSTRUCTIONS TO CANDIDATES

*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  $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$  and  $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$

**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.**



## SECTION A PHYSICAL SCIENCE

Answer **ONE** question from this section.

1. (a) State:  
(i) **two** properties of x-rays;  
(ii) **three** applications of electrolysis. (5 marks)
- (b) Explain the forces acting in the nucleus of an atom. (4 marks)
- (c) Differentiate between 'lattice' and 'hydration' energy changes when ionic compound is dissolved in polar water. (4 marks)
- (d) Write:  
(i) balanced chemical equation for complete combustion of methane gas.  
(ii) the molecular formula for the following hydrocarbons:  
(I) propene;  
(II) ethane;  
(III) ethyne. (7 marks)
2. (a) State the laws of refraction of light. (2 marks)
- (b) A light ray passes from glass to water striking the glass-water interface at an angle of  $26.3^\circ$  with the normal. The refractive indices of glass and water are 1.5 and 1.33 respectively.  
Determine:  
(i) refractive index of water with respect to glass;  
(ii) angle of refraction;  
(iii) critical angle for glass-water interface. (6 marks)
- (c) With aid of a diagram, describe energy changes when a pendulum bob is displaced from equilibrium position released to swing freely. (7 marks)
- (d) (i) State **two** precautions taken to minimize loss of heat by calorimeter to the surrounding.  
(ii) A metallic material of mass 5 kg absorbs 184 kJ of heat energy causing its temperature to rise from  $10^\circ\text{C}$  to  $90^\circ\text{C}$ . Determine its specific heat capacity. (5 marks)



SECTION B: MECHANICAL SCIENCE

Answer *ONE* question from this section.

3. (a) (i) Define the term 'shaft coupling' as used in power transmission.
- (ii) State **two** factors to consider when choosing a shaft coupling for an application.
- (3 marks)

- (b) A body of mass 200 kg and moving at 60 m/s is stopped in 3 seconds of impact after a collision with a stationary object of mass 120 kg.

Determine the:

- (i) initial common velocity;
- (ii) average impact force.
- (7 marks)

- (c) (i) State **two** advantages and **one** disadvantages of inertia type over centrifugal type governors.
- (ii) Explain the principles of operation of centrifugal engine governors.
- (6 marks)

- (d) A crane lifts a 1100 kg car vertically at a constant speed to a height of 4 m in 6 seconds. Determine the:
- (i) work done by the lifting force;
- (ii) power of the crane.
- (force of gravity is 9.8 N/kg)
- (4 marks)

4. (a) State:
- (i) the parallelogram law of coplanar forces;
- (ii) **two** conditions for static equilibrium of coplanar forces.
- (4 marks)

- (b) (i) Differentiate between centrifugal and centripetal forces.
- (ii) A centrifuge machine is used to separate cream from milk of mass 20 kg in a container fitted 80 cm from the centre of rotation. The machine makes one rotation in 4 seconds.  
Determine the:
- (I) angular velocity;  
(II) centrifugal force.
- (6 marks)
- (c) State the following laws of thermodynamics:
- (i) first law;  
(ii) second law.
- (4 marks)
- (d) Figure 1, shows a horizontal pipe with a narrow section. A fluid of density  $800 \text{ kg/m}^3$  flowing through the pipe passes the narrow section at a speed of 4 m/s.  
Determine the:
- (i) speed of fluid in the pipe;  
(ii) pressure difference due to the narrow section.
- (6 marks)

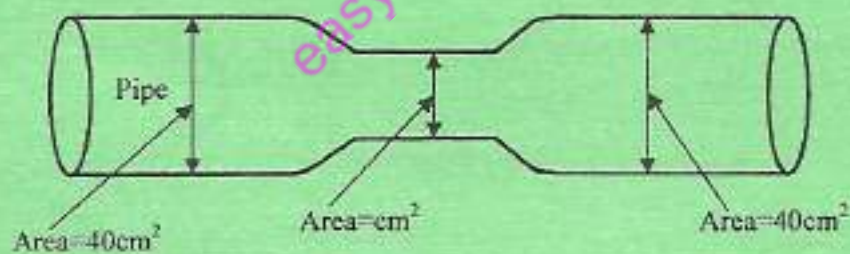


Fig. 1



SECTION C: ELECTRICAL ENGINEERING PRINCIPLE

Answer **THREE** question from this section.

5. (a) State three disadvantages of dry Lechlanch'e cells.
- (b) Describe the following methods of charging a battery:
- (i) Booster charging;
  - (ii) Trickle charging.

(6 marks)

- (c) Figure 2, shows series- parallel arrangement of 5 identical cells connected across a 5 ohm resistor. Each cell has an internal resistance of 0.15 ohm and an e.m.f of 2.2 V. Using superposition theorem, determine the current through the 5 ohms resistor.

(11 marks)

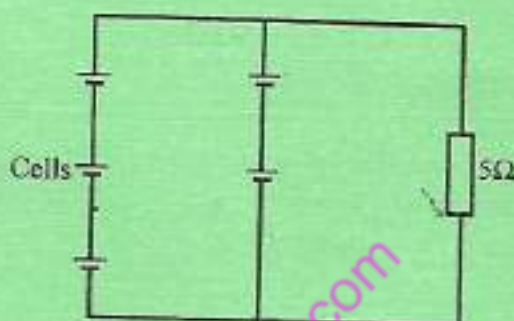


Fig. 2

6. (a) (i) Define temperature coefficient of resistance of a conductor.
- (ii) Explain how temperature change affects electrical conductivity of a material.
- (b) The resistance of a copper coil at 20°C is 200 ohms. Determine the resistance of the coil when its temperature rises to 45°C. (Temperature coefficient of resistance of copper is 0.0043/°C at 0°C)
- (c) (i) Explain the term 'loading effect' of a voltmeter.
- (ii) State how loading effect in C(i);
- (I) alters voltmeter reading;
  - (II) can be minimized.

(4 marks)

- (d) Figure 3 shows a voltmeter circuit connection. The voltmeter has a full-scale-deflection of 50 V and a sensitivity of  $2.4 \text{ k}\Omega/\text{V}$ . Determine the:
- Voltage across the  $60 \text{ k}\Omega$  resistor when voltmeter is not connected;
  - Voltage indicated by the voltmeter.

(8 marks)

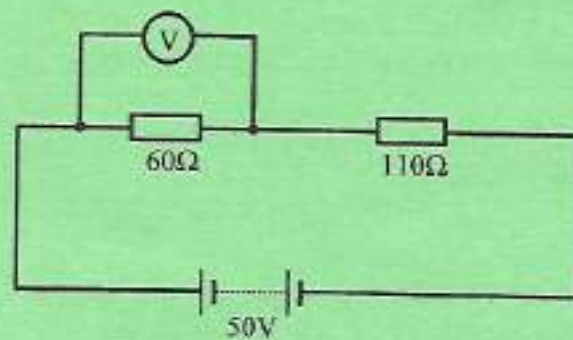


Fig. 3

7. (a) Define magnetic flux density. (2 marks)
- (b) Figure 4 shows a section through a magnetic circuit of uniform cross-section area  $2 \text{ cm}^2$  and mean length of 25 cm. The flux density in the air gap is 0.8 tesla and the field strength is 750 A/m. Determine the:
- circuit reluctance;
  - magnetomotive force;
  - current in the coil.

(8 marks)

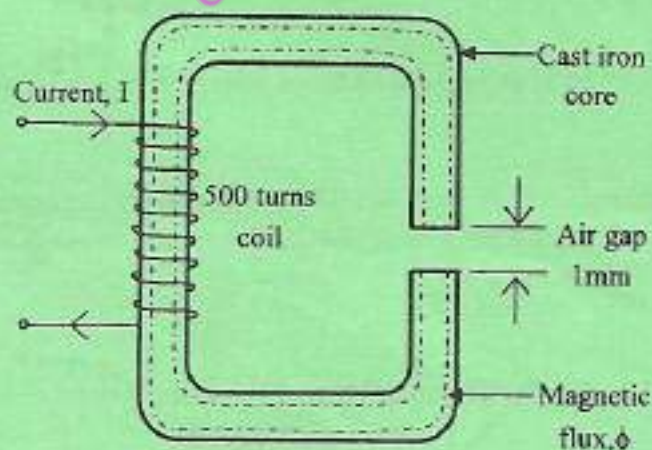


Fig. 4



- (c) A static capacitor of capacitance  $22 \mu\text{F}$  is connected in parallel with an  $80 \Omega$  resistive load across a  $240 \text{ V}$ ,  $50 \text{ Hz}$  supply. Determine the:
- supply current;
  - power factor.
- (8 marks)
- (d) State **two** benefits of improving power factor of an electrical load. (2 marks)

8. (a) (i) Explain the term resistance matching.
- (ii) Describe how transformer is used as a resistance matching device. (4 marks)
- (b) With the aid of a circuit diagram, describe the construction of an auto-transformer. (6 marks)
- (c) Figure 5 shows a series-parallel capacitor circuit. The capacitors  $X$ ,  $Y$  and  $Z$  are identical and the total equivalent capacitance of the circuit is  $2.4 \mu\text{F}$ . Determine the:
- Value of capacitor  $X$ ;
  - Voltage across capacitor  $Y$ .

(10 marks)

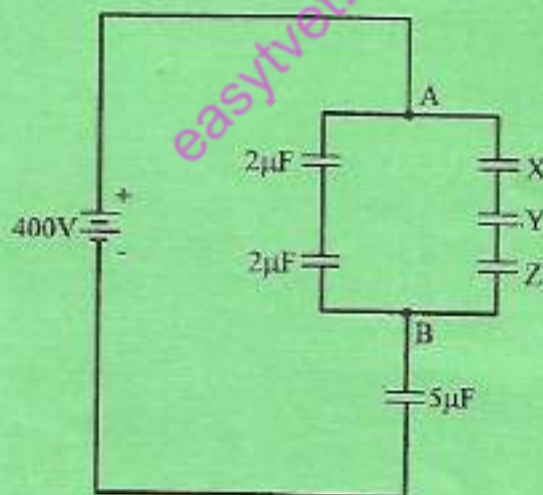


Fig. 5

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