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2603/102

PHYSICAL SCIENCE, MECHANICAL SCIENCE
AND ELECTRICAL ENGINEERING PRINCIPLES

June/July 2019

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 **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 $U^{\circ} = 4\pi \times 10^{-1} \text{ H/m}$ and $\epsilon^{\circ} = 8.85 \times 10^{-12} \text{ F/m}$.

This paper consists of 8 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 **four** properties of acids. (4 marks)
- (b) (i) Outline **two** advantages of nuclear fuel over fossil fuel.
- (ii) Explain the function of the following components of a nuclear reactor:
- (I) graphite core;
- (II) control rods. (6 marks)
- (c) (i) Name **two** homologous series for hydrocarbons.
- (ii) Differentiate between 'covalent' and 'dative' bonds. (6 marks)
- (d) Explain **two** factors which determine preferential discharge of ions during electrolysis. (4 marks)
2. (a) (i) State **two** uses of microwaves.
- (ii) Determine the energy possessed by microwave at a wavelength of 20 cm. Take plank's constant as 6.63×10^{-34} Js and speed of light as 3.0×10^8 m/s. (6 marks)
- (b) Define the following terms as used in simple harmonic motion:
- (i) displacement;
- (ii) amplitude. (2 marks)
- (c) Derive an expression for velocity, V of a simple harmonic motion in terms of displacement, y , amplitude, A and angular speed, ω . (5 marks)
- (d) Small pieces of dry melting ice of total mass 220 g at 0°C were added to water of mass 300 g at 95°C contained in well lagged copper calorimeter of heat capacity 300 J/k. When all ice has melted and the content stirred, a steady temperature of 30°C was obtained. The specific heat capacity of water is 4200 J/kgk. Determine the specific latent heat of fusion of the ice. (7 marks)

SECTION B: MECHANICAL SCIENCE

Answer **ONE** question from this section.

3. (a) (i) Define the following terms as used in mechanics:
- (I) kinetic energy;
 - (II) impulse.
- (ii) An object of mass 12 kg falls freely from a height of 8 m above the ground level. Determine the impulse experienced by the object on hitting the ground. (force of gravity is 9.8 N/kg) (8 marks)
- (b) State **three** applications of impulse in mechanics. (3 marks)
- (c) Figure 1 shows 100 kg object supported by a hinged rigid beam. Determine the magnitude of force in the beam. (3 marks)

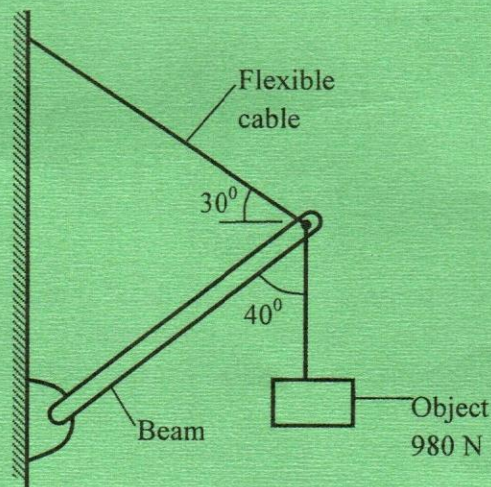


Fig. 1

- (d) (i) State the principle of transmission of fluid pressure;
- (ii) With aid of a diagram, describe turbulent flow of liquid in circular pipe. (6 marks)

4. (a) Outline **three** differences in operation of centrifugal type over inertia type of governors. (6 marks)
- (b) Explain how drive belt coupling can be used to change speed of driven shaft. (2 marks)
- (c) Figure 2 shows an angular position-time graph for a particle moving in a circular path:
- (i) Describe the velocity of motion;
- (ii) Determine the period of motion.

(6 marks)

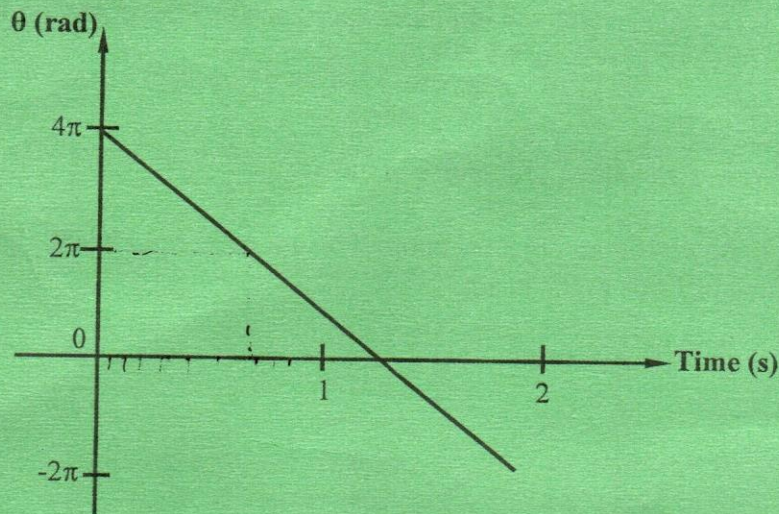


Fig. 2

- (d) An electric power transmission cable is made of aluminium alloy of cross-section area 120 mm^2 and length 95 m . The tensile stress and Young modulus of the cable is 290 MN/m^2 and 70 GN/m^2 respectively. Determine the:
- (i) greatest tensile force it can withstand;
- (ii) maximum extension on the cable under stress condition.

(6 marks)

SECTION C: ELECTRICAL ENGINEERING PRINCIPLES

Answer **THREE** questions from this section.

5. (a) Describe the effects of the following forces produced in electrical indicating instruments:
- (i) deflecting force;
 - (ii) damping force;
 - (iii) controlling force.
- (6 marks)
- (b) Outline **two** differences between a moving-coil and a moving-iron instrument.
- (4 marks)
- (c) **Figure 3**, shows a signal waveform on a cathode ray oscilloscope (CRO) display. The time-base setting is 2.1 ms/cm while the sensitivity is 2.5 V/cm. Determine the:
- (i) mean value of the signal;
 - (ii) supply frequency.

(6 marks)

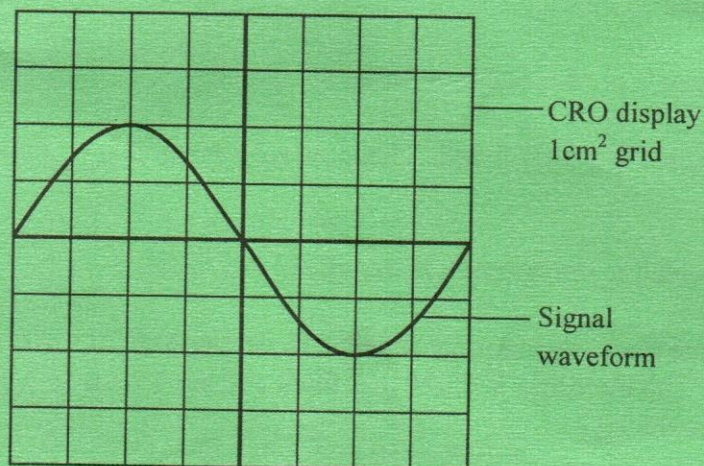


Fig. 3

- (d) Differentiate between 'constant-voltage' and 'constant-current' methods of charging a battery.
- (4 marks)

6. (a) State Kirchoff's laws. (4 marks)
- (b) Figure 4 shows electric circuit. Using Kirchoff's laws, determine the current flowing through the $5\ \Omega$ resistor. (7 marks)

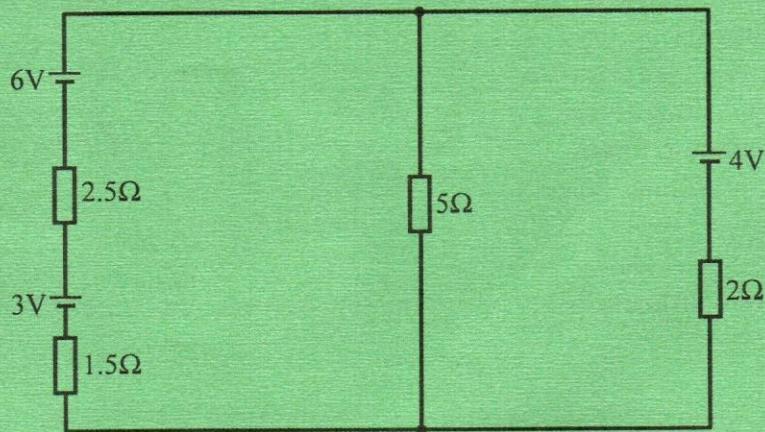


Fig. 4

- (c) An aluminium overhead power cable has cross-section area of $1.2 \times 10^{-4}\ \text{m}^2$. The resistivity of the aluminium is $2.6 \times 10^{-8}\ \Omega\ \text{m}$. Determine the resistance of a 3000 m length of the cable. (3 marks)
- (d) (i) Draw a phasor diagram for an RL circuit;
- (ii) Sketch the current and voltage waveforms of d(i) on the same axes. (6 marks)
7. (a) Define dielectric strength of a material. (2 marks)
- (b) A two-plate mica capacitor has a dielectric strength of $50 \times 10^6\ \text{V/m}$ and a plate area of $940\ \text{cm}^2$. The dielectric is 0.025 mm thick and has a relative permittivity of 5. Determine the:
- (i) rated terminal voltage;
- (ii) capacitance;
- (iii) maximum energy it can store. (6 marks)
- (c) Figure 5 shows an electromagnetic circuit:
- (i) Draw the circuit and indicate direction of current flow in the solenoid;
- (ii) Identify the poles of the magnet;
- (iii) Show the lines of magnetic flux. (8 marks)

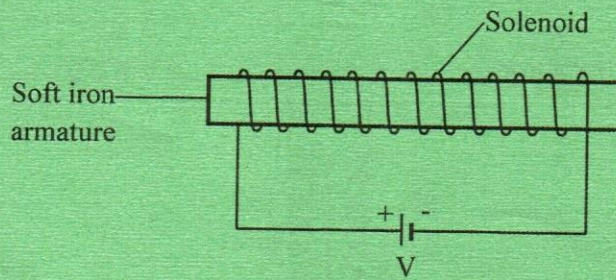


Fig. 5

(d) A conductor 6 cm long cuts a magnetic field of flux density 0.85 T at a speed of 62 m/s. Determine the e.m.f induced:

- (i) at maximum flux linkage;
- (ii) when conductor cuts flux at an angle of 60° .

(4 marks)

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

- (i) advantages of auto-transformers;
- (ii) applications of a(i).

(4 marks)

(b) The instantaneous value of a.c voltage supply is given by

$$V = 110 \sin (100 \pi t + 0.2 \pi) \text{ volts}$$

Determine the:

- (i) amplitude;
- (ii) r.m.s value of the voltage;
- (iii) phase angle;
- (iv) supply frequency.

(6 marks)

(c) Figure 6 shows an equivalent circuit of a transformer:

- (i) Sketch a simplified equivalent circuit;
- (ii) For the circuit in c(i), determine the:
 - (I) equivalent impedance;
 - (II) phase angle.

(10 marks)

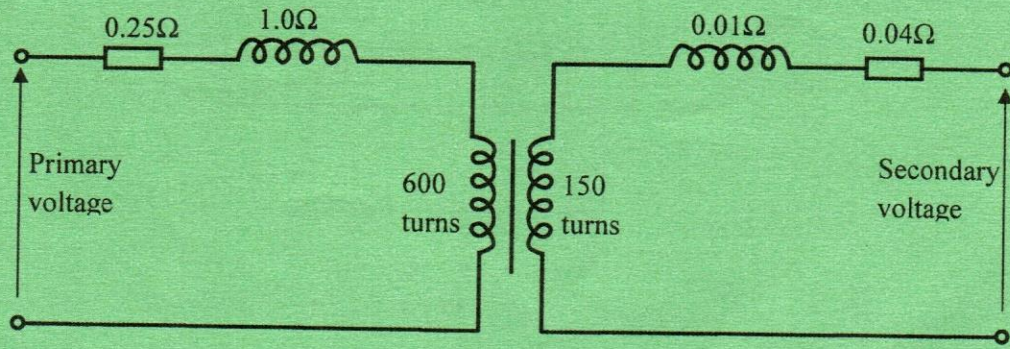


Fig. 6

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