2601/102
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2603/102
PHYSICAL SCIENCE, MECHANICAL SCIENCE
AND ELECTRICAL ENGINEERING PRINCIPLES
June/July 2020
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:
Answer booklet;
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.***
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.
Take: $\mu = 4\pi \times 10^{-7} H/m$ *and* $\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$
Speed of light, $C = 3.0 \times 10^{8}\ m/s$
Plank's constant, $h = 6.63 \times 10^{-34} J$

This paper consists of 6 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) Define each of the following as applied to radioactivity:

(I) background radiation;
(II) half-life.

(ii) A Geiger Muller tube records a background count of 6 B_q. When a sample of a radioactive substance is held near it, the count rate is increased to 3854 B_q. After 27 hours, the count rate is reduced to 487 B_q. Determine the half-life of the radioactive substance.

(6 marks)

(b) Differentiate between damped vibration and forced vibration. (4 marks)

(c) **Figure 1** shows a mass M suspended from a spring with spring constant k. If the mass is displaced by an extension x from equilibrium position and allowed to undergo a simple harmonic motion, show that periodic time, $T = 2\pi\sqrt{\frac{M}{k}}$. (5 marks)

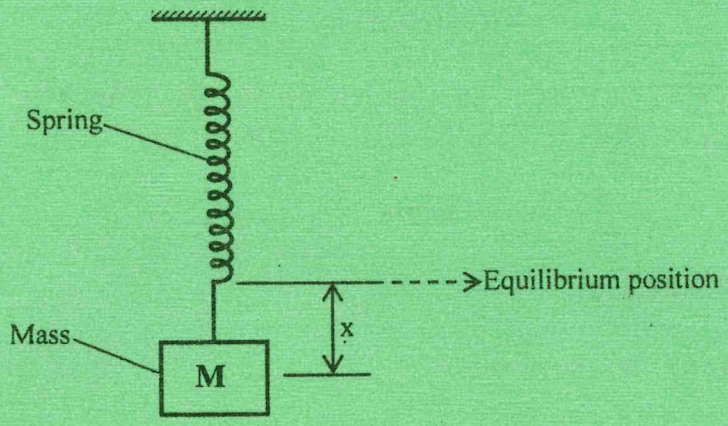

Fig. 1

(d) A hydrocarbon is represented by the formula C_6H_{12}.

(i) Determine the molecular weight of the hydrocarbon.
(ii) Name **two** products formed when the hydrocarbon is burnt in excess oxygen.

(5 marks)

2. (a) (i) State the **two** laws of reflection of light.

(ii) Differentiate between longitudinal and transverse waves, citing **one** example in each case.

(6 marks)

(b) (i) Convert 113° F to Kelvin.

(ii) A material of mass 20 kg absorbs 310 kJ of heat causing its temperature to rise from 26° C to 160° C. Determine its specific heat capacity.

(6 marks)

(c) Explain how each of the following affect thermal conductivity of a material:

(i) temperature gradient;
(ii) thickness of the material.

(4 marks)

(d) (i) State **two** properties of bases.

(ii) Outline the procedure for determining the pH value of a basic solution.

(4 marks)

SECTION B: MECHANICAL SCIENCE

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

3. (a) (i) Differentiate between elastic and gravitational potential energy.

(ii) A body is to be moved at a constant velocity of 2 m/s. A force of 60 N is resisting its motion. Determine the tractive power necessary to keep the body moving at this speed.

(5 marks)

(b) (i) Define each of the following as used in statics:

(I) vector quantity;
(II) concurrent forces.

(ii) The following are concurrent forces: 350 N acting horizontally to the right, 290 N at 60° and 600 N at 150°. With the aid of a vector diagram, determine the magnitude and direction of the resultant force. (8 marks)

(c) The density of fluid in a container is $13\,g/cm^3$ and the force of gravity is $9.81\,m/s^2$.

(i) Determine the pressure at a point 3 m below the surface of the fluid.
(ii) State with reason, the effect on pressure in (c) (i) if the:

(I) fluid in the container is replaced with a less dense fluid;
(II) level of fluid in the container is increase.

(7 marks)

4. (a) (i) State **two** areas of application of fluid couplers.

(ii) Describe the operation of fluid couplers.

(7 marks)

(b) A mild steel material of gauge length 140 mm and cross-sectional area 200 mm^2 can withstand a maximum load of 100 kN. The gauge length at fracture is 185 mm. Determine the:

(i) tensile strength;
(ii) percentage elongation.

(5 marks)

(c) Explain each of the following with reference to governors:

(i) equilibrium speed;
(ii) controlling force.

(4 marks)

(d) A pulley of diameter 210 mm driving a belt turns at 172 revolutions per minute. Determine the:

(i) angular velocity of the pulley;
(ii) linear velocity of the belt.

(4 marks)

SECTION C: ELECTRICAL ENGINEERING PRINCIPLES

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

5. (a) Compare alkaline cells to lead-acid cells with reference to the following:

(i) internal resistance;
(ii) efficiency;
(iii) e.m.f generated;
(iv) charge loss.

(4 marks)

(b) Describe each of the following battery charging methods:

(i) booster charging;
(ii) trickler charging.

(4 marks)

(c) An electric kettle draws 5 A from a 250 V, 50 Hz supply. Determine the:

(i) energy it consumes in 2 hours;
(ii) rating of the kettle;
(iii) conductance of the heater element.

(8 marks)

(d) Table 1 shows derived quantities and corresponding derived units. Complete the table. (4 marks)

Table 1

Derived quantities	Derived units
Resistivity	
	Volt-ampere
Current	
	Joule/coulomb

6. (a) Illustrate the connection of a voltmeter and ammeter in a circuit with 12 V d.c supply and a $4\,\Omega$ load to measure the p.d across the load and current flowing in the circuit. (4 marks)

(b) A moving coil instrument has a coil resistance of $15\,\Omega$ and maximum permissible instrument current of 24 mA. Draw the equivalent circuit diagram and determine the value of resistor required to convert the instrument to a 0 - 300 V voltmeter. (6 marks)

(c) State the effect of each of the following on resistance of conductors:

(i) change in temperature;
(ii) length of conductor;
(iii) cross-section area of conductor. (3 marks)

(d) A copper cable has resistance of $200\,\Omega$ at 20° C. The temperature coefficient of resistance of copper is $0.0043/^{\circ}C$. Due to current flow, the cable temperature raises to 90° C. Determine its new resistance. (7 marks)

7. (a) State **three** factors which affect capacitance of a capacitor. (3 marks)

(b) A capacitor has two parallel plates each of effective area $6\,cm^2$. The plates are separated by 0.14 mm of ceramic of relative permittivity 100. A potential difference of 220 V is applied across the plate. Determine the:

(i) capacitance;
(ii) charge stored in the capacitor. (6 marks)

(c) Compare the values of inductances in the following pair of inductors, assuming equal ampere-turns in each case:

(i) air-cored and iron-cored inductors;
(ii) short-thick and long-thin inductors. (6 marks)

(d) (i) Distinguish between self-inductance and mutual inductance.

(ii) A 16 H inductor coil has a current of 13 A flowing through it. Determine the energy stored.

(5 marks)

8. (a) Define each of the following with reference to a.c waveform:

(i) instantaneous values;
(ii) peak value;
(iii) frequency.

(3 marks)

(b) **Figure 2** shows an a.c circuit;

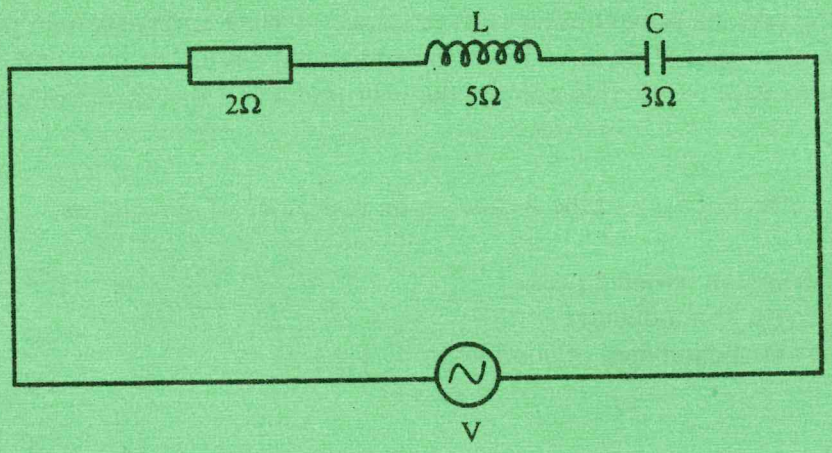

Fig. 2

(i) determine the phase angle of the circuit;
(ii) draw the phasor diagram for the circuit.

(5 marks)

(c) A 48 kVA ideal single-phase transformer has a turns ratio of 46:1 and is fed from a 11.5 kV supply. For a full load kVA, determine the:

(i) secondary current;
(ii) primary current.

(8 marks)

(d) (i) Draw a labelled construction diagram of a shell type transformer.

(ii) State the reason for laminations in transformers.

(4 marks

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