2601/102
2602/102
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.

Turn over

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)

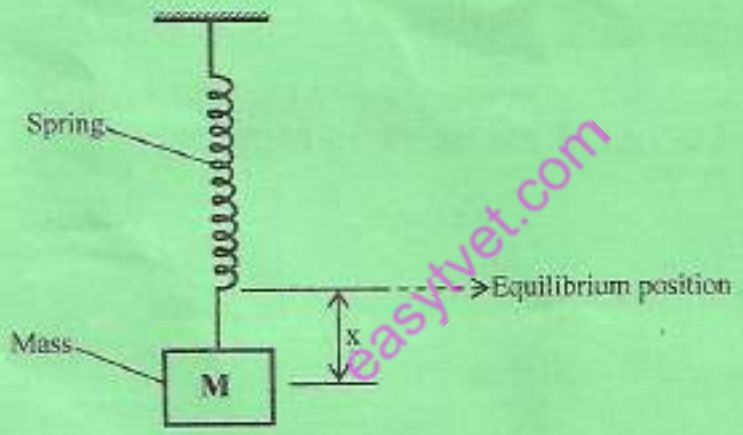

Fig. 1

(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.

- The incidaul ray - The angle of incidence is equal to the angle of reflection.

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

- Transverse wave are waves always characterized by particle motion being perpendicular to wave motion. longitudinal waves is a wave in which particles of the medium move in a direction parallel to the direction that the wave moves

Trans - Radio waves Long - Sand wave.

(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; ↑ with increase temp the electrical conductivity of a pure metal decrease. This implies little variance with thermal conductivity of the pure metal shows little variance with an increase in temp

(ii) thickness of the material. Fourie's law shows that thermal energy move from warmer materials to cooler material. (4 marks)

(d) (i) State **two** properties of bases.
- They are bitter in taste
- Bases feel slippery or soapy.

(ii) Outline the procedure for determining the pH value of a basic solution.
To calculate the pH of an aqueous solution you need to know the concentration of the hydronium ion in moles per liter. The pH is then calculated using the expression $pH = \log(H_3O^+)$ (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.

- Automobile transmission - Marine and industrial machine drives

(ii) Describe the operation of fluid couplers. (7 marks)

The fluid coupling consists of a pump impeller and a runner. Both impellers are housed in the same casing. The pump impeller pushes the fluid inside the runner which causes the output shaft to rotate.

(b) A mild steel material of gauge length 140 mm and cross-sectional area 200 mm² 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:

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

(4 marks)

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

(i) booster charging; - high current for a short period of time
(ii) trickler charging. - charging charged battery on a low

(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; $E = Pxt = 250x5 = 1250W$
(ii) rating of the kettle;
(iii) conductance of the heater element.

But $E = Pxt$
$= 1250 \times 2 \times 60 \times 60$
$= 9.0 \times 10^6 J$ (8 marks)

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

Table 1

Derived quantities	Derived units
Resistivity	Ohm-m
Power	Volt-ampere
Current	Ampere
Potential difference/Voltage	Joule/coulomb

6. (a) Illustrate the connection of a voltmeter and ammeter in a circuit with 12 V d.c supply and a 4 Ω 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 Ω 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 Ω at 20° C. The temperature coefficient of resistance of copper is 0.0043/°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;

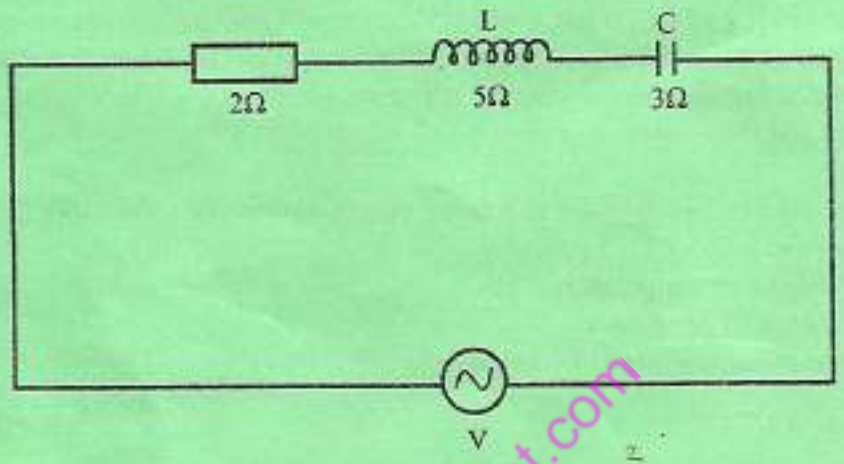

Fig. 2

(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

THIS IS THE LAST PRINTED PAGE.