1501/102
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1509/102
MECHANICAL SCIENCE I AND
ELECTRICAL PRINCIPLES
Oct./Nov. 2021
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

CRAFT CERTIFICATE IN MECHANICAL ENGINEERING (PRODUCTION OPTION)
CRAFT CERTIFICATE IN WELDING AND FABRICATION
CRAFT CERTIFICATE IN CONSTRUCTION PLANT ENGINEERING

MODULE I

MECHANICAL SCIENCE I AND ELECTRICAL PRINCIPLES

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet.
Drawing instruments;
Non-programmable scientific calculator.
*This paper consists of **EIGHT** questions in **TWO** sections; **A** and **B**.*
*Answer **FIVE** questions taking at least **TWO** questions from each section in the answer booklet provided.*
All questions carry equal marks.
Maximum marks for each part of a question are indicated.
Candidates should answer the questions in English.

Take: $g = 9.81 m/s^2$;
$\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$
$\mu_s = 4\pi \times 10^{-7}\ H/m$

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: MECHANICAL SCIENCE I

*Answer at least **TWO** questions from this section.*

1. (a) (i) State the law of parallelogram of forces.

(ii) Two coplanar forces are such that 16 N acts horizontally while 24 N acts at 60° to the 16 N force. Using the triangle of forces method and an appropriate scale, determine the magnitude and direction of the resultant force.

(7 marks)

(b) Define:

(i) angle of friction;
(ii) coefficient of friction.

(4 marks)

(c) An object of mass 4.32 kg is placed on a horizontal surface. It requires a force of 12 N applied parallel to the surface to keep it moving at a constant speed. Determine the:

(i) normal force;
(ii) dynamic coefficient of friction.

(5 marks)

(d) Explain the effect of each of the following on the dynamic coefficient of friction:

(i) lubricating the contact surface;
(ii) increasing the mass of the object.

(4 marks)

2. (a) (i) Define couple with respect to mechanics.
(ii) State **two** areas of application of couples in mechanics.

(4 marks)

(b) Explain the term constant acceleration. (2 marks)

(c) A body starts from rest and moves at a constant acceleration. Sketch the:

(i) displacement - time graph;
(ii) velocity-time graph.

(6 marks)

(d) The velocity of a body increases uniformly from 3 m/s to 67 m/s in 32 seconds. Determine the:

(i) acceleration;
(ii) velocity;
(iii) distance moved after 30 seconds.

(8 marks)

3. (a) State each of the following theorems of coplanar force systems:

(i) Lemi's theorem;
(ii) Varignon's theorem.

(4 marks)

(b) Differentiate between 'gravitational' and 'elastic' potential energy. (4 marks)

(c) An object of mass 2.5 kg at a height of 600 cm above the ground level is set to undergo free fall. Determine the:

(i) potential energy possessed by the object;
(ii) velocity of the object just before hitting the ground;
(iii) time it takes to reach the ground.

(9 marks)

(d) Figure 1 shows a spanner used to loosen a nut.

Fig. 1

(i) identify **two** factors upon which the applied moment depends on;
(ii) state the S.I unit for the moment.

(3 marks)

4 (a) Define work done as applied to mechanics, citing its S.I unit. (3 marks)

(b) Distinguish between 'dynamic' and 'limiting' friction. (4 marks)

(c) (i) Explain equilibrium of moments.

(ii) **Figure 2** shows a crane supported at both ends in a horizontal position. Determine the reactions of the supports when the beam is in equilibrium.

(7 marks)

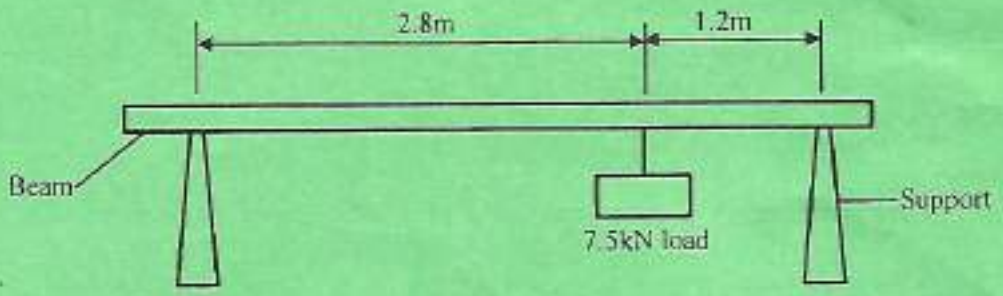

Fig. 2

(d) (i) State Bow's notation.

(ii) **Figure 3** shows forces in all the members of a frame. Draw its space diagram and corresponding vector diagram. (6 marks)

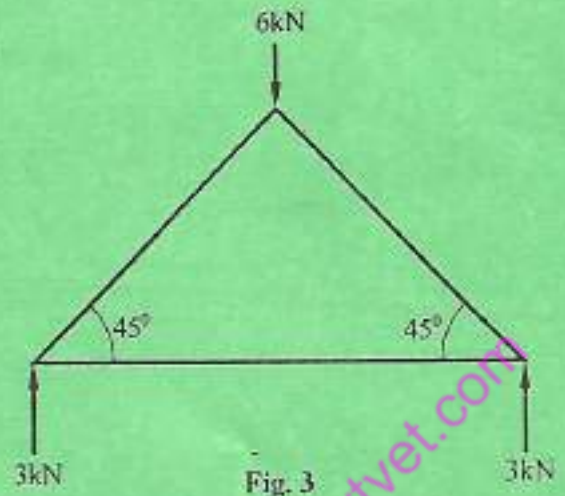

Fig. 3

SECTION B: ELECTRICAL PRINCIPLES

*Answer at least **TWO** questions from this section.*

5. (a) Table 1 shows electrical quantities, symbols and their SI units. Draw and complete the table. (8 marks)

Table 1

Quantity	SI units	Symbol
	Ohms	
		A
Voltage		
	Watts	

(b) **Figure 4** shows an electrical circuit.

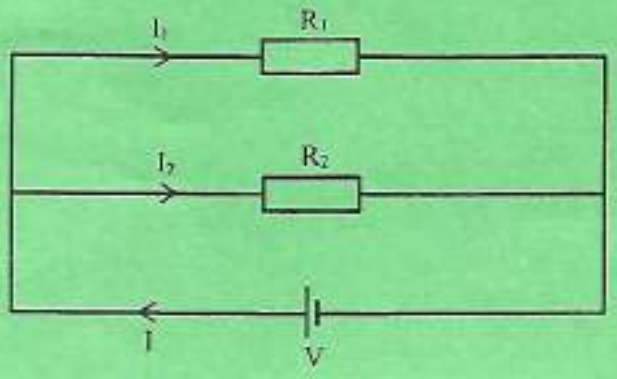

Fig. 4

Show that $I_1 = \left(\frac{R_2}{R_1 + R_2}\right)I$. (4 marks)

(c) **Figure 5** shows an electrical circuit.

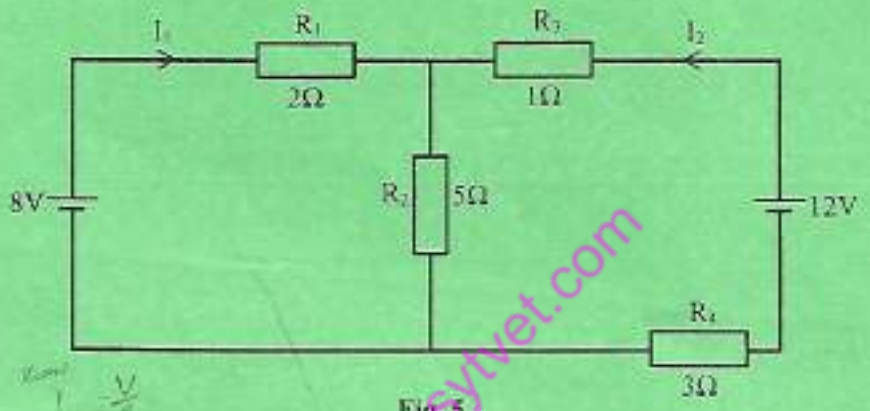

Fig. 5

Use Kirchhoff's laws to determine the currents I_1 and I_2. (8 marks)

6. (a) (i) Draw a labelled diagrams showing the atomic structure of a carbon atom.
(ii) Define the term doping as used in semi-conductor theorem.
(iii) Distinguish the terms forward bias and reverse bias with reference to semi-conductors.

(7 marks)

(b) A capacitor has 9 plates which measure (2 cm x 2.5 cm). The plates are separated by dielectric material of thickness 0.5 mm and relative permittivity of 3. If the capacitor is connected across 36 V d.c supply, determine the:

(i) capacitance of the capacitor;
(ii) charge stored by the capacitor;
(iii) energy stored by the capacitor.

(8 marks)

(c) Name:

(i) any **three** types of capacitors based on dielectric material;
(ii) **two** areas of application of capacitors.

(5 marks)

7. (a) Define the following terms as used in magnetism:

(i) magnetic flux;
(ii) magnetic flux density.

(4 marks)

(b) With the aid of a labelled diagram, describe the hysteresis loop. (8 marks)

(c) (i) Name **three** types of transformer losses.
(ii) A transformer is rated 240 V/12 V. Determine the:

(I) number of secondary turns if the primary turns are 200;
(II) primary current if secondary current is 5 A.

(8 marks)

8. (a) Define the following terms as used in a.c circuits:

(i) impedance;
(ii) power factor.

(4 marks)

(b) A 20 Ω resistor is connected in parallel with a 0.09 H inductor across a 240 V, 50 Hz a.c supply. Determine the:

(i) supply current;
(ii) power factor of the circuit.

(10 marks)

(c) With the aid of a circuit diagrams, explain the principle of operation of a d.c shunt motor. (6 marks)

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