

2501/102      2503/102      2509/102

2502/102      2508/102

**MECHANICAL SCIENCE, ELECTRICAL AND  
ELECTRONIC PRINCIPLES**

Oct./Nov. 2021

Time: 3 hours



**THE KENYA NATIONAL EXAMINATIONS COUNCIL**

**DIPLOMA IN MECHANICAL ENGINEERING  
(PRODUCTION OPTION)  
(PLANT OPTION)**

**DIPLOMA IN AUTOMOTIVE ENGINEERING  
DIPLOMA IN WELDING AND FABRICATION  
DIPLOMA IN CONSTRUCTION PLANT ENGINEERING**

**MODULE I**

**MECHANICAL SCIENCE, ELECTRICAL AND ELECTRONIC PRINCIPLES**

**3 hours**

**INSTRUCTIONS TO CANDIDATES**

*You should have the following for this examination:*

*drawing instruments;*

*scientific calculator/mathematical tables;*

*answer booklet.*

*This paper consists of **EIGHT** questions in **TWO** sections; **A** and **B**.*

*Answer **FIVE** questions taking at least **TWO** questions from each section.*

*All questions carry equal marks.*

*Maximum marks for each part of a question are indicated.*

*Candidates should answer the questions in English.*

*Take  $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$*

**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.**

## SECTION A: MECHANICAL SCIENCE

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

1. (a) State:
- (i) **three** forms of energy;
  - (ii) the law of conservation of energy. (5 marks)
- (b) Show that the kinetic energy of a body of mass  $M$ , that accelerates uniformly from rest to final velocity  $V$ , is given by  $KE = \frac{1}{2}MV^2$ . (6 marks)
- (c) A planing machine has a cutting stroke of 2 m and the stroke takes 4 seconds. If the constant resistance to the cutting tool is 900 N, calculate for each cutting stroke:
- (i) the power consumed;
  - (ii) the power input to the system if the efficiency is 75%. (9 marks)
2. (a) Define the following terms with reference to forces:
- (i) statics;
  - (ii) equilibrium. (2 marks)
- (b) **Figure 1** shows a system of coplanar forces. Determine their resultant force using resolution of forces method. (10 marks)

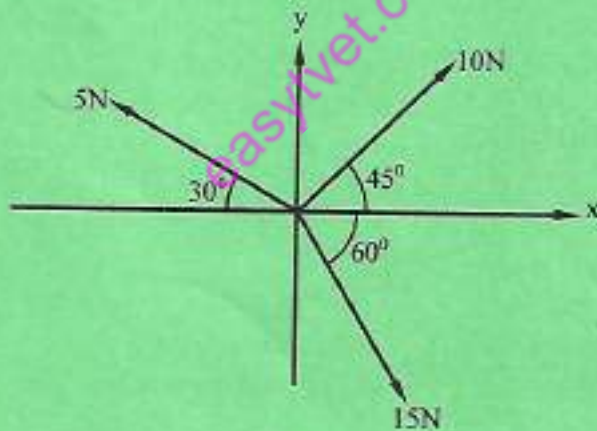


Fig. 1

- (c) A uniform horizontal bar is suspended on a fulcrum as shown in Figure 2. Determine the magnitude of:
- load  $W$  at equilibrium;
  - $R$  at the support.
- (8 marks)

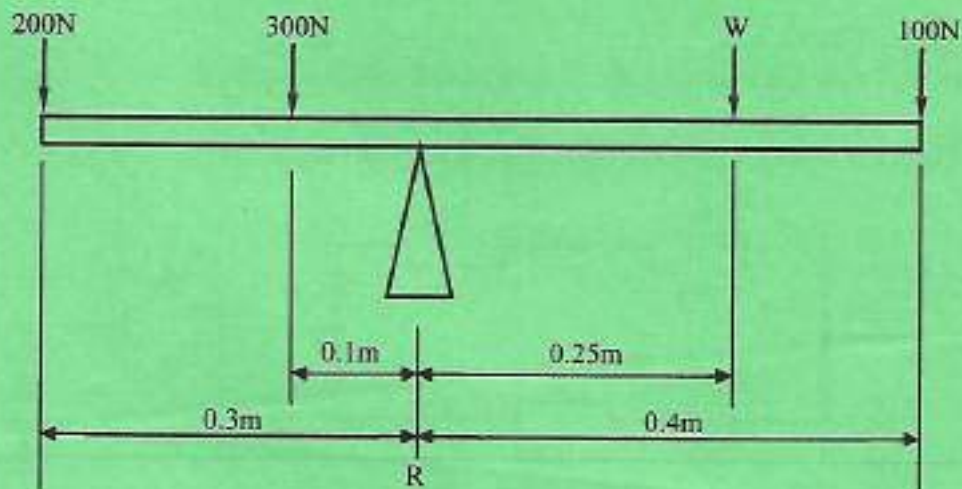


Fig. 2

3. (a) (i) Distinguish between isothermal and isobaric processes.  
 (ii) State Dalton's law of partial pressure. (4 marks)
- (b) With aid of a diagram, explain the operation of liquid in glass thermometer. (6 marks)
- (c) 100 g of water at  $70^{\circ}\text{C}$  is added to 200 g of cold water at  $10^{\circ}\text{C}$  and well stirred. If specific heat capacity of water is  $4200\text{ J/kgK}$  and neglecting heat absorbed by the container, determine the final temperature of the mixture. (10 marks)
4. (a) State three:
- laws of friction;
  - advantages of friction. (6 marks)
- (b) A lifting machine has a velocity ratio of 50. Tests were carried out on the machine and it was found that an effort of 180 N lifted a load of 2000 N while an effort of 300 N lifted a load of 5000 N.
- Derive the expression for law of the machine;
  - Given a load of 10,000 N, determine the:
    - effort,
    - mechanical advantage;
    - percentage efficiency.
  - Limiting efficiency of the machine. (14 marks)

## SECTION B: ELECTRICAL AND ELECTRONIC PRINCIPLES

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

5. (a) State:

- (i) Ohm's law;
- (ii) **two** applications of resistors in electronic circuits.

(4 marks)

(b) Figure 3 shows a parallel - series resistance circuit.

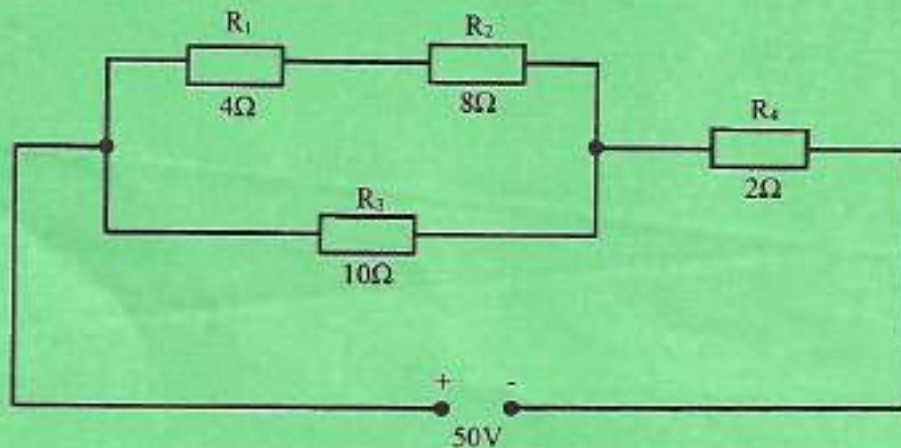


Fig. 3

Determine the:

- (i) total circuit resistance;
- (ii) potential difference across the 8Ω resistor;
- (iii) power dissipated by the 2Ω resistor.

(12 marks)

(c) A copper wire of length 600 mm has a cross-sectional area of 4 mm<sup>2</sup>. If the resistivity of copper is  $1.7 \times 10^{-8} \Omega \text{m}$ , determine the:

- (i) resistance;
- (ii) conductance.

(4 marks)

6. (a) State Faraday's laws of electromagnetic induction.

(4 marks)

(b) Define each of the following terms with reference to magnetic circuits:

- (i) magnetic flux density;
- (ii) permeability;
- (iii) magnetomotive force.

(3 marks)

- (c) (i) A coil of 400 turns is wound on a closed iron former with a mean magnetic length of 25 cm and a cross-sectional area of  $4 \text{ cm}^2$ . The relative permeability of the iron is 750, determine the self inductance of the coil.
- (ii) Two coils when connected in series aiding and series opposing have a total inductance of 0.8 H and 3.2 H respectively. If the self inductance of the second coil is 0.4 H, determine:
- I. mutual inductance between the coils;
  - II. self inductance of the first coil;
  - III. coupling coefficient between the coils.

(13 marks)

7. (a) Define the following terms as applied to semi-conductors:

- (i) donor atom;
- (ii) acceptor atom.

(2 marks)

(b) Draw the characteristic graph of bipolar junction transistor and hence explain how it performs the function of:

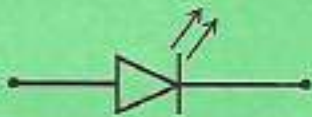
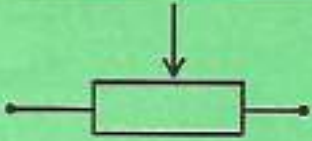

- (i) switching;
- (ii) amplification.

(9 marks)

(c) Table 1 shows symbols of different semi-conductor devices. Complete the table.

(6 marks)

Table 1

Symbol	Component name	Application
		
		
		

- (d) Draw a sinusoidal waveform and show the following:
- (i) cycle;
  - (ii) amplitude. (3 marks)
8. (a) With the aid of circuit diagrams, distinguish between series wound and shunt wound d.c motor. (4 marks)
- (b) Derive the equation for torque of a d.c motor. (9 marks)
- (c) A current of 250 mA flows in a circuit when the applied voltage is 100 V at a frequency of 50 Hz. If the power dissipated by the circuit is 25 W, determine the:
- (i) apparent power;
  - (ii) power factor;
  - (iii) reactive power. (7 marks)

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