2501/102 2508/102
2502/102 2509/102
2503/102
MECHANICAL SCIENCE AND ELECTRICAL
AND ELECTRONICS PRINCIPLES
Oct./Nov. 2022
Time: 3 hours

A

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 AND ELECTRICAL AND ELECTRONICS PRINCIPLES

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Drawing instruments;
Mathematical tables/non-programmable scientific calculator.
*This paper consists of **EIGHT** questions in **TWO** sections; **A** and **B**.*
*Answer **FIVE** questions taking **TWO** questions from section **A**, **TWO** questions from section **B** and **ONE** question from either section **A** or section **B**.*
All questions carry equal marks.
Maximum marks for each part of a question are shown.
Candidates should answer the questions in English.
Take: $g = 9.81\ m/s^2$
$\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$
$\mu_0 = 4\pi \times 10^{-7}\ H/m$

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.

SECTION A: MECHANICAL SCIENCE

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

1. (a) (i) State Newton's second law of motion;
(ii) List **two** non desirable effects of friction in machines;
(iii) With the aid of a sketch, explain the term angle of friction. (6 marks)

(b) A car starts from rest and accelerates uniformly for 10 seconds. It then proceeds at uniform velocity for the next 2 minutes, before retarding to rest in a further 20 seconds. The total distance travelled is 2.5 km.
(i) Sketch the velocity - time graph for the motion of the car;
(ii) Determine the:
I. acceleration and retardation;
II. distance travelled by the car in the final minute. (7 marks)

(c) A load of mass 250 kg rests on a plane which is inclined at 20° to the horizontal. A force of 1991N acting parallel to the plane pulls the load up the plane at uniform speed. Determine the coefficient of friction between the load and the surface. (7 marks)

2. (a) (i) Define the following terms and state their S.I units:
I. Heat;
II. Specific latent heat of vaporization.

(ii) State the following gas laws:
I. Boyle's law;
II. Charles's law. (6 marks)

(b) During a heat treatment process, a metal component of mass 40 kg was heated to 400° C and quenched by immersing it into 300 litres of oil of relative density 0.9. The specific heat capacity of the oil was 3.85 kJ/kg° C and the maximum temperature attained by the oil was 80° C. The initial oil temperature was 20° C and 10% of the heat from the metal is lost to the surroundings and the oil vessel. Determine the specific heat capacity of the metal.
(Take the density of water as 1000 kg/m^3) (7 marks)

(c) (i) With the aid of a labelled diagram, explain the principle operation of a simple barometer;
(ii) List **two** engineering appliance which operate under the effect of atmospheric pressure. (7 marks)

3. (a) (i) Define the term force and state its S.I units:
(i) Distinguish between scalar and vector quantities giving **one** example for each.
(ii) State the parallelogram law of forces. (7 marks)

(b) **Figure 1** shows a turbine casing of mass 120 kg, suspended from a mono-rail crane using two chains. Determine the tension in each chain. (6 marks)

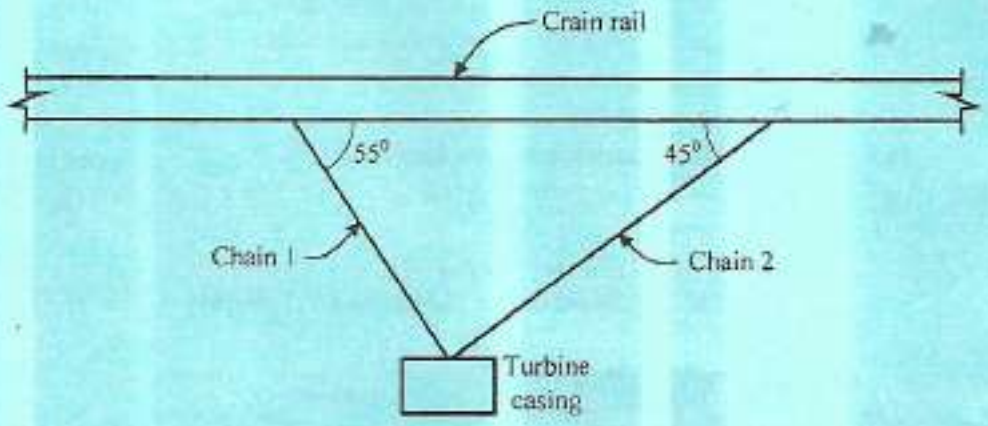

Fig. 1

(c) **Figure 2** shows a system of four coplanar forces acting at a pin of a mechanism. Determine the:
(i) magnitude of the resultant force;
(ii) inclination of resultant force to the horizontal. (7 marks)

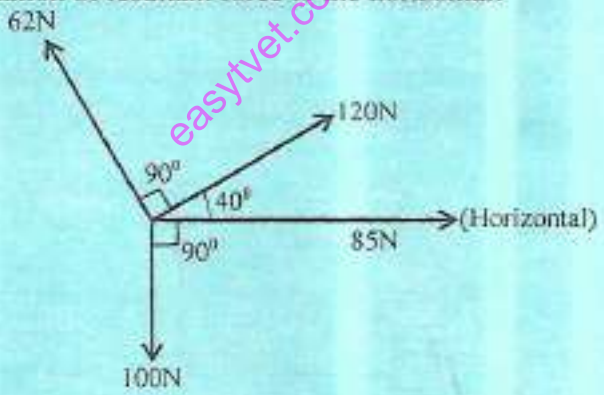

Fig. 2

4. (a) Distinguish between energy and power and state their S.I units. (4 marks)

(b) A forklift raises a load of mass 1.8 tonnes vertically upwards through a distance of 2.4 m in 12 seconds. If the efficiency of the forklift is 88%, determine the:
(i) work done by the forklift;
(ii) power dissipated;
(iii) total energy expended while raising the load. (6 marks)

(c) Table 1 shows the results obtained from a test on a screw jack whose velocity ratio is 4.

Table 1

Load W(N)	1.10	1.80	2.20	2.50	2.90	3.10
Effort E (N)	0.31	0.38	0.42	0.45	0.49	0.51

Draw the effort-load graph for the machine and hence determine the:

(i) law of the machine;
(ii) efficiency of the machine at a load of 0.8 N. (10 marks)

SECTION B: ELECTRICAL AND ELECTRONICS PRINCIPLES

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

5. (a) State each of the following laws as used in electric circuits:

(i) Ohm's law;
(ii) Kirchoff's voltage law. (4 marks)

(b) With the aid of a labelled circuit diagram, explain how a Wheatstone bridge can be used to determine the value of an unknown resistor. (10 marks)

(c) **Figure 3** shows an electric circuit. If the power dissipated by R_1 is 81W, determine the value of the unknown Resistor, R_4. (6 marks)

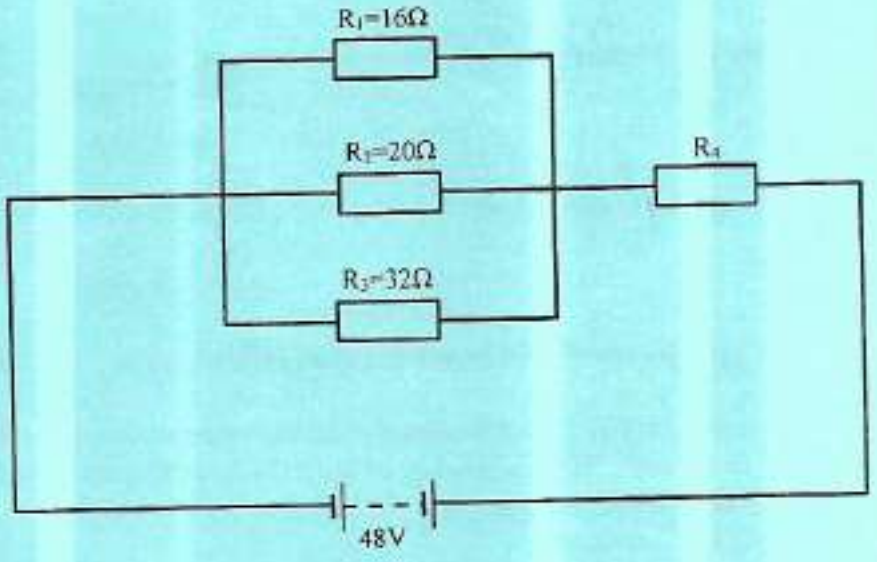

Fig. 3

6. (a) State **three** effects of increasing the shunt capacitor filter size in a smoothing circuit. (3 marks)

(b) With the aid of labelled circuit diagram, describe the operation of a half-wave voltage doubler. (8 marks)

(c) List **three** advantages of a bridge rectifier over a 2-diode full-wave rectifier. (3 marks)

(d) With the aid of a schematic symbol, describe the construction and operation of a photo transistor. (6 marks)

7. (a) Define the following terms as applied to magnetic circuits and state their S.I units:

(i) magneto motive force;
(ii) relative permeability. (4 marks)

(b) Describe each of the following parts of a d.c. machine:

(i) Field system;
(ii) Armature;
(iii) commutator. (6 marks)

(c) An alternating voltage $V = 339 \sin 314t$ is applied across a coil of resistance 32 Ω and inductance of 100 mH. Determine the:

(i) circuit impedance;
(ii) current flowing through the coil;
(iii) power consumed by the coil;
(iv) circuit power factor. (10 marks)

8. (a) Describe the formation of each of the following semiconductors:

(i) N-type extrinsic semiconductor;
(ii) P-type extrinsic semiconductor. (6 marks)

(b) With the aid of a circuit diagram, explain the effects of a reverse biased P-N junction. (4 marks)

(c) (i) Explain the operation a photoconductive cell.
(ii) Draw the circuit symbol for the device in (i). (5 marks)

(d) **Figure 4** shows an electric circuit with Zener diode used as a voltage regulator.

If V_{in} is varied from 20 V to 30 V, determine the:

(i) minimum current in the Zener diode.

(ii) maximum current in the Zener diode. (5 marks)

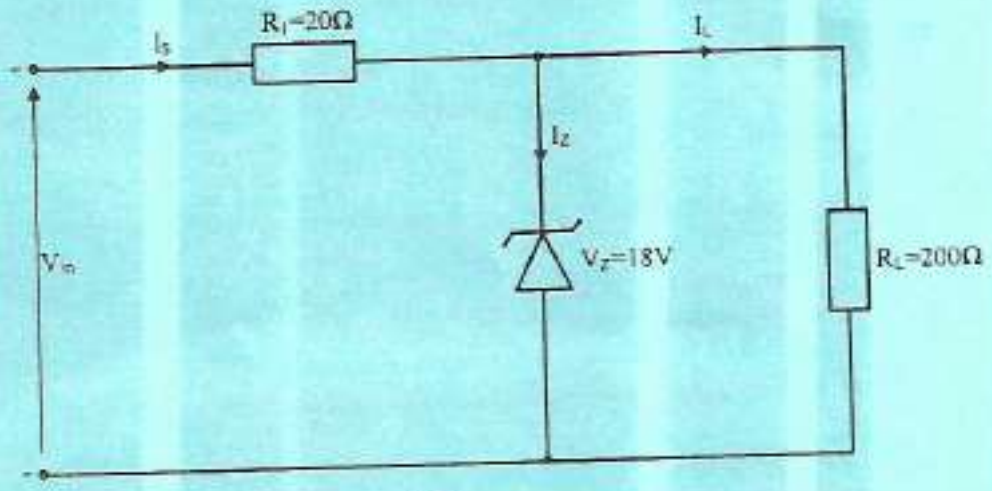

Fig. 4

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