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MECHANICAL SCIENCE I AND
ELECTRICAL PRINCIPLES
June/July 2023
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;
Mathematical tables;
Non-programmable scientific calculator;
Drawing instruments.
*This paper consists of **EIGHT** questions in two sections **A** and **B**.*
*Answer **FIVE** questions by choosing at least **TWO** question in 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: $g = 9.81\ m/s^2$;
$\epsilon_o = 8.85 \times 10^{-12}\ F/M$;
$\mu_o = 4\pi \times 10^{-7}\ H/M$

This paper consists of 8 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 B: MECHANICAL SCIENCE I

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

1. (a) Define the following terms as applied to motion of bodies and state their S.I units:

(i) displacement;

(ii) acceleration.

(4 marks)

(b) An engine flywheel of 400 mm diameter accelerates from rest to a speed of 1800 rev/min in 20 seconds.

Determine the:

(i) angular acceleration;

(ii) number of revolutions made during the acceleration period;

(iii) linear acceleration of a point on the flywheel rim.

(10 marks)

(c) A body starts from rest and accelerates uniformly for 30 seconds. It then retards uniformly back to rest in the subsequent 20 seconds. The total distance moved by the body is 100 metres.

Sketch the velocity-time graph for the motion and hence determine the acceleration and retardation.

(6 marks)

2. (a) (i) State the:

(I) polygon law of forces;

(II) principle of moments.

(ii) Explain the term couple as applied to mechanics.

(6 marks)

(b) **Figure 1** shows a loaded beam. Determine the reaction at each support. (4 marks)

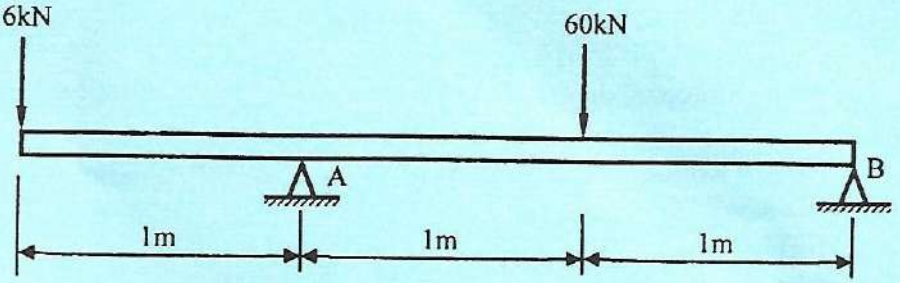

Fig. 1

(c) **Figure 2** shows three forces acting at a static joint of a framework. Determine the magnitudes of forces P and Q. (10 marks)

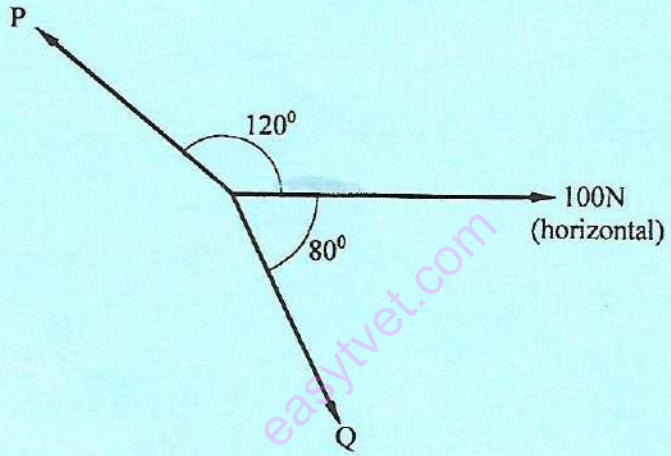

Fig. 2

3. (a) Define the following terms and state their S.I units:

(i) work;

(ii) power;

(iii) energy.

(6 marks)

(b) A monolith crane raises a load of mass two tonnes of concrete vertically upward to a height of 60 metres in two minutes. The efficiency of the crane is 88%.

Determine the:

(i) force raising the load;

(ii) work done by the crane;

(iii) power developed;

(iv) energy consumed by the crane.

(8 marks)

(c) A van of mass 1.5 tonne accelerates from a speed of 36 km/h to 102 km/h. Determine the gain in kinetic energy. (6 marks)

4. (a) (i) With the aid of a sketch, explain the term angle of friction.

(ii) List **three** non-desirable effects of friction in machines.

(6 marks)

(b) A body of mass 100 kg rests on a horizontal surface. A horizontal force of 588.6 N is required to pull the body on the plane at uniform speed.

Determine the:

(i) coefficient of friction between the body and the plane;

(ii) total reaction;

(iii) angle of friction.

(12 marks)

(c) State **two** methods of reducing friction in machines. (2 marks)

SECTION B: ELECTRICAL PRINCIPLES

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

5. (a) Explain each of the following as applied to conductor materials:

(i) temperature coefficient of resistance;

(ii) resistivity.

(4 marks)

(b) **Table 1** shows electrical quantities and their SI units.

Table 1

Electrical quantity	**SI unit**
Voltage	
	Ampere (A)
Resistance	
	Watts (W)
Electrical energy	

Copy and complete the table. (5 marks)

(c) **Figure 3** shows an electrical circuit.

Determine the:

(i) supply current;

(ii) current through the 6 Ω resistor;

(iii) power dissipated by the 18 Ω resistor.

(8 marks)

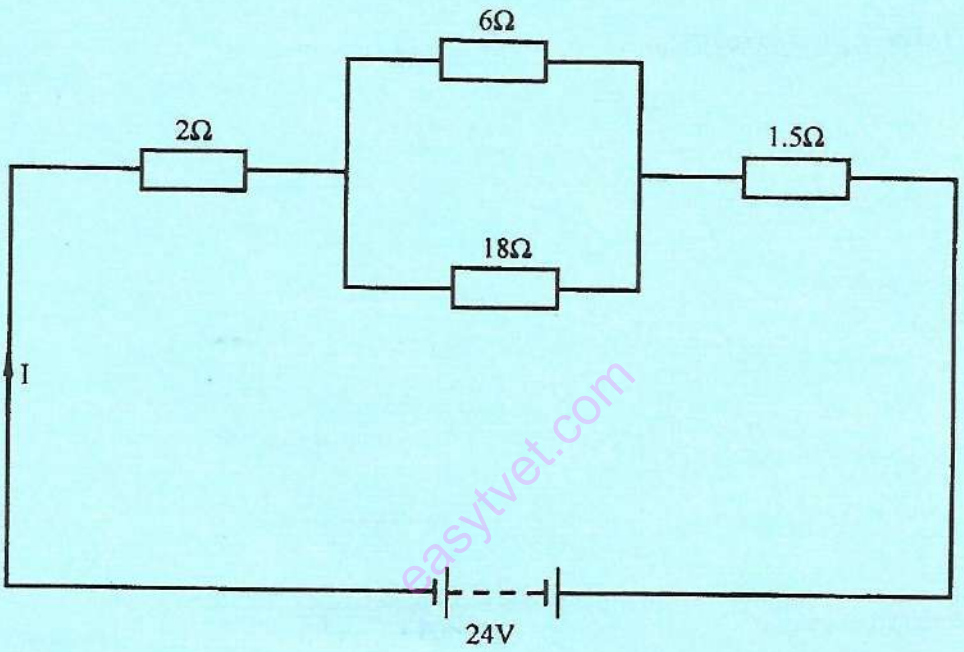

Fig. 3

(d) Determine the resistance of 1600 m of a copper cable having diameter of 10 m, given that the resistivity of copper is 1.7×10^{-8} Ω m. (3 marks)

6. (a) State any **three** applications of the magnetic effect of electric current. (3 marks)

(b) List **three** properties of magnetic lines of force. (3 marks)

(c) Describe the construction of each of the following capacitors:-

(i) aluminium electrolytic capacitor;

(ii) paper capacitors.

(6 marks)

(d) **Figure 4** shows a magnetic circuit of uniform cross-sectional area 2.5 cm^2. The core is made of cast steel and has a mean length of 30 cm. The air gap is 1 mm wide and the coil has 5600 turns.

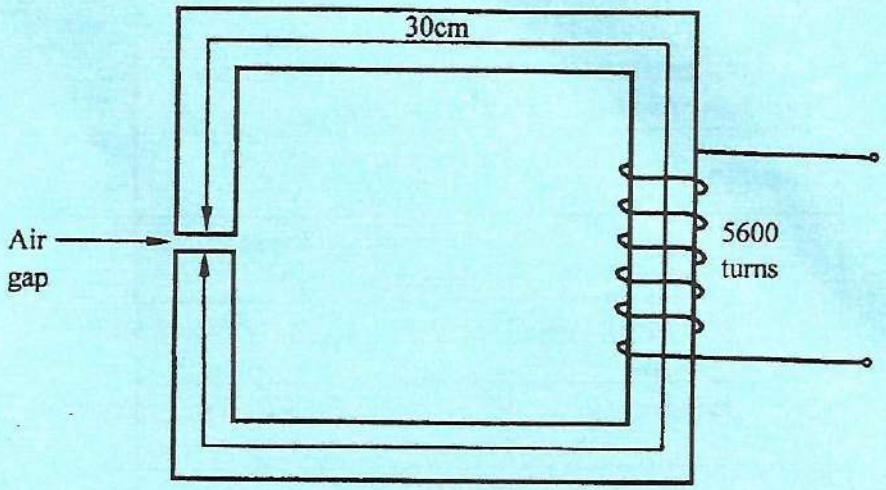

Fig. 4

If a current in the coil is to produce a flux density of 0.80 T in the air gap, assuming that all the flux passes through both parts of the magnetic circuit, determine the:

(i) reluctance of the core

(ii) reluctance of the air gap

(iii) current to flow in the coil

Take magnetic field strength that corresponds to a flux density of B = 0.80 T for cast steel to be H = 750 A/M. (8 marks)

7. (a) Distinguish between intrinsic and extrinsic semiconductors. (4 marks)

(b) **Table 2** shows the comparison between Bipolar junction transistor and field effect transistor.

Table 2

Bipolar Junction Transistor (BJT)	**Field Effect Transistor (FET)**
	It is a unipolar device
	It is a voltage driven device
Low input impedance	
Low noise level	
	Better thermal stability

Copy and complete the table. (5 marks)

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

(d) List **three** applications of a photo-conductive cell. (3 marks)

8. (a) Derive the e.m.f equation of a direct current (d.c) generator. (7 marks)

(b) A 30 kVA transformer has 600 turns on the primary winding and 45 turns on the secondary winding. If the primary is connected to 3000 V, 50 Hz supply. Determine the:

(i) full-load primary and secondary currents;

(ii) secondary voltage;

(iii) maximum core flux. (7 marks)

(c) A 240 V, 50 Hz supply is connected to a circuit containing 25 Ω resistor and 45 μF capacitor connected in series. Determine the:

(i) circuit impedance;

(ii) supply current;

(iii) circuit power factor. (6 marks)

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