

Name _____ Index No. _____ / _____

2501/102

Candidate's Signature _____

2503/102

MECHANICAL SCIENCE, ELECTRICAL AND
ELECTRONIC PRINCIPLES

Date _____

Oct/Nov 2012

Time: 3 hours



THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN MECHANICAL ENGINEERING (PRODUCTION OPTION)

DIPLOMA IN AUTOMOTIVE ENGINEERING

MECHANICAL SCIENCE, ELECTRICAL AND ELECTRONICS PRINCIPLES

3 hours

INSTRUCTIONS TO CANDIDATES

Write your name and index number in the spaces provided above.

Sign and write the date of the examination in the spaces provided above.

You should have drawing instruments and scientific calculator/mathematical tables for this examination.

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

Answer any **THREE** questions from section **A** and any **TWO** questions from section **B** in the spaces provided in this question paper.

All questions carry equal marks.

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

Take:

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

$$g = 9.81 \text{ m/s}^2$$

For Examiner's Use Only

SECTION A

Questions	1	2	3	4	TOTAL
Marks					

SECTION B

Questions	5	6	7	8	TOTAL
Marks					

GRAND
TOTAL

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This paper consists of 16 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 any **THREE** questions from this section in the spaces provided in this question paper.

1. (a) Define each of the following terms with respect to forces and moments:
- (i) vector quantity;
 - (ii) couple. (2 marks)
- (b) State the triangle law of forces. (2 marks)
- (c) With the aid of diagrams, explain stable, unstable and neutral equilibrium with respect to the centre of gravity. (6 marks)
- (d) A vehicle has a total mass of 1.8 tonnes and a wheelbase of 4 m. The centre of gravity is 0.85 m above road level. When at rest the load on the front axle is 960 kg. If the coefficient of friction between the tyres and the road is 0.75, determine the normal road reaction on the front wheels when:
- (i) all four wheels are fully braked;
 - (ii) the front wheels only are fully braked;
 - (iii) the rear wheels only are fully braked. (10 marks)
2. (a) Define each of the following terms:
- (i) friction;
 - (ii) velocity ratio. (2 marks)
- (b) Explain four advantages of friction in engineering. (8 marks)
- (c) Write the equation for efficiency. (3 marks)
- (d) 12 kg block of metal was placed on an inclined plane and the angle of inclination of the plane gradually increased until the block slid steadily down the plane. If the angle of inclination at this point was 17.5° , determine:
- (i) coefficient of friction between the block and the plane;
 - (ii) minimum horizontal force required to move the block when the plane is horizontal;
 - (iii) minimum force parallel to the plane required to pull the block steadily up the plane when the plane is inclined at 35° to the horizontal;
 - (iv) force required to move the block up the plane at uniform speed. (7 marks)

3. (a) Define each of the following terms:
- (i) velocity;
 - (ii) acceleration. (2 marks)
- (b) Show that displacement, $S = ut + \frac{1}{2}at^2$. (3 marks)
- (c) With the aid of diagrams, derive the centripetal acceleration equation. (8 marks)
- (d) A wheel initially at rest is subject to a constant angular acceleration of 4.8 rad/s^2 for 80 seconds. It is then immediately retarded until it comes to rest 110 seconds later.
- Determine:
- (i) maximum angular velocity attained;
 - (ii) angular retardation;
 - (iii) total number of revolutions made by the wheel. (7 marks)
4. (a) Define each of the following terms:
- (i) pressure;
 - (ii) latent heat of fusion;
 - (iii) density. (3 marks)
- (b) (i) State the Archimedes' principle.
- (ii) With the aid of a diagram, derive the relationship between pressure and volume at constant temperature. (6 marks)
- (c) With the aid of a diagram, explain the operation of a hydraulic brake. (7 marks)
- (d) A storage tank is 4 m square and contains water to a depth of 3.5 m. If the base of the tank is horizontal and the density of water is 1000 kg/m^3 , determine:
- (i) pressure of the water on the base;
 - (ii) total force on the base;
 - (iii) total force on a side. (4 marks)

SECTION B: ELECTRICAL AND ELECTRONICS PRINCIPLES

Answer any **TWO** questions from this section in the spaces provided in this question paper.

5. (a) Define each of the following terms and in each case state the unit of measure:
- (i) resistance; (2 marks)
 - (ii) conductivity. (3 marks)
- (b) State **three** effects of electric current. (6 marks)
- (c) With the aid of a diagram, explain how a potentiometer is used to determine the magnitude of voltage of a source of unknown value. (9 marks)
- (d) The arms of a wheatstone bridge have the following resistance: AB, 10Ω ; BC, 20Ω ; CD, 30Ω ; and DA 10Ω . A 40Ω galvanometer is connected between B and D and a 2 v cell of negligible internal resistance is connected across A and C, with its positive end connected to A. Determine the current through the galvanometer and state its direction. (9 marks)
6. (a) Define each of the following terms:
- (i) reluctance; (2 marks)
 - (ii) magnetic field strength. (2 marks)
- (b) State Fleming's Right Hand Rule. (6 marks)
- (c) With the aid of a labelled diagram, explain how emf is induced in a coil by passing current in an adjacent coil. (10 marks)
- (d) The voltage drops across four series connected resistors are;
- $$V_1 = 100 \sin 377t$$
- $$V_2 = 125 \cos (377t + \frac{\pi}{3})$$
- $$V_3 = 150 \sin (377t - \frac{\pi}{4})$$
- $$V_4 = 120 \cos 377t$$
- Determine analytically:
- (i) resultant emf and its phase angle in the same form;
 - (ii) supply voltage frequency;
 - (iii) R.M.S. value of the supply voltage. (10 marks)

7. (a) State two disadvantages of Leclanché cell. (2 marks)
- (b) Differentiate between ampere-hour efficiency and watt hours efficiency of a cell. (3 marks)
- (c) Explain the following charging methods:
- (i) trickle;
- (ii) floating system. (4 marks)
- (d) (i) Derive the torque equation of a d.c. motor.
- (ii) A 50 kw, 500 v, d.c shunt generator has armature and field resistances of 0.03Ω and 250Ω respectively. With the aid of circuit diagrams, determine the total armature power developed when working as a;
- generator;
- motor. (11 marks)
8. (a) Define each of the following terms:
- (i) doping;
- (ii) depletion layer. (2 marks)
- (b) With the aid of characteristic curves, explain the forward bias of silicon and germanium diodes. (6 marks)
- (c) With the aid of a circuit diagram, explain the π filter as used in smoothing circuits. (7 marks)
- (d) With the aid of a circuit diagram, describe the NPN common collector configuration. (5 marks)