

2506/103

2507/103

ENGINEERING MATHEMATICS I AND
ENGINEERING SCIENCE I

June/July 2018

Time: 3 hours



THE KENYA NATIONAL EXAMINATIONS COUNCIL
DIPLOMA IN AERONAUTICAL ENGINEERING
(AIRFRAMES AND ENGINES OPTION)
(AVIONICS OPTION)

MODULE I

ENGINEERING MATHEMATICS I AND ENGINEERING SCIENCE I

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 **THREE** questions from section **A** and **TWO** questions from section **B**.*

All questions carry equal marks.

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

Candidates should answer the questions in English.

This paper consists of 5 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: ENGINEERING MATHEMATICS I (60 marks)

Answer **THREE** questions from this section.

1. (a) A d.c. circuit in an aeroplane has currents i_1, i_2 and i_3 related by the system of equations:

$$i_1 + i_2 + i_3 = 6$$

$$2i_1 - i_2 + 3i_3 = 9$$

$$i_1 + 2i_2 - 3i_3 = -4$$

Use elimination method to determine the values of the currents. (10 marks)

- (b) Given that $z_1 = 6 + 2j$ and $z_2 = 4 - 7j$ evaluate $\frac{z_1}{z_2}$, expressing the answer in the form $a + bj$. (3 marks)

- (c) Obtain the cube roots of the complex number, $z = \sqrt{3} + \sqrt{5}j$. (7 marks)

2. (a) Prove the identity:

$$\frac{(\cos \theta - \sin \theta)^2}{\sin \theta} = \operatorname{cosec} \theta - 2 \cos \theta. \quad (4 \text{ marks})$$

- (b) Solve the equation:

$$\sin 2x + \sin x = 0$$

for values of x between $x = 0^\circ$ to $x = 360^\circ$. (6 marks)

- (c) Solve the equation:

$$2 \sinh x + \cosh x = 1. \quad (6 \text{ marks})$$

- (d) A minor segment is bounded by a chord of length 6.4 cm and a circle of diameter 21.8 cm. Calculate the length of the arc forming the segment. (4 marks)

3. (a) Show that $f(x) = \frac{3x+2}{5x-3}$ is a self inverse function. (6 marks)

- (b) Determine the number of five letter words that can be formed from the word ELECTROMECHANICAL. (5 marks)

- (c) Determine the cartesian equation of the ellipse given by the polar equation:

$$5 \sin^2 \theta + 4 = \frac{36}{r^2}. \quad (5 \text{ marks})$$

- (d) Solve the equation:

$$5(2^x) = 3^{x-8}. \quad (4 \text{ marks})$$

4. (a) Differentiate $y = x^3$ from the first principles. (4 marks)
- (b) The displacement x in metres of a body at time t in seconds is given by:
- $$x = t^3 + t^2 + t + 1.$$
- Determine the:
- (i) velocity;
- (ii) acceleration;
- after 5 seconds. (6 marks)
- (c) A cuboid has dimensions $x = 20$ cm, $y = 15$ cm and $z = 10$ cm. If the values of x , y and z are measured with errors of $+0.1$ cm, -0.2 cm and $+0.15$ cm respectively, determine the error made in calculating its volume. (5 marks)

- (d) A cube of side 0.3 m was melted and then moulded into a hemisphere. If 10% of the volume was wasted in the process, determine the radius of the hemisphere. (5 marks)

5. (a) Evaluate the integrals:

(i)
$$\int \frac{x^2 + x - 1}{(x - 2)(x^2 + 1)} dx;$$

(ii)
$$\int_0^{\frac{\pi}{4}} e^{-\frac{1}{2}x} \cos 2x dx.$$
 (9 marks)

- (b) Use integration to find the mean value of $y = \sin x$ between $x = 0$ and $x = \frac{\pi}{2}$. (4 marks)

- (c) Determine the area bounded by the curve $y = 6x - x^2 - 8$ and the x axis. (7 marks)

SECTION B: ENGINEERING SCIENCE I (40 marks)

Answer TWO questions from this section.

6. (a) Define the terms:
- (i) velocity;
 - (ii) linear acceleration. (2 marks)
- (b) A military jet moves vertically upward with an acceleration of $5g$. Determine the reaction force acting on the pilot if he weighs 65 kg.
- (Take $g = 10 \text{ m/s}^2$). (5 marks)
- (c) A driving gear wheel having 23 teeth engages with a second wheel with 92 teeth. A third wheel with 30 teeth on the same shaft as the second engages with a fourth wheel having 60 teeth.
- Determine the:
- (i) velocity ratio;
 - (ii) mechanical advantage of the gear system if efficiency is 85%. (8 marks)
- (d) An automobile of mass 2000 kg travels at a speed of 90 km/h . Determine the:
- (i) kinetic energy of the automobile;
 - (ii) work done on it by friction to reduce its speed to 30 km/h . (5 marks)
7. (a) A quantity of a gas in a chamber has an initial pressure of 140 kN/m^2 and volume 0.14 m^3 . It is compressed isothermally to a pressure of 520 kN/m^2 . Determine the final volume of the gas. (4 marks)
- (b) Determine the values of p, q, r and s in the combustion of ethane given by:
- $$p\text{C}_2\text{H}_6 + q\text{O}_2 = r\text{CO}_2 + s\text{H}_2\text{O}. \quad (5 \text{ marks})$$
- (c) Outline **four** advantages of mercury over alcohol as a thermometric liquid. (4 marks)

- (d) An aeronautical engineer is working on a new engine design. One of the moving parts contain 3.0 kg of aluminium and 0.8 kg of iron. If the engine operates at 180°C , determine the amount of heat needed to raise its temperature from 25°C to 180°C .

(Take specific heat capacities of aluminium and iron as 920 J/kgK and 460 J/kgK respectively). (7 marks)

8. (a) A jet produces sound of intensity level of 100 decibels. Determine the intensity in W/m^2 .

(Take the threshold intensity for hearing of the human ear as 10^{-12} W/m^2 . (6 marks)

- (b) A 60 kg block resting on a level ground is pulled using a chain as shown in figure 1. Determine the tension in the chain needed to set the block in motion.

(Take the coefficient of friction as 0.7). (5 marks)

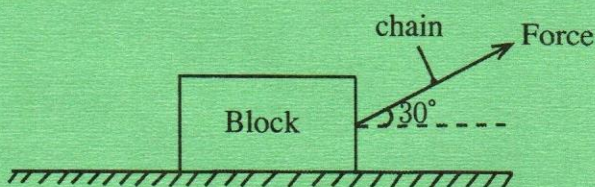


Fig. 1

- (c) (i) Outline two types of electromagnetic waves.
- (ii) A radar uses microwaves of frequency $10 \times 10^9\text{ Hz}$. Calculate the wavelength associated with the microwave as it moves through space. (5 marks)
- (d) The drain plug on a car's engine is required to be tightened to a torque of 30 Nm. If a wrench of length 0.15 m is used when changing the oil, calculate the minimum force needed. (4 marks)

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