

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:
- $$\begin{aligned}i_1 + i_2 + i_3 &= 6 \\2i_1 - i_2 + 3i_3 &= 9 \\i_1 + 2i_2 - 3i_3 &= -4\end{aligned}$$
- 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  $5g$   $m/s$ . Determine the reaction force acting on the pilot if he weighs 65 kg.
- (Take  $g = 10 m/s^2$ ). (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  $140 kN/m^3$  and volume  $0.14 m^3$ . It is compressed isothermally to a pressure of  $520 kN/m^3$ . 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:
- $$pC_2H_6 + qO_2 = rCO_2 + sH_2O. \quad (5 \text{ marks})$$
- (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  $180^{\circ}\text{C}$ , determine the amount of heat needed to raise its temperature from  $25^{\circ}\text{C}$  to  $180^{\circ}\text{C}$ .

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

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

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

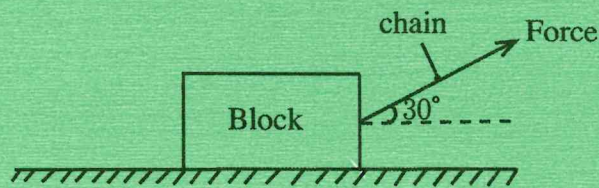


Fig. 1

- (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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