

2506/103

2507/103

ENGINEERING MATHEMATICS I AND

ENGINEERING SCIENCE I

Oct./Nov. 2019

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:

Drawing instruments;

Non programmable scientific calculator/Mathematical table;

Answer booklet.

This paper consists of EIGHT questions in TWO sections; A and B.

Answer THREE questions from Section A and TWO questions from Section B.

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

Answer any **THREE** questions from this section.

1. (a) Solve the equation:

$$(5^x)^2 - 6(5^x) + 5 = 0$$

(6 marks)

- (b) Solve the equations:

(i) $\sin(3x + 120^\circ) + \sin(x + 40^\circ) = 0$

(ii) $\sin x + \cos x = 1$

For: $0 \leq x \leq 360^\circ$.

(10 marks)

- (c) A committee of four is to be formed from eight men and six women. Determine the number of ways in which this can be done such that there are at most two women in the committee.

(4 marks)

2. (a) (i) Use the binomial theorem to expand $\frac{1}{1+2x}$ upto the fourth term.

- (ii) Use the result in (i) to determine the value of $\frac{1}{1.2}$ correct to two decimal places.

(7 marks)

- (b) (i) Given that $f(x) = \sqrt{\frac{x}{1+x}}$, determine $f^{-1}(x)$.

- (ii) Given the function $f(x) = \sin x \cos x$, show that $f^{-1}(x) = \frac{1}{2} \sin^{-1}(2x)$.

(10 marks)

- (c) Determine the area of the triangle whose sides are 13 cm, 20 cm and 21 cm.

(3 marks)

3. (a) Express the cartesian equation:

$$\frac{x^2}{4} + y^2 = 1 \text{ in polar form.}$$

(5 marks)

- (b) The frustrum of a solid cone has a height of 4 cm. If the top and bottom radii are $3\frac{1}{2}$ cm and 5 cm respectively, determine the:

- (i) volume;
(ii) total surface area of the frustrum.

(10 marks)

- (c) Use Simpson's rule with seven ordinates to approximate the area under the graph of $y = x^3 + x^2 + x + 1$ between $x = 0$ and $x = 3$. (5 marks)
4. (a) Given the complex numbers $Z_1 = 5 - 2j$, $Z_2 = 3 + 4j$ and $Z_3 = 1 + j$, evaluate:
- (i) $Z_3(Z_1 + Z_2)$;
- (ii) $\frac{Z_3(Z_1 + Z_2)}{Z_1 + Z_2 + Z_3}$. (8 marks)
- (b) Given the function $Z = e^{xy}$ find:
- (i) $\frac{\partial Z}{\partial x}$;
- (ii) $\frac{\partial Z}{\partial y}$. (4 marks)
- (c) Locate the stationary points of the function:
- $$f(x) = x^3 - 6x^2 - 15x + 1.$$
- (8 marks)
5. (a) Determine the roots of the equation $Z^3 + 3 - 4j = 0$ giving the answer in the form $a + jb$. (10 marks)
- (b) Evaluate the integral:
- $$\int \frac{x}{3x+1} dx.$$
- (4 marks)
- (c) Determine the volume of the solid of revolution generated when the function $y = x + 1$ is revolved through 360° about the x-axis. (6 marks)

SECTION B: ENGINEERING SCIENCE I

Answer any *TWO* questions from this section.

6. (a) Hot gas from a combustion chamber enters a heat exchanger at 310°C and leaves at 25°C . 75 kg of the gas passes through the exchanger per minute. If the average specific heat capacity of the gas is 1200 J/kg K , determine the heat transferred per hour. (5 marks)
- (b) Air is compressed in a diesel engine cylinder. The initial pressure and temperature are 120 kN/m^2 and 27°C respectively and the final pressure is 8 MN/m^2 . In order to ignite the atomised fuel injected at the end of the compression, the temperature needed is 977°C . Calculate the compression ratio needed for this to be possible. (6 marks)
- (c) Define each of the following processes:
- (i) isothermal;
 - (ii) isobaric;
 - (iii) isovolumetric.
- (3 marks)
- (d) A car of mass 1200 kg is uniformly accelerated from rest for a distance of 100 m along a level road. If the final velocity is 20 m/s , determine the:
- (i) uniform acceleration;
 - (ii) time taken to cover the 100 m ;
 - (iii) average power of the engine during the acceleration.
- (6 marks)
7. (a) With reference to harmonic motion, define each of the following terms:
- (i) amplitude;
 - (ii) frequency;
- (2 marks)
- (b) Two forces of magnitude 200 N and 100 N act at a point. If the angle between them is 60° , determine the magnitude of the resultant force. (6 marks)
- (c) A metal sphere 100 mm in diameter is fully immersed in oil of relative density 0.7 , and its apparent weight is 39.2 N . Determine the density of the metal. (Take $g = 9.8\text{ N/kg}$). (7 marks)

- (d) (i) The frequency of a simple harmonic oscillator is doubled from 25 Hz to 50 Hz. Determine the change in the periodic time.
- (ii) A transverse wave has a wavelength of 0.65 m and a frequency of 40 Hz. Calculate the speed of the wave. (5 marks)
8. (a) Explain how litmus paper is used to test a solution for acidity, basicity and neutrality. (4 marks)
- (b) Write a balanced chemical equation for the reaction between potassium hydroxide and sulphuric acid. (2 marks)
- (c) (i) Differentiate between the empirical and molecular formulae of a compound.
- (ii) A compound has the empirical formula CH_2 and a molecular mass 42. Determine its molecular formula. (Take atomic masses as $\text{C} = 12, \text{H} = 1$) (6 marks)
- (d) A lifting machine has a velocity ratio of 40. An effort of 120 N is required to raise a load of 1000 N and an effort of 240 N is required for a load of 4000 N. Determine the:
- (i) law of the machine;
- (ii) the limiting efficiency. (8 marks)

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