

2506/103

2507/103

ENGINEERING MATHEMATICS I

AND ENGINEERING SCIENCE I

June/July 2020

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 any THREE questions from section A and any 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 6 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

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

1. (a) An aviation company has three engineers, eight technologists and thirty technicians. A team consisting of one engineer, two technologists and six technicians is to be selected to undertake a certain duty. Determine the number of ways that the team can be formed. (3 marks)

- (b) (i) Use the binomial theorem to expand

$$\frac{1}{(1-x)(1+2x)} \text{ up to the term in } x^2.$$

- (ii) Hence by taking $x = 0.1$ evaluate

$$\frac{1}{1.08}$$

(6 marks)

- (c) A mechanical system in equilibrium is subject to three forces F_1 , F_2 and F_3 in newtons, satisfying the equations:

$$F_1 + F_3 = 3$$

$$4F_1 - 2F_2 + F_3 = 10$$

$$F_1 - 2F_2 + 2F_3 = 0$$

Solve the equations by elimination method.

(11 marks)

2. (a) (i) Evaluate;

$$\frac{2\log_a 125 + \log_a 625}{8\log_a 5 - 2\log_a 25}$$

- (ii) Solve the equation;

$$3^{2x+1} = 8^{x-2}$$

correct to three decimal places.

(9 marks)

- (b) Two capacitors connected in series have effective capacitance of $3.6 \mu F$. When they are connected in parallel, the effective capacitance is $15.0 \mu F$. Determine the capacitance of each capacitor. (11 marks)

3. (a) Given the complex numbers $Z_1 = 8 + j12$, $Z_2 = 4 - j7$ and $Z_3 = 5 + j12$; determine
- (i) $Z_3(Z_1 + Z_2)$;
- (ii) $\frac{1}{Z_1 + Z_3}$
- giving the answer in cartesian form. (6 marks)

- (b) Solve the equation $Z^3 = -12 - j5$, giving the answer in the form $a + jb$ (8 marks)

- (c) (i) Convert the equation

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

- (ii) Sketch the curve in (i). (6 marks)

4. (a) Solve the equation

$$\sin 2\theta + \cos \theta = 0 \text{ for values of } \theta \text{ between } 0^\circ \text{ and } 360^\circ \text{ inclusive.} \quad (5 \text{ marks})$$

- (b) A minor segment is enclosed between a circle of radius 10 cm and a chord of length 12 cm. Determine the area of the segment. (5 marks)

- (c) Solve the equation:

$$\cosh \theta + 2 \sinh \theta = 1 \quad (5 \text{ marks})$$

- (d) A function is given by

$$f(x) = \frac{x-1}{8+x}$$

Determine:

(i) $f^{-1}(x)$;

(ii) $f^{-1}(2)$.

(5 marks)

5. (a) Find $\frac{dy}{dx}$ for the functions:

(i) $y = \frac{\sin 2x}{x^3}$

(ii) $x = \sin 2\theta$, $y = \cos \theta$

(6 marks)

- (b) Determine the equation of the normal to the curve:

$$x^2 + 5xy^2 - 24y = 8 \text{ at the point } (3,1). \quad (8 \text{ marks})$$

- (c) Evaluate the integral:

$$\int \frac{5}{(x-1)(x^2+4)} dx \quad (6 \text{ marks})$$

SECTION B: ENGINEERING SCIENCE

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

6. (a) Three forces F_1 , F_2 and F_3 in kN act at a point O as shown in **figure 1**. Determine the magnitude of the resultant force.

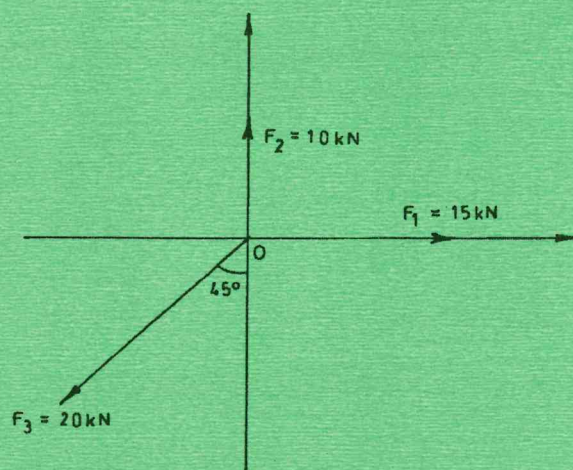


Fig. 1

(3 marks)

- (b) A uniform beam of length 10 metres and weight 1 kN sits horizontally on two supports at both ends. If it carries a load of 3 kN, 2 metres from one end, determine the reaction at each end. (5 marks)
- (c) An air balloon filled with a gas of density 0.16 kg/m^3 floats in air of density 1.25 kg/m^3 . If the volume of the balloon is 120 m^3 , determine the maximum load that it can lift. (Take $g = 9.81 \text{ m/s}^2$) (8 marks)

(d) A hydraulic press is to lift a load of 1.96 kN. The cross-sectional area of the piston in the load cylinder is 0.8 m^2 , and the cross-sectional area on the effort side is 0.1 m^2 . Calculate the:

(i) pressure in the fluid;

(ii) effort.

(4 marks)

7. (a) A block of weight 4000 N is to be raised up a plane inclined at 22° to the horizontal. If the co-efficient of friction between the block and the plane is 0.08, determine the minimum force needed. (6 marks)

(b) A plane of mass 50 tonnes accelerates uniformly from rest along a level runway of length 800 m. If the take-off velocity at the end of the runway is 50 m/s, determine the:

(i) constant acceleration of the plane;

(ii) average power generated by the engine.

(8 marks)

(c) A machine raises a load of 10,000 N and the effort required is 2000 N. The distance moved by the load is 0.5 m when the effort moves 3.0 m. For the machine, determine the:

(i) mechanical advantage;

(ii) velocity ratio;

(iii) efficiency.

(6 marks)

8. (a) (i) Differentiate between longitudinal and transverse waves.

(ii) A sound wave travels in air at a velocity of 340 m/s. If the period of the wave is 0.05 s. Calculate the:

(I) frequency;

(II) wavelength.

(6 marks)

(b) Define the following processes:

- (i) isobaric;
- (ii) isovolumetric;
- (iii) isothermal;
- (iv) adiabatic.

(4 marks)

(c) A gas is heated at a constant pressure until its absolute temperature is doubled. If the initial volume is 7.5 litres, calculate the final volume. (3 marks)

(d) Differentiate between:

- (i) an atom and a molecule;
- (ii) an element and a compound.

(4 marks)

(e) Sketch the structure of the following molecules:

- (i) ethene;
- (ii) ethyne;
- (iii) methane.

(3 marks)

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