

2506/103
2507/103
ENGINEERING MATHEMATICS I
AND ENGINEERING SCIENCE I
June/July 2022
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;

Non-programmable Scientific calculator/ mathematical tables.

This paper consists of 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 shown.

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) Given that $P \cosh x + Q \sinh x = 3^{e^x} + 7^{e^x}$, evaluate the values of the constants P and Q. (7 marks)
- (b) Solve the equation;
 $12 \cosh \theta - 15 \sinh \theta = 8$ (6 marks)
- (c) (i) Express $\cosh^{-1} 3x$ in logarithmic form.
(ii) Hence, evaluate $\cosh^{-1} (4.5)$ (7 marks)
2. (a) A vibrating system has the mean displacement $F(\theta)$ given by
$$F(\theta) = \int_0^\pi (1 + \sin \theta) d\theta$$

Use Simpson's rule with six strips to determine the mean displacement correct to 5 decimal places. (5 marks)
- (b) Given that $\tan A = \frac{15}{8}$ and $\sin B = \frac{7}{25}$, evaluate $\sec(A + B)$ without using calculator. (6 marks)
- (c) Solve the equation :
 $6 \sin^2 \theta - \cos \theta - 5 = 0$, for values of θ between 0° and 360° inclusive. (9 marks)
3. (a) Given the complex numbers $Z_1 = 8 - j5$, $z_2 = 3 + j7$ and $Z_3 = j5$, determine in the form $a + jb$.
(i) $z_2 + \frac{z_1 z_3}{z_1 - z_3}$
(ii) $\text{Arg}(z_1 + z_2)$ (6 marks)
- (b) Use Demoiivre's theorem to express $\sin^5 \theta$ as a series of sines of multiples of θ . (5 marks)
- (c) Evaluate the integral:
(i) $\int_0^{\sqrt{\frac{5}{8}}} \frac{dx}{\sqrt{5 - 16x^2}}$
(ii) $\int \frac{x}{(x-1)(x+3)} dx$ (9 marks)

4. (a) Solve the equation
 $\log_x 16 + \log_2 x = 4$ (5 marks)

(b) Three couples C_1 , C_2 and C_3 in KN acts on a crankshaft such that they satisfy the simultaneous equations

$$7C_1 - C_2 + 2C_3 = 63$$

$$3C_1 + 4C_2 - 5C_3 = 11$$

$$6C_2 - C_3 = 13$$

Use substitution method to solve the equations. (8 marks)

(c) An error of 3% is made in measuring the volume of a spherical block. Use binomial theorem to approximate the percentage error in its radius. (5 marks)

(d) Without using calculator, evaluate

$${}^8C_3 \div {}^6P_3$$

(2 marks)

5. (a) Convert the equations:

(i) $y^2 = 12x - 12$ to polar form;

(ii) $\cos^2 \theta = \frac{144 - 16r^2}{r^2}$ to Cartesian form.

(7 marks)

(b) Determine $\frac{dy}{dx}$ given:

(i) $y = \frac{x-2}{x+1}$

(ii) $y = \ln|\sin 2x|$

(6 marks)

(c) Locate the stationary points of the function.

$$f(x, y) = x^2 + 3xy + y^2$$

and hence determine their nature.

(7 marks)

SECTION B: ENGINEERING SCIENCE

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

6. (a) (i) Define the term isomerism.
(ii) The structure shown in Figure 1 is a polymer.

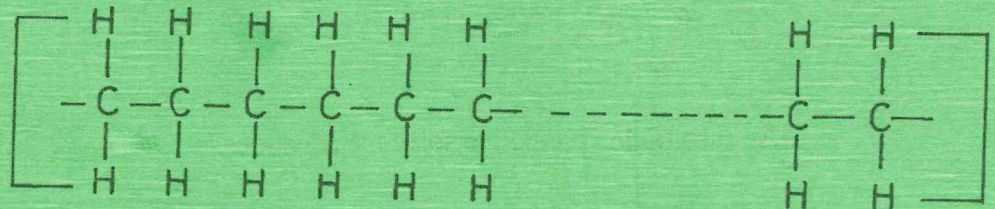


Fig. 1

Identify

- (I) the monomer
(II) its polymer. (5 marks)
- (b) (i) Define the term neutralization.
(ii) State **two** properties of bases.
(iii) Sodium atom has atomic number 11 and mass number 23. Determine the number of:
(I) electrons;
(II) neutrons
in the atom. (5 marks)
- (c) (i) Define specific latent heat of fusion of a substance.
(ii) A piece of iron of mass 0.6 kg and specific heat capacity of 0.46 KJ/kgK is heated to a temperature of 400°C and then placed into pieces of ice of mass 1.0 kg at 0°C. Determine the mass of ice melted.
(Take specific latent heat of fusion of ice as 336 kJ/kg and specific heat capacity of water as 4.2 KJ/Kg) (5 marks)
- (d) (i) State:
(I) Boyle's law
(II) Charles' law.
(ii) A gas is compressed to $\frac{1}{8}$ of its original volume in an ignition engine. If the initial pressure and temperature were 2 atm and 20°C; while the final pressure was 64 atm, calculate the final temperature. (5 marks)

7. (a) (i) List **two** applications of friction;
(ii) A force of 2000 N is needed to drag a body of mass 100 kg along a horizontal surface. Calculate the coefficient of friction between the block and the surface. (Take $g = 9.8 \text{ m/s}^2$) (5 marks)
- (b) (i) Two forces $F_1 = 15 \angle 45^\circ \text{ KN}$ and $F_2 = 20 \angle 150^\circ \text{ KN}$ act at a point. Determine the
(i) magnitude;
(ii) direction
of the equilibrant force. (6 marks)
- (c) (i) State the principle of moment
(ii) A uniform beam of length 16 m and mass 80 kg is supported at both ends A and B. A load of 2000 N is applied 5 m from end B. Determine the reaction force at each end. (5 marks)
- (d) (i) State:
(I) Archimedes' principle
(II) the buoyancy law.
(ii) A block floats on ethanol with $\frac{2}{3}$ of its volume submerged. If the density of ethanol is 0.8 g/cm^3 , determine the density of the block. (4 marks)
8. (a) (i) Define the terms:
(I) Work;
(II) energy;
(ii) A truck of mass 4000 kg moves up an inclined plane at constant speed of 10 m/s, overcoming a resistance force of 6 KN. Determine:
(I) Its Kinetic energy;
(II) the power developed by its engine. (7 marks)
- (b) The difference in mercury levels in the arms of a U-tube pressure gauge connected to a gas cylinder is 250 mm. If the density of mercury is 13.6 g/cm^3 , determine the absolute pressure of the gas. (Take $g = 9.81 \text{ m/s}^2$ and atmospheric pressure as 101.3 kPa) (4 marks)
- (c) (i) State Newton's second law of motion.
(ii) A jet fighter ascends vertically upwards with an acceleration of $(6g) \text{ m/s}^2$. Determine the reaction force between the pilot and his seat, if he weighs 68 kg. (Take $g = 9.81 \text{ m/s}^2$) (4 marks)

- (d) A wheel and axle system has a wheel of radius 480 mm and an axle of radius 80 mm. A load of 480 kN requires an effort of 100 kN to lift. For the system, determine the:
- (i) velocity ratio;
 - (ii) Mechanical advantage;
 - (iii) efficiency

(5 marks)

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