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;
- Mathematical tables/Non-programmable scientific calculator;
- 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.

(Take: \( g = 10 \text{ N/kg} \)).

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.

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Answer THREE questions from this section.

A. (a) Solve the equations:
   
   (i) \[ 2^{2x} - 3(2^x) + 2 = 0 \]
   
   (ii) \[ x^{1.2} = 41.15 \] correct to 4 significant figures.

   (9 marks)

   (b) Solve the simultaneous equations:
   
   \[ \frac{x - 1}{3} + \frac{y + 2}{5} = \frac{2}{15} \]
   
   \[ \frac{1 - x}{6} + \frac{5 + y}{2} = \frac{5}{6} \]

   (6 marks)

   (c) Solve the equation \[ 2x^2 + 5x = 3 \] by completing the square.

   (5 marks)

B. (a) Evaluate \[ \frac{3 \tan 60^\circ - 2 \cos 30^\circ}{\tan 30^\circ} \] without using tables or a calculator.

   (3 marks)

   (b) Solve the equation \[ 1 + \cos \theta = 2 \sin^2 \theta \] for \[ 0^\circ \leq \theta \leq 360^\circ \].

   (6 marks)

   (c) A triangle ABC has sides \( a = 9.0 \) cm, \( b = 7.5 \) cm and \( c = 6.5 \) cm. Determine the:

   (i) magnitudes of the three angles;

   (ii) the area of the triangle.

   (11 marks)

C. (a) Express \( \left( \frac{2 + j}{3 - 2j} \right)^2 \) in the form \( a + jb \).

   (4 marks)

   (b) If \( Pe^x + Qe^{-x} = 3 \cosh x - 4 \sinh x \), find the values of \( P \) and \( Q \).

   (4 marks)

   (c) (i) Determine the middle term in the binomial expansion of \( (3x + 2y)^{10} \).

   (ii) Find the first three terms of the binomial expansion of \( \sqrt{1 - x} \). Hence by substituting \( x = \frac{1}{9} \), find the value of \( \sqrt{8} \).

   (12 marks)
4. (a) Differentiate:

(i) \[ y = 5 \tan^3 2x \]
(ii) \[ y = 5\sqrt{t} \ln 3t \]  

(b) Determine the stationary points of the function \[ f(x,y) = 2x^3 + 6xy^2 - 3y^3 - 150. \]

5. (a) Evaluate the integrals:

(i) \[ \int 2x(2x^2 + 5)^6 dx; \]
(ii) \[ \int \sin^3 x \cos^2 x dx; \]
(iii) \[ \int x^3 \ln x dx. \]

(b) Find the area bounded above by \( y = 3x + 2 \), below by \( x \)-axis between \( x = 1 \) and \( x = 3 \).

5 marks

SECTION B: ENGINEERING SCIENCE I

Answer TWO questions from this section.

6. (a) (i) Outline two types of electromagnetic waves.

(ii) Figure 1 shows a snapshot of a wave form in a string. The numbers in the diagram show the scale in centimetres. The speed of the wave is 10 m/s.

Fig. 1
Determine the:
(I) wavelength;
(II) amplitude;
(III) frequency;
(IV) period of oscillation. (8 marks)

(b) (i) Outline four forms of energy.

(ii) Calculate the work done by a stone mason in lifting a stone of mass 15 kg through a height of 3.0 m. (8 marks)

(c) An electric motor raises a 50 kg load at a constant velocity. Calculate the power of the motor if it takes 40 seconds to raise the load through a height of 24 m. (4 marks)

7. (a) (i) State the principle of moments.

(ii) A uniform meter rule pivoted at its centre is balanced by a force of 9.6 N at the 20 cm mark and some other forces, P and 4.0 N on the 66 cm and 90 cm marks respectively. Calculate the force P. (10 marks)

(b) A wooden box of mass 50 kg rests on a rough floor. The coefficient of friction between the floor and the box is 0.4.

(i) Calculate the force required to just move the box.

(ii) If a force of 120 N is applied to the box, determine its acceleration. (5 marks)

(c) A car of mass 2400 kg travelling at 90 m/s is brought to rest in 6 seconds. Calculate the:

(i) average retardation of the car;

(ii) average force applied by the brakes. (5 marks)
A block and tackle pulley system is used to lift a mass of 200 kg. This machine has a velocity ratio of 5 and efficiency of 80%.

(i) Sketch a possible arrangement of the pulleys, showing how the rope is wound.

(ii) Calculate the effort applied.

The volume \( V \) of a gas at pressure \( P \) is reduced to \( \frac{2}{7} \) \( V \) without change of temperature. Determine the new pressure of the gas.

A certain mass of a gas occupies 220 \( cm^3 \) at 18\(^\circ\)C and 740 mmHg pressure. Determine the temperature of the gas when it is compressed to a volume of 180 \( cm^3 \) and pressure of 770 mmHg.

A model Aircraft engine-block alloy contains 50 kg of Iron and 5.0 kg of Aluminium. Calculate the heat capacity of the engine-block alloy.

Take:

\[
\text{specific heat capacity of Iron} = 460 \text{ J/kgK;}
\]
\[
\text{specific heat capacity of Aluminium} = 880 \text{ J/kgK.}
\]