

1501/203
1508/203
1509/203
MATHEMATICS II AND
MECHANICAL SCIENCE II
Oct./Nov. 2022
Time: 3 hours



THE KENYA NATIONAL EXAMINATIONS COUNCIL
CRAFT CERTIFICATE IN MECHANICAL ENGINEERING
(PRODUCTION OPTION)
CRAFT CERTIFICATE IN WELDING AND FABRICATION
CRAFT CERTIFICATE IN CONSTRUCTION PLANT ENGINEERING
MATHEMATICS II AND MECHANICAL SCIENCE II

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 NINE questions in TWO sections; A and B.

Answer FIVE questions choosing 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 shown.

Candidates should answer the questions in English.

This paper consists of 5 printed pages.

Candidates should check the question paper to ascertain that all pages are printed as indicated and that no questions are missing.

SECTION A: MATHEMATICS II

Answer any THREE questions from this section.

1. (a) Given the matrices $P = \begin{bmatrix} 3 & 1 \\ x & 2 \end{bmatrix}$ $Q = \begin{bmatrix} 6 & 2 \\ 4 & y \end{bmatrix}$ and $PQ = QP$, determine the values of x and y . (7 marks)

- (b) Use matrix method to solve the following simultaneous equations:

$$\frac{3}{x} - \frac{2}{y} = 0$$

$$\frac{1}{x} + \frac{4}{y} = 14$$

(9 marks)

- (c) A wholesaler sold a refrigerator to a retailer making a profit of 25%. The retailer later sold the refrigerator for Ksh. 48,750 making a profit of 30%. Determine the amount of money the wholesaler had paid for the refrigerator. (4 marks)

2. (a) Table I shows marks obtained by 80 students in a certain Mechanical science test.

Table I

Marks	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
No of students	2	4	8	14	x	13	9	y	2	1

- (i) Determine the values of x and y if the median is 46.
 (ii) Hence, calculate the mode of the distribution. (9 marks)

- (b) A box contains 100 bolts of which 27 are oversize and 16 are undersize. If a bolt is selected from the box at random, tested and replaced, a second bolt is then similarly treated. Determine the probability that:

- (i) both are acceptable;
 (ii) first is oversize and second is undersize;
 (iii) one is oversize and the other is undersize. (11 marks)

3. (a) Given that angle θ is acute and $\cos \theta = \frac{3}{5}$, determine the values of the following without using a calculator or mathematical tables:

- (i) $\sin \theta$
 (ii) $\tan \theta$
 (iii) $\operatorname{cosec} \theta$ (4 marks)

1501/203

1508/203

1509/203

Oct./Nov. 2022

- (b) Prove that $\sin 3\theta = 3 \sin \theta - 4 \cos^3 \theta$. (5 marks)
- (c) Figure 1 shows the shape of a metal plate (not drawn to scale). Use cosine rule to determine:
- (i) length BD;
- (ii) angle BCD. (6 marks)

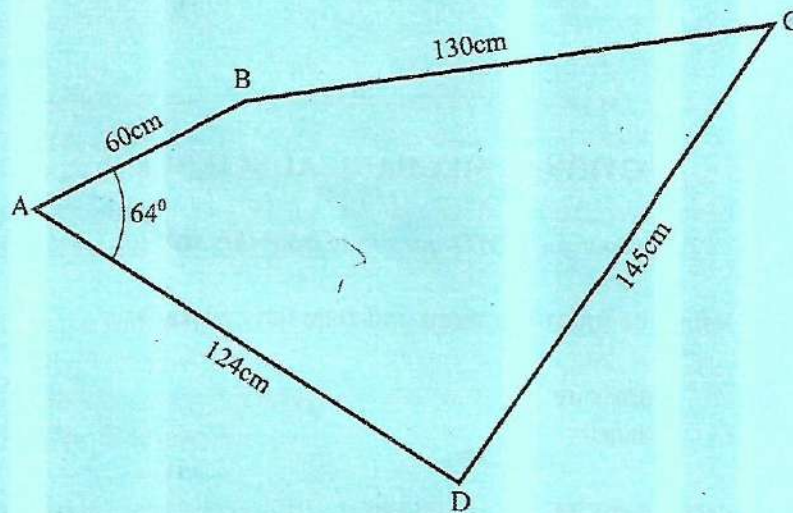


Fig. 1

- (d) Solve the equation $\tan \theta = 2 \sin \theta$ for values of θ from $0^\circ \leq \theta \leq 360$. (5 marks)
4. (a) Determine the following integrals:
- (i) $\int x^2(x^3 + 7)^{\frac{3}{2}} dx$
- (ii) $\int \frac{1}{1 + \sin x + \cos x} dx$ (12 marks)
- (b) The acceleration of a body is due to four coplanar accelerations. These are: 5 m/s^2 due west, 4 m/s^2 due north, 7 m/s^2 to the south-east and 8 m/s^2 to the south-west. Determine the magnitude and direction of the resultant accelerations. (8 marks)
5. (a) The parametric equations of a curve are $y = 2t^3 + 5t$ and $x = 4t^2 - 3t$. Determine at $t = 1$, the values of:
- (i) $\frac{dy}{dx}$

- (ii) $\frac{d^2y}{dx^2}$ (8 marks)
- (b) Determine the stationary points of the function $f(x,y) = x^3 - 6xy + y^2 + 4$ and hence determine their nature. (10 marks)
- (c) The radius of a circle is increasing at the rate of 0.02 cm/s. Use ordinary derivatives to determine the rate at which the area of the circle is changing at the instant when the radius is 6 cm. (2 marks)

SECTION B: MECHANICAL SCIENCE II

Answer any *TWO* questions from this section.

6. (a) (i) Define the following terms and state their SI units:
- I. pressure;
 - II. density.
- (ii) State the Archimedes' principle. (6 marks)
- (b) With the aid of a labelled diagram, describe the measurement of atmospheric pressure using a simple barometer. (7 marks)
- (c) A solid plastic cube has a side length of 300 mm. When placed on water, it floats with its top face being horizontal and a height of 50 mm remains above the water. Determine the density of the plastic. (7 marks)
7. (a) Define the following terms and state their S.I units:
- (i) latent heat;
 - (ii) specific latent heat of fusion. (4 marks)
- (b) Describe the **three** methods of heat transfer. (6 marks)
- (c) A tap discharges water at $20\text{ }^\circ\text{C}$ and a flow rate of 1 litre per minute. A second tap releases water at $60\text{ }^\circ\text{C}$ and a flow rate of 2 litres per minute. The two taps are simultaneously turned on to flow into a perfectly lagged vessel. Determine the temperature of the water in the tank after three minutes flow, if:
- (i) vessel is initially empty;
 - (ii) vessel initially contains 2 litres of water at $60\text{ }^\circ\text{C}$. (10 marks)

8. (a) (i) Define the term specific latent heat of vaporisation.
(ii) State the ideal gas equation and define the quantities involved. (4 marks)
- (b) 0.88 kg of a gas at 800 kN/m^2 and $420 \text{ }^\circ\text{C}$ expands inside an engine cylinder to a final 120 kN/m^2 . Determine the volume and temperature, if the:
- (i) volume of the gas is doubled;
(ii) expansion follows Boyle's law.
- Take $R = 0.290 \text{ kJ/kg K}$. (12 marks)
- (c) During a heat treatment process, a metallic component of mass 4.5 kg and specific heat capacity $6.12 \text{ kJ/kg }^\circ\text{C}$ was heated to $480 \text{ }^\circ\text{C}$. It was then immersed in 100 litres of oil at an initial temperature of $20 \text{ }^\circ\text{C}$. The density and specific heat capacity of oil are 840 kg/m^3 and $3.45 \text{ kJ/kg }^\circ\text{C}$. Neglecting heat losses, determine the maximum temperature attained by the oil. (4 marks)
9. (a) Explain the following as applied to simple machines:
- (i) mechanical advantage ;
(ii) law of a machine. (4 marks)
- (b) Outline two factors that affect the values of the velocity ratio of each of the following systems:
- (i) pulley;
(ii) screw jack;
(iii) chain drive;
(iv) gear train. (8 marks)
- (c) A simple machine has a velocity ratio of 8. Using the machine, an effort of 50 N raises a load of 250 N and an effort of 105 N raises a load of 800 N. Determine the:
- (i) law of the machine;
(ii) efficiency of the machine while it raises a load of 500 N. (8 marks)

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