1501/203   1509/203
1508/203
MATHEMATICS II AND
MECHANICAL SCIENCE II
June/July 2020
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

MODULE II

MATHEMATICS II AND MECHANICAL SCIENCE II

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
> *Answer booklet;*
> *Mathematical tables/Non-programmable scientific calculator;*
> *Drawing instruments.*
*This paper consists of **NINE** questions in **TWO** sections; A and B.*
*Answer **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 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.

    Turn over

SECTION A: MATHEMATICS II

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

1. (a) Given the matrices $A = \begin{bmatrix} 3 & 2 \\ 1 & -1 \end{bmatrix}$, $B = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix}$ and $C = \begin{bmatrix} 3 & 4 \\ 6 & -2 \end{bmatrix}$. Determine:

   (i) $A + B - C$

   (ii) ABC

   (iii) $A^{-1}B^{-1}$

   (11 marks)

   (b) Two forces F_1 and F_2 in Newtons acting on a mechanical structure are related by the simultaneous equations:

   $$3F_1 + 4F_2 = 18$$

   $$2F_1 - 3F_2 = -5$$

   Solve the equations using the inverse matrix method.

   (9 marks)

2. (a) The lengths in centimeters of 100 steel bars are distributed as in Table I.

   Table I

Length (cm)	33 - 35	36 - 38	39 - 41	42 - 44	45 - 47	48 - 50
Number of bars	7	12	22	36	14	9

   Determine the:

   (i) median;
   (ii) mean;
   (iii) standard deviation;
   (iv) mode.

   (14 marks)

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(b) The probabilities of machines A and B failing in one week's time are $\frac{2}{9}$ and $\frac{3}{11}$ respectively.

Calculate the probability that:

(i) both fail;

(ii) none fails;

(iii) only one fails

in a week's time. (6 marks)

3. (a) The angle of elevation to the top of a mast is measured as $16°$ from a distance x metres. When the angle is measured 30 metres nearer the mast, it is $20°$.

Calculate the:

(i) distance x;

(ii) height of the mast correct to one decimal place. (8 marks)

(b) Three forces F_1, F_2 and F_3 of magnitude 12 N, 16 N and 36 N respectively act on a point. F_2 and F_3 are inclined to F_1 at angles $60°$ and $150°$ respectively. Determine the:

(i) magnitude;

(ii) direction;

of the resultant force. (12 marks)

4. (a) Ksh. 50,000 was deposited in a bank which pays compound interest at 8% per annum. Calculate the interest earned after three years to the nearest shilling. (5 marks)

(b) A triangle ABC has sides A = 12 cm, B = 35 cm and C = 37 cm.

(i) Show that the triangle is right-angled.

(ii) Hence determine the values of the interior acute angles. (7 marks)

(c) (i) Sketch the function

$$f(x) = -x^2 + 5x - 4$$

between $x = 1$ and $x = 4$.

(ii) Hence determine the area enclosed between $f(x)$ and the x-axis, using integration.

(8 marks)

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

(i) $y = \sqrt{x} - x$

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

(iii) $y = x^2 \cos x$

(8 marks)

(b) Evaluate the integral

$$\int_2^5 (x + 2)^2 \, dx$$

(4 marks)

(c) Determine the nature of the stationary points of the function

$$f(x) = x^3 + 3x^2 - 9x + 5.$$

(8 marks)

SECTION B: MECHANICAL SCIENCE II

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

6. (a) (i) Differentiate between mass and weight.

(ii) State the SI unit of each of the quantities in (i).

(4 marks)

(b) An empty bottle weighs 40 grams. When full of pure water, it weighs 240 grams. If it weighs 196 grams when full of oil, determine the density of the oil in kg/m³.

(6 marks)

(c) (i) State the Archimedes principle.

(ii) A rectangular wooden block of dimensions 40 cm by 30 cm by 10 cm floats in pure water. If the mass of the block is 7.2 kg, determine:

      (I)   its density;

      (II)   minimum downward force needed to fully merge it.

                                                                                   (10 marks)

7. (a) Explain the meaning of upper and lower fixed points of a thermometer. (4 marks)

(b) Outline **four** disadvantages of water as a thermometric liquid when compared to mercury. (4 marks)

(c) An electric immersion heater of power rating 2.0 kW, is placed in a calorimeter of heat capacity 80 J/K containing one litre of water at 15 °C. Determine the time in minutes taken to bring the water to boiling point at 100 °C.
(Specific heat capacity of water is 4200 J/kgK). (7 marks)

(d) An insulated container of negligible heat capacity contains 2.0 kg of water at 100 °C. Determine the mass of ice that must be added to the water for the final temperature of the mixture to be dropped to 20 °C.
(Specific heat capacities of water and ice are 4200 J/kgK and 2100 J/kgK; and specific latent heat of fusion of ice is 336,000 J/kg) (5 marks)

8. (a) Define the terms:

(i) mechanical advantage;
(ii) velocity ratio;
(iii) limiting efficiency.

                                                                         (3 marks)

(b) A machine has a velocity ratio of 40 and an efficiency of 55%. It is used to lift a load of 1200 N. Determine the:

(i) effort needed to lift the load;

(ii) energy lost due to friction when the load rises 2.0 m.

                                                                    (12 marks)

(c) (i) Outline the **three** classes of levers.

(ii) Sketch the arrangement of one of the levers in (i).

                                                                         (5 marks)

9. (a) State the law associated with:

   (i) constant pressure;

   (ii) constant temperature.

   (4 marks)

   (b) (i) Express the ideal gas law in mathematical form.

   (ii) A cylinder has a volume of 80 litres and contains air at 1.8 MN/m² at a temperature of 37 °C. Calculate the mass of air in the cylinder.
   (Take gas constant of air as 267J/kgK)

   (6 marks)

   (c) Explain how static pressure varies with:

   (i) depth;
   (ii) density;
   (iii) gravity;
   in a liquid.

   (3 marks)

   (d) A tank contains fuel oil of relative density 0.8 to a depth of 6 m. Calculate the load on a valve plate of area 750 mm² in the base of the tank due to the oil.

   (7 marks)

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