2501/202 2502/202
2503/202 2508/202
2509/202
STRENGTH OF MATERIALS AND
MECHANICS OF MACHINES
June/July 2016
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN MECHANICAL ENGINEERING (PRODUCTION OPTION)
DIPLOMA IN MECHANICAL ENGINEERING (PLANT OPTION)
DIPLOMA IN AUTOMOTIVE ENGINEERING
DIPLOMA IN WELDING AND FABRICATION
DIPLOMA IN CONSTRUCTION PLANT ENGINEERING

MODULE II

STRENGTH OF MATERIALS AND MECHANICS OF MACHINES

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Mathematical table Calculator.
*This paper consists of **EIGHT** questions in **TWO** sections; A and B.*
*Answer **FIVE** questions choosing **TWO** questions from section A, **TWO** questions from section B and **ONE** question from either section.*
Maximum marks for each part of a question are indicated.
Candidates should answer the questions in English.

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.

SECTION A: STRENGTH OF MATERIALS

Answer at least TWO questions from this section

1. (a) State **three** types of load that a beam can be subjected to. (3 marks)

(b) Define the following terms as applied to beams and state their S.I units:

(i) shear force;
(ii) bending moment. (4 marks)

(c) Figure 1 shows a a simply supported beam.

(i) Draw the shearing force diagram for the beam;
(ii) Draw the bending moment diagram hence determine the points of contraflexures (13 marks)

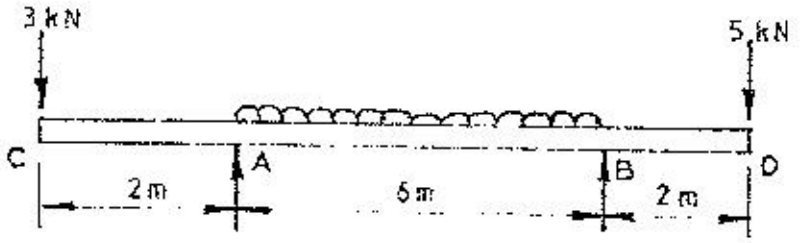

Fig. 1

2 (a) (i) State any two assumptions made in deriving the torsion equation
(ii) Derive the equation for pure torsion. (10 marks)

(b) (i) Figure 2 shows a shaft ABC of length 500 mm and external diameter 40 mm bored for a part of its length AB, to a 20 mm diameter and the remaining BC to a 30 mm diameter. If the shear stress is not to exceed 80 MN/m^2, determine the maximum power that the shaft can transmit at a speed of 200 rev/min.

(ii) If the angles of twist in the two sections are equal, determine the lengths AB and BC. (10 marks)

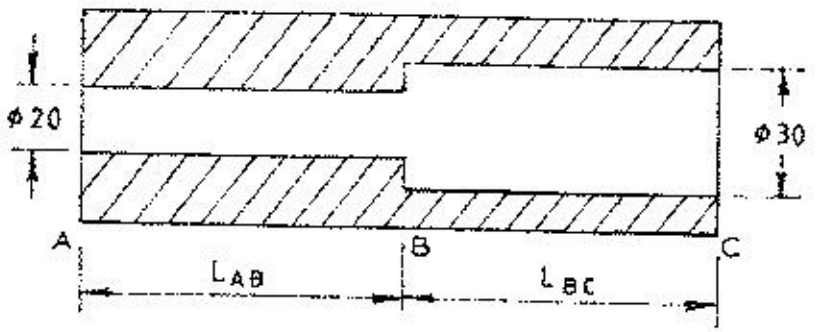

Fig. 2

3. (a) Figure 3 shows a rectangular thin bar of breath 20 mm and depth of 2 mm, firmly fixed at A. Using Castigliano's theorem, derive an expression for the vertical deflection at C. (14 marks)

(b) If the force P is 20 N, calculate the vertical deflection.
Take E = 200 GN/m^2. (6 marks)

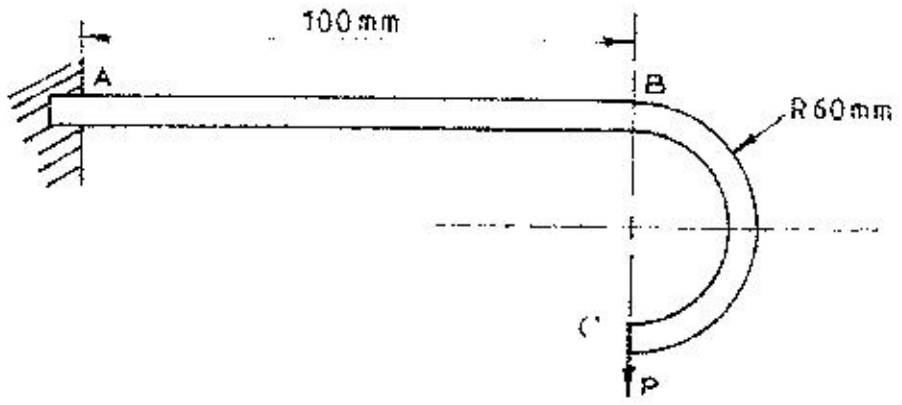

Fig. 3

4 (a) (i) Name **two** types of direct stress.
(ii) State Hooke's law of elasticity (4 marks)

(b) Sketch the load-extension graph for mild steel loaded to destruction and label the critical points. (4 marks)

(c) A mild steel rod 20 mm diameter and 30 mm long is enclosed centrally in a hollow copper tube of external diameter 30 mm and internal diameter 25 mm The ends of the rod and the tube are brazed together. The composite bar is subjected to an axial pull of 40 kN.

If E for steel and copper are 200 GN/m^2 and 100 GN/m^2 respectively, determine

(i) the stresses developed in the rod and tube,
(ii) the extension of the rod

(12 marks)

SECTION B: MECHANICS OF MACHINES

Answer at least TWO questions from this section

5. (a) State any:

(i) **two** conditions necessary for complete dynamic balance of a shaft;
(ii) **two** effects of unbalanced forces in the rotating parts of a machine. (4 marks)

(b) Four masses A, B, C and D are carried on a shaft with their centres of mass 150 mm, 200 mm, 70 mm and 60 mm respectively from the shaft axis. The mass A = 9 kg, B = 18 kg, C = 21 kg and D = 14 kg. The distance of the planes of rotation measured from mass A are B = 3 m, C = 5 m and D = 7 m respectively. The angular positions of B, C and D measured anti-clockwise from A are 75°, 160° and 240° respectively. Two balance masses are fixed as follows:

- M_1, midway between A and B, whose centres of mass from the shaft axis is 110 mm.
- M_2, midway between C and D, whose centre of mass from the shaft axis is 90 mm.

Determine:

(i) the value of the balance masses M_1 and M_2.
(ii) the angular position of the masses with respect to A.
Show the angular positions on an end elevation. (16 marks)

6. (a) State the following:

(i) principle of conservation of linear momentum;
(ii) parallel axes theorem. (4 marks)

(b) Define moment of inertia. (2 marks)

(c) An electric motor drives a winding drum of a mean diameter 1.2 m and moment of inertia 100 kgm^2 via a speed reduction gear drive of ratio 25.1. A cable runs round the drum carrying a load of 5.5 tonnes on one end and a balancing mass of 3.5 tonnes on the other end. If the moment of inertia of the motor shaft is 4 kgm^2 and the transmission efficiency is 89% at an instant when the upward velocity and acceleration of the load is 2.5 m/s and 1.2 m/s^2 respectively, determine:

(i) power generated by the motor;
(ii) total kinetic energy of the system. (14 marks)

7. (a) Show that the ratio of the tensions of a flat belt drive is given by:

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

Where $T_1 and\ T_2$ = tensions on belt

θ = angle of lap
μ = coefficient of friction. (8 marks)

(b) An open-belt drive connects two pulleys of 1.8 m and 1 m diameters respectively, on parallel shafts 4.5 m apart. The maximum belt tension is not to exceed 2 kN and the belt has a mass of 0.75 kg/m length. The larger pulley, which is the driver, runs at 300 rev/min. Taking $\mu = 0.3$, calculate the torque on each of the two shafts and the output power transmitted. (12 marks)

8. (a) Define the following terms as applied to spur gears:

(i) pitch circle diameter;
(ii) circular pitch;
(iii) base circle. (6 marks)

(b) Fig. 4 shows the parts of an epicydic gear train. The number of teeth on the gears are; B = 88, P_1 = 40, P_2 = 24 and S_1 = 24. The input shaft A rotates at 1,800 rev/min. Determine the.

(i) speed of the output shaft C;
(ii) torque transmitted at this speed, if the output power is 2 kW with an overall efficiency of 90%. (14 marks)

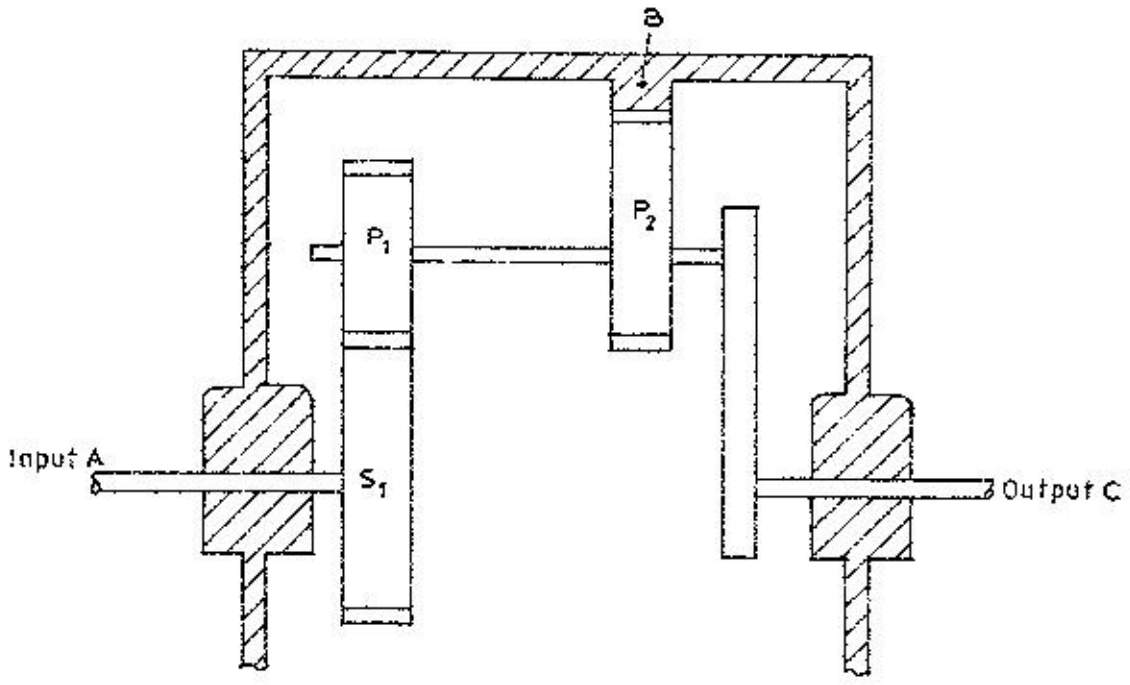

Fig. 4

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