2501/202 2508/202
2502/202 2509/202
2503/202
STRENGTH OF MATERIALS AND
MECHANICS OF MACHINES
June/July 2023
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;
Drawing instruments;
Scientific calculator.
*This paper consists of **EIGHT** questions in **TWO** sections; **A** and **B**.*
*Answer **FIVE** questions, taking at least **TWO** question from each section.*
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 7 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) Define each of the following terms as applied to strength of materials:

(i) stress;

(ii) strain. (4 marks)

(b) A steel pipe has an inside diameter of 30 mm and an outside diameter of 40 mm. The pipe carries a compressive load of 20 kN. The modulus of elasticity of the steel is 210 GN/m² and Poison's ratio is 0.36.

(i) Determine the changes in length and thickness of the pipe.

(ii) Strain energy stored in the bar. (7 marks)

(c) **Figure 1** shows a bent cantilever ABC made from an alloy bar of 10 mm diameter. AB is horizontal and BC is vertical. The cantilever is fixed at C and carries a vertical load of 200 N at A. If the modulus of elasticity of the alloy is 165 GN/m², determine the vertical deflection at A. (9 marks)

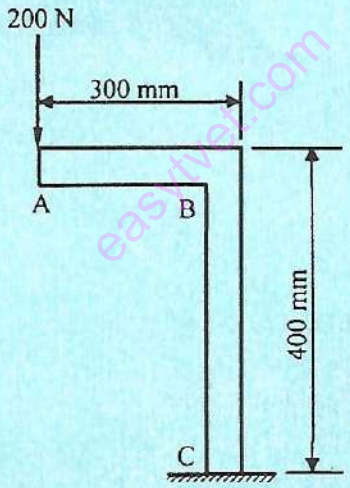

Fig. 1

2. (a) State **three** factors which affect the magnitude of the bending stress at any point along a loaded beam. (3 marks)

(b) **Figure 2** shows a loaded beam with a flexural rigidity EI=220 kNm².
Determine for the beam:

(i) support reactions;

(ii) shear force and bending moment at point C;

(iii) the radius of curvature at C. (10 marks)

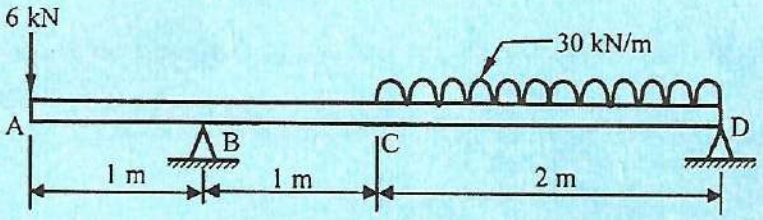

Fig. 2

(c) A 2.5 m long alloy beam of negligible mass is simply supported at its two ends and carries a concentrated load of 2 kN at mid span. The flexural rigidity of the beam is 150 kNm².
Working from first principles, determine maximum deflection of the beam.
(7 marks)

3. (a) State **three** assumptions made in the simple theory of torsion. (3 marks)

(b) From first principles, show that the maximum shear stress τ in a solid circular shaft is given by

$$\tau = \frac{16T}{\Pi d^3}$$

Where d =shaft diameter
T = torque transmitted. (8 marks)

(c) A hollow circular shaft has an outside diameter of 35 mm and a thickness fo 5 mm. The maximum permissible stress in the shaft material is 50 MN/m² and the maximum angular twist is 1.5 degrees per metre length. Determine the maximum power which the shaft can transmit at a speed of 1500 per rev/min.
Take G= 80 GN/m²
(9 marks)

4. (a) With the aid of sketches, distinguish between a spiral spring and a helical spring.
(4 marks)

(b) Show that the bending stress σ ,induced in a semi elliptic leaf spring of length L and carrying a central concentrated load W is given by

$$\sigma = \frac{3WL}{2nbt^3}$$

Where:

b= breath of each plate
t = plate thickness
n = number of plates (8 marks)

(c) The following data refers to a semi elliptic leaf spring carrying a central load W:

length of the spring = 1200 mm
breadth of each plate = 60 mm
central deflection = 100 mm
modulus of elasticity = 210 GN/m^2
number of plates = 5

From first principles, determine the central load W. (8 marks)

SECTION B: MECHANICS OF MACHINES

*Answer at least **TWO** questions from this section.*

5. (a) With the aid of a diagram, describe the construction of a compound epicyclic gear train. (7 marks)

(b) **Figure 3** shows a double reduction spur gear box. The numbers of teeth on the wheels are: P = 20; Q = 60 and S = 100. The driving shaft transmits 50 kW at a rotational speed of 1800 rev/min and the overall efficiency of the gear train is 90%. The fixing torque for the gear housing is 1167.1 Nm in the direction of rotation of the input shaft.
Determine the:

(i) resistive torque at the output shaft;

(ii) speed of the output shaft;

(iii) number of teeth on gear wheel R. (13 marks)

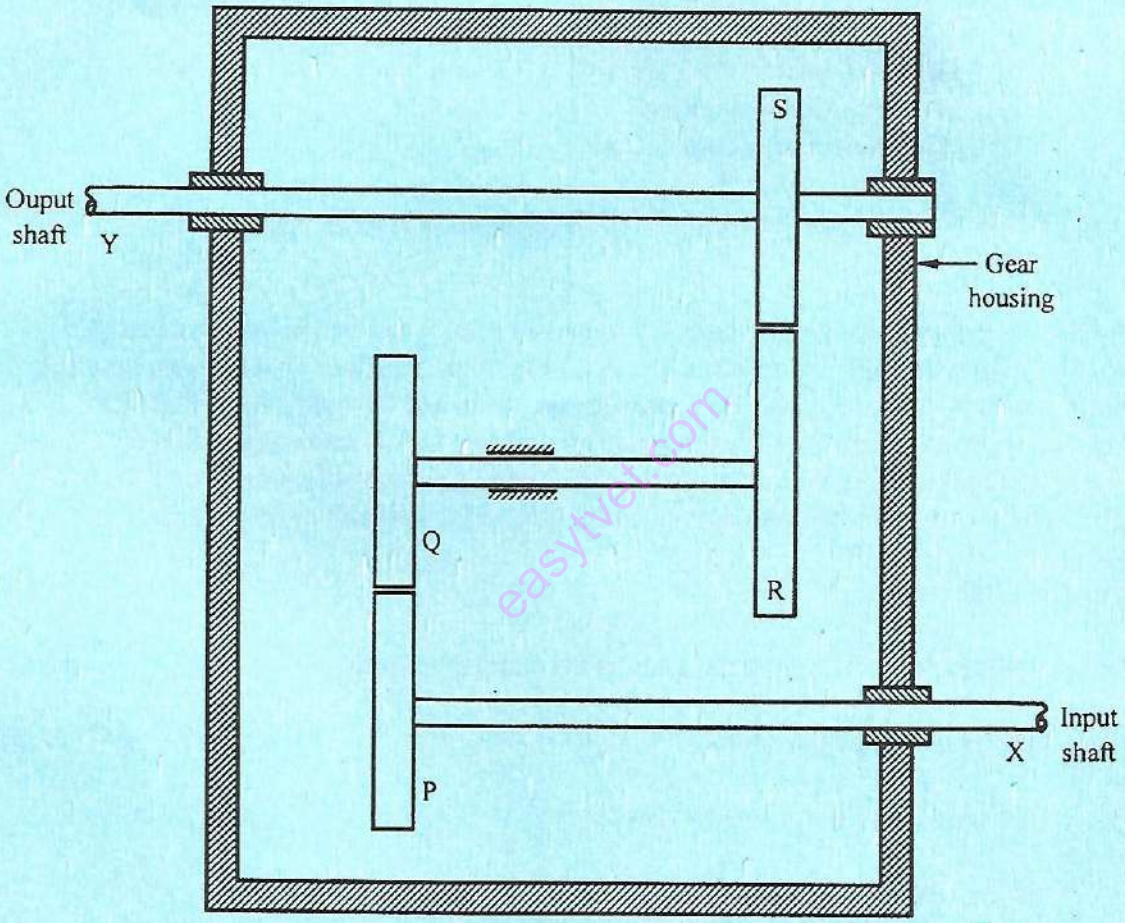

Fig. 3

6. (a) With the aid of sketches, distinguish between open and crossed belt drives. (4 marks)

(b) Assuming uniform wear, show that the torque T transmitted by a friction clutch is given by

$$T = \mu WR .$$

Where:
μ = coefficient of friction.
W = axial spring load pressing the surfaces.
R = mean radius of the friction ring. (10 marks)

(c) The following data refers to a plate clutch assembly designed to transmit 30 kW at a rotational speed of 1200 rev/min:

Outer diameter of friction ring = 300 mm
Inside diameter of friction ring = 200 mm
Axial spring load = 2 kN
Coefficient of friction = 0.52

Assuming uniform wear, determine the number of pairs of friction surfaces required. (6 marks)

7. A hoisting gear raises a load of mass 0.5 tonnes vertically to a height of 10 metres. At an instant when the load speed is 3/s, its acceleration is 0.24 m/s^2. The drum diameter is 1.6 m and the gear reduction ratio between the drum and the motor is 10:1. The mass of hoisting rope is 1 kg/m. The drum has a mass of 20 kg and a radius of gyration of 200 mm. The rotor of the driving motor has a mass of 10 kg and a radius of gyration of 100 mm. The friction couple at the drum bearing is 2.5 Nm and the efficiency of the gear train is 88%.

Determine the:

(a) torque required to drive the drum at the start of hoisting; (10 marks)

(b) power of the driving motor. (10 marks)

8. (a) Define each of the following quantities:

(i) angular momentum;

(ii) angular impulse. (4 marks)

(b) An engine flywheel has a mass of 40 kg and a radius of gyration of 260 mm. The flywheel accelerates from rest to a speed of 2000 rev/min in 240 revolutions. The friction couple at the flywheel shaft bearing is 20 Nm.

Determine the:

(i) angular acceleration in rad/s^2;

(ii) time taken for the acceleration;

(iii) accelerating torque. (7 marks)

(c) A pile driver of mass 3 tonnes falls through 6 metres onto a pile of mass 4 tonnes. There is no rebound on impact and the pile is driven 8 mm into the ground.

Determine the:

(i) kinetic energy loss on impact;

(ii) ground resistance to penetration. (9 marks)

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