2501/202 2508/202
2502/202 2509/202
2503/202
STRENGTH OF MATERIALS AND
MECHANICS OF MACHINES
Oct./Nov. 2022
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 tables / Scientific calculator;*
- *Drawing instruments.*

*This paper consists of **EIGHT** questions in **TWO** sections; A and B.*
*Answer **FIVE** questions, taking at least **TWO** questions 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 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) Define the following terms as applied to strength of materials:

(i) stress;
(ii) strain. (4 marks)

(b) A hollow steel member has an inside diameter of 50 mm, a wall thickness of 5 mm, a length of 1500 mm and a modulus of elasticity of 210 GN/m^2. If the member is subjected to a tensile load of 5 kN, determine each of the following dimensional changes:

(i) elongation;

(ii) change in thickness.

Take Poisson's ratio to be 0.4. (8 marks)

(c) Figure 1 shows a simply supported beam.

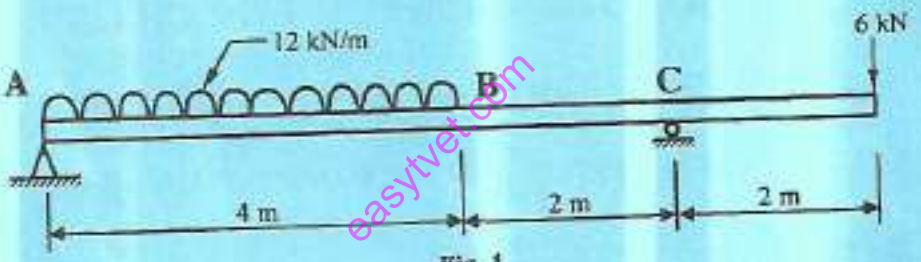

Fig. 1

Determine for the beam, the:

(i) reactions at the supports;

(ii) shear force and bending moment at a point 2 m from A. (8 marks)

2. (a) State **four** assumptions made when deriving the equation for pure bending. (4 marks)

(b) A timber cantilever has a length of 1.5 m and carries a uniformly distributed load of 5 kN/m over its full span. The width and depth of the beam are 80 mm and 150 mm respectively. The deflection at the free end of the beam is 5 mm. Working from first principles, determine the modulus of elasticity of the timber. (10 marks)

(c) A cylindrical pressure vessel is to be designed to store 3800 litres of a gaseous fuel at a pressure of 400 kN/m². The cylinder length is to be 1.8 times its diameter, and the ultimate strength of the shell plate is 480 MN/m². If a factor of safety of 10 is to be used, determine the required:

(i) cylinder diameter;

(ii) cylinder length;

(iii) plate thickness. (6 marks)

3. (a) Distinguish between proof resilience and modulus of resilience of an engineering material and state their respective S.I units. (4 marks)

(b) A hollow circular shaft has its outside diameter three times the inside diameter. Show that the resilience of the shaft is given by:

$$Resilience = \frac{5\tau^2}{18G}$$

Where τ = maximum stress in the shaft
G = modulus of rigidity (9 marks)

(c) A solid circular shaft of 40 mm diameter transmits 100 kW at a speed of 1200 rev/min. If the modulus of rigidity of the shaft is 85 GN/m², determine the:

(i) maximum shear stress in the shaft;

(ii) angular twist in radians per metre length. (7 marks)

4. (a) With the aid of sketches, distinguish between closed and open coiled helical springs. (4 marks)

(b) A semi-elliptic leaf spring carries a central load w. Show that the maximum bending stress (σ) in the spring is given by:

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

Where:

L = Length of the spring;
b = breadth of the plates;
n = number of plates;
t = thickness of each plate. (8 marks)

(c) A semi-elliptic leaf spring is to be designed to carry a load of 6 kN. The stress in the spring is not to exceed 142 MN/m^2 and the spring length is to be 540 mm. The thickness and breadth of the available plates are 8 mm and 90 mm respectively and the modulus of elasticity is 210 GN/m^2. Determine the:

(i) number of plates required;

(ii) radius to which the plates should be formed. (8 marks)

SECTION B: MECHANICS OF MACHINES

Answer at least TWO questions from this section.

5. (a) Show that for a flat belt drive using two pulleys of equal diameters, the ratio of the tensions in the two reaches of the belt is given by:

$$\frac{T_1}{T_2} = 23.14^{\mu}$$

Where:

T_1, T_2 = Tensions on the tight and slack sides respectively;

μ = coefficient of friction between the belt and pulleys.

(10 marks)

(b) An open V-belt drive is required to transmit 52 kW from an electric motor running at 1600 rev/min to a pump running at 800 rev/min. The maximum permissible tension in the belt is 1.8 N and the available pulley on the motor shaft has a diameter of 200 mm. The angle of groove is 40° and the coefficient of friction between the belt and pulleys is 0.44. The centre distance between the pulleys is 1400 mm and the mass of each belt is 0.6 kg/m. Determine the:

(i) diameter of the pulley required for the pump shaft;

(ii) number of belts required. (10 marks)

6. (a) The velocity (V) of a torpedo after t seconds from the start of motion is given by the equation $V = 8t^2 - 6t$, where V is in m/s and t is in seconds. Determine the:

(i) velocity and acceleration of the body during the fourth second;

(ii) distance moved by the torpedo between the third and eighth seconds.

(7 marks)

(b) A mine cage of mass 800 kg is to be raised from a depth of 120 metres to the ground level, using a hoist drum of mass 120 kg and a radius of gyration of 0.6 m. The drum diameter is 1.4 m and the speed reduction gear ratio is 12/1 with an efficiency of 85%. A balance mass of 100 kg is to be used.
The mass and radius of gyration of the motor rotor are 20 kg and 0.4 m respectively. The mass of the hoisting rope is 1 kg / m. Determine the power drawn from the hoisting motor if the velocity and acceleration of the cage at the start of its motion are 5 m/s and 0.8 m/s^2 respectively.
(13 marks)

7. (a) With the aid of diagrams, distinguish between simple and compound gear trains.
(4 marks)

(b) In a simple epicyclic gear train, the sun wheel has 80 teeth and each of its two planet wheels has 40 teeth. The sun wheel carries the input shaft which transmits 100 kW at a rotational speed of 1600 rev/min. The planet carrier is integral with the output shaft and the overall efficiency of the train is 90%. The annulus is fixed. Sketch the gear train, hence determine the:

(i) velocity ratio;

(ii) mechanical advantage;

(iii) magnitude and direction of the torque required to fix the annulus.
(16 marks)

8. (a) Define angular momentum and state its S.I units.
(2 marks)

(b) An engine flywheel of mass 60 kg and radius of gyration 400 mm rotates at 1800 rev/min. The flywheel is suddenly connected to a stationary shaft of mass 35 kg and radius of gyration 200 mm by means of a clutch. Determine the:

(i) final rotational speed of the system;

(ii) kinetic energy loss due to the coupling.
(8 marks)

(c) A 1.2 m long shaft is supported on two bearings; A and B at its two ends. The shaft carries two gear wheels P and Q at distances of 0.4 m and 0.6 m respectively, from bearing A. The masses of P and Q are 8 kg and 6 kg respectively and the angular dispositions between them is 120°. The eccentricities of P and Q are 10 cm and 15 cm respectively. Determine the dynamic load on bearing B at a shaft speed of 2400 rev/min.
(10 marks)

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