2501/202 2508/202
2502/202 2509/202
2503/202
STRENGTH OF MATERIALS
AND MECHANICS OF MACHINES
Oct./Nov. 2017
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;*
- *Scientific calculator/Mathematical tables;*
- *Drawing Instruments.*

*This paper consists of **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 shown.
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.

Turn over

SECTION A: STRENGTH OF MATERIALS

Answer at least TWO questions from this section.

1. (a) Distinguish between close coiled and open coiled helical springs. (2 marks)

(b) Show that the spring rate of a close coiled helical spring S is given by:

$$S = \frac{Gd^4}{8D^3n}$$

where,
d = wire diameter
D = coil diameter
n = number of coils
G = modulus of rigidity

(8 marks)

(c) The following data refers to an open coiled helical spring:

rod diameter	= 8 mm
coil diameter	= 80 mm
pitch	= 50 mm
number of coils	= 10
axial load carried	= 5 kg
Young's modulus	= 200 GN/m^2
modulus of rigidity	= 80 GN/m^2

Determine the:

(i) helix angle;

(ii) length of the spring rod;

(iii) maximum bending stress;

(iv) maximum shear stress. (10 marks)

2. (a) Define the following terms:

(i) modulus of elasticity;

(ii) Poisson's ratio. (4 marks)

(b) A solid rectangular steel bar has cross sectional dimensions 25 mm by 15 mm and a length of 800 mm. The bar is subjected to a compressive load of 5 kN. The modulus of elasticity of the steel is 204 GN/m^2 and the Poisson's ratio is 0.36.

Determine the :

(i) change in length of the bar;

(ii) increment on the 25 mm side of the cross section;

(iii) strain energy stored in the bar. (9 marks)

(c) Figure 1 shows a simply supported beam.

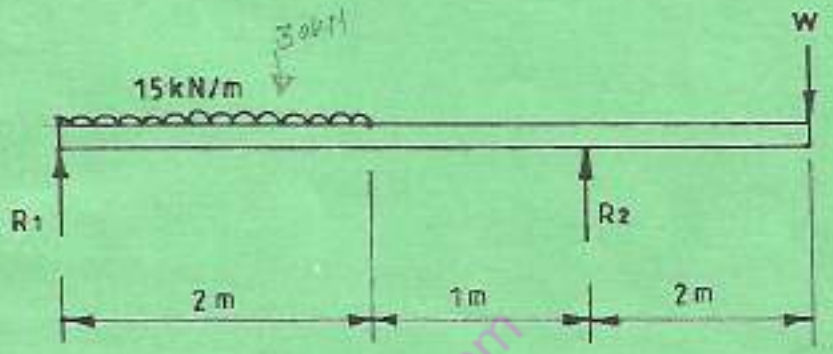

Fig. 1

Determine the:

(i) value of the concentrated load W if the two support reactions are to be equal;

(ii) shear force and bending moment at the midspan of the uniformly distributed load for the value of the concentrated load in c(i) (7 marks)

3. (a) State Castigliano's theorem for deflection. (2 marks)

(b) Show that the strain energy U stored in a member of length L, which is subjected to a bending moment M, is given by:

$$U = \frac{M^2 L}{2EI}$$

Where EI = flexural rigidity. (6 marks)

(c) Figure 2 shows a loaded cantilever steel bar ABC, made from 10 mm diameter solid rod. A vertical rod of 25 N acts at the free end C.

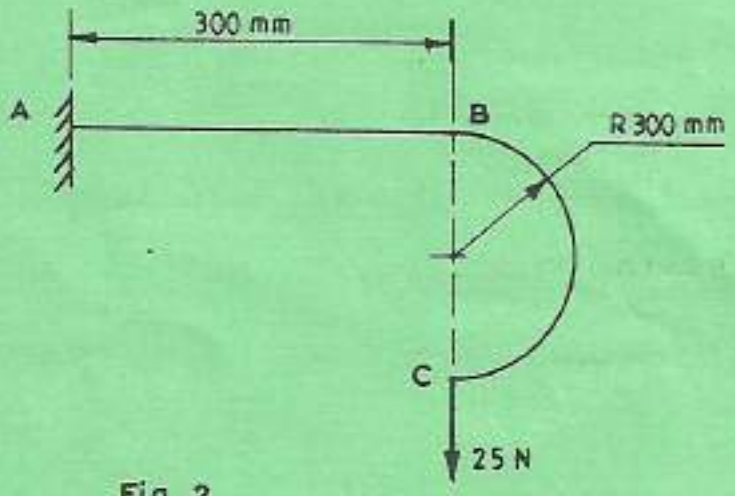

Fig. 2

Determine the vertical deflection at C.
Take E = 200 GN/m^2. (12 marks)

4. (a) State **three** factors which affect the angular twist of a power transmission shaft. (3 marks)

(b) A hollow circular shaft has an outside diameter which is twice its inner diameter. Show that the strain energy per unit volume U of the shaft is given by:

$$U = \frac{5\tau^2}{16G}$$

where τ = maximum stress in the shaft
G = modulus of rigidity. (7 marks)

(c) A hollow circular shaft is to be designed to transmit 80 kW of power at a speed of 1500 rev/min. The outside diameter is to be twice the inside diameter and the stress in the shaft is not to exceed 60 MN/m^2. If the angular twist of the shaft is not to exceed 1.5 per metre length, determine the minimum permissible diameters for the required shaft.
Take G = 80 GN/m^2. (10 marks)

$T = G \frac{\pi D^4}{16}$

SECTION B: MECHANICS OF MACHINES

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

5. (a) State the following theorems of moments of inertia:

(i) perpendicular axes;

(ii) parallel axes. (4 marks)

(b) Show that the mass moment of inertia I of a circular ring of radius R and mass M, is given by:

$$I = \frac{MR^2}{2}$$

(7 marks)

(c) Figure 3 shows a T-section.

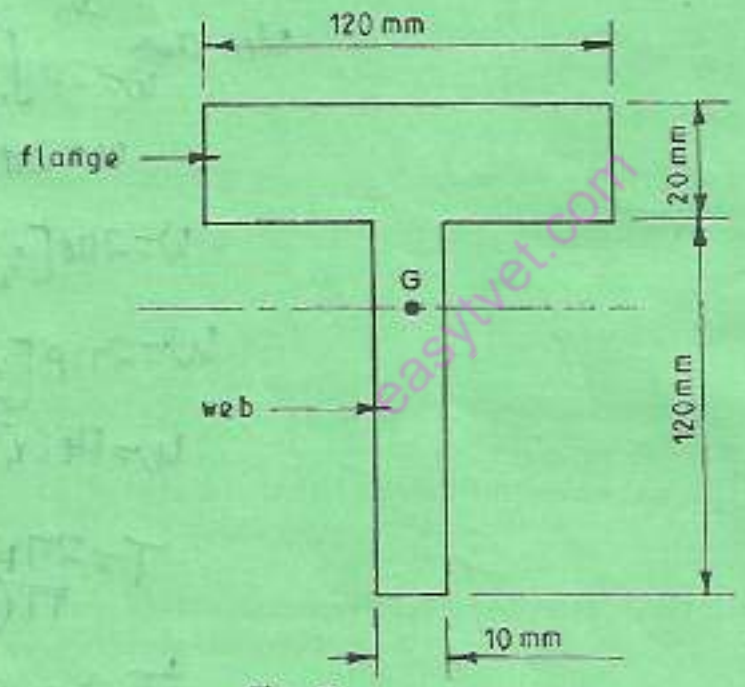

Fig. 3

Determine the:

(i) moment of inertia about an axis passing through the centroid G and parallel to the top of the flange;

(ii) radius of gyration. (9 marks)

6. (a) List **four** factors which affect the power transmitted by a plate clutch assembly. (4 marks)

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

$T = \mu WR$

where μ = coefficient of friction
W = axial spring force
R = mean radius of the friction surfaces. (8 marks)

(c) The following data refers to a cone clutch;

Outside diameter of friction ring = 300 mm,
Inside diameter of friction ring = 150 mm,
Coefficient of friction $\mu = 0.48$,
Cone angle = 48°,
Rotational speed = 750 rev/min,
Axial force = 2.5 kN.

Determine the power transmitted by the assembly, assuming uniform:

(i) wear;

(ii) pressure. (8 marks)

7. (a) (i) Define the term linear momentum and state its S.I unit.

(ii) Show that the force applied to a body equals its rate of change of momentum. (7 marks)

(b) A locomotive of mass 25 tonnes moving at 80 km/h collides head-on with a second locomotive of mass 20 tonnes, travelling at 60 km/h. Determine the energy loss due to impact, if:

(i) the locomotives move together after impact;

(ii) the 25 tonnes, locomotive comes to rest on impact. (12 marks)

8. (a) State **two** conditions which must be fulfilled for complete balance of a system of rotating masses. (4 marks)

(b) A shaft carries four eccentric loads A, B, C and D, of masses 1 kg, 1.5 kg, 1 kg and M kg respectively, and eccentricities 10 cm, 10 cm, 15 cm and 12 cm. The distances of B, C and D from the plane of A are 300 mm, 500 mm and 800 mm respectively.

Determine, for complete balance:

(i) angular inclinations of masses B, C, and D from mass A;

(ii) value of M. (16 marks)

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