2501/202 2508/202
2502/202 2509/202
2503/202
STRENGTH OF MATERIALS AND
MECHANICS OF MACHINES
June/July 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;*
- *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 questions 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.

SECTION A: STRENGTH OF MATERIALS

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

1. (a) Define each of the following as applied to engineering materials:

(i) modulus of elasticity;
(ii) Poisson's ratio. (4 marks)

(b) From first principles, show that for a cylindrical pressure vessel, the strain in the circumferential direction is twice the strain in the longitudinal direction. (10 marks)

(c) A cylindrical pressure vessel has a diameter of 420 mm and a shell thickness of 3.8 mm. The vessel contains oxygen gas at a pressure of 600 kN/m². Determine the strain in the vessel in each of the following directions:

(i) circumferential;
(ii) longitudinal.
Take E = 200 GN/m² (6 marks)

2. (a) State **three** assumptions made when deriving the equation of pure torsion. (3 marks)

(b) Show that the strain energy U, stored in a solid circular shaft transmitting a torque T, is given by

$$U = \frac{\tau^2}{4G} \times Volume$$

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

(c) A solid stepped shaft has a diameter of 35 mm over a length of 0.6 m and a diameter of 30 mm over a length of 0.4 m. At a rotational speed of 2000 rev/min, the total angular twist of the shaft is 1.8°.
Determine the power transmitted by the shaft.
Take G = 80 GN/m². (10 marks)

3. (a) Define each of the following terms as applied to strain energy:

(i) proof resilience;
(ii) modulus of resilience. (2 marks)

(b) Shows that the spring rate S, for a close coiled helical spring, is given by

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

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

(10 marks)

(c) Table 1 shows data for two close coiled helical springs X and Y. When the two springs are connected in parallel, the combined stiffness of the composite is 3075 N/m. Determine the value of n.

(8 marks)

Table 1

Spring	X	Y
wire diameter (mm)	6.2	8.5
coil diameter (mm)	120	145
number of coils	10	n
modulus of rigidity GN/m²	80	83

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

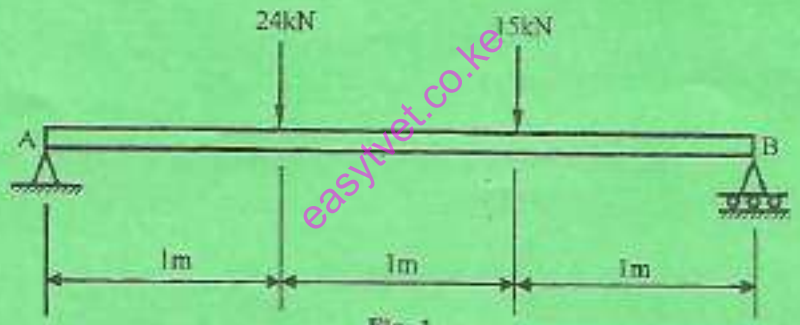

Fig. 1

Determine for the beam:

(i) support reactions;
(ii) shear force and bending moment at midspan.

(7 marks)

(b) Figure 2 shows a loaded bent cantilever. The bar has a solid diameter of 10 mm.

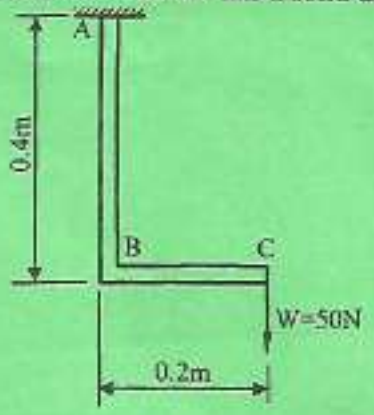

Fig. 2

Determine the vertical deflection at the free end C.
Take G = 200 GN/m²

(13 marks)

SECTION B: MECHANICS OF MACHINES

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

5. (a) Define each of the following terms and state their S.I units:

(i) linear impulse;
(ii) angular momentum. (4 marks)

(b) Working from the first principles, show that for a rotating body, angular impulse is equal to change in the angular momentum. (5 marks)

(c) A torpedo of mass 5 tonnes travelling eastwards at 600 km/h hits an aircraft of mass 15 tonnes travelling North eastwards at 300 km/h. After impact, the torpedo embeds into the aircraft and the two move together.
Determine the:

(i) magnitude of the common velocity immediately after the impact;
(ii) energy gain due to the impact. (11 marks)

6. (a) State **three** factors which affect the power transmitted by a belt drive. (3 marks)

(b) Assuming uniform pressure, show that the torque T transmitted by a pair of friction clutches in given by:

$$T = \frac{2}{3}\mu W \frac{(r_1^3 - r_2^3)}{(r_1^2 - r_2^2)}.$$

Where:
μ = coefficient of friction
W = axial load
r_1 = outside radius of friction surface
r_2 = inside radius of friction surface.

(10 marks)

(c) The following data refers to a plate clutch assembly using three pairs of friction surfaces:

Outside diameter of friction ring = 300 mm
Inside diameter of friction ring = 180 mm
Axial spring load = 1.5 kN
Rotational speed = 2100 rev/min
Coefficient of friction = 0.58

Assuming the friction surfaces to be new, determine the power transmitted by the clutch assembly. (7 marks)

7. (a) Explain the phrase 'dynamics of rigid bodies'. (2 marks)

(b) A 1.2 m long shaft is supported in two bearings X and Y at its two ends. The shaft carries three gear wheels P, Q and R at distances 0.3, 0.6 and 0.9 m respectively from bearing X. Table 2 shows details for the gear wheels.

Table 2

Gear wheel	P	Q	R
Eccentricity (mm)	20	10	10
Mass (kg)	3.0	2.0	1.0
Angular inclination in degrees	0°	30°	150°

Construct the couple and force polygons for the shaft, hence determine the dynamic load in each bearing at a speed of 400 rev/min. (18 marks)

8. (a) With the aid of a diagram, describe the double reduction compound spur gear train.

(4 marks)

(b) In a simple epicyclic gear train, the sun wheel has 60 teeth, and each of the three planet wheels has 30 teeth. The sun wheel carries the input shaft and the planet carrier is integral with the output shaft. The overall efficiency of the gear train is 92%. the input shaft transmits 50 kW at 420 rev/min.

(i) Sketch the gear train.
(ii) Determine the torque required to fix the annular wheel.

(16 marks)

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