2501/202 2508/202
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2503/202
STRENGTH OF MATERIALS AND
MECHANICS OF MACHINES
Oct./Nov. 2016
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN MECHANICAL ENGINEERING
(PRODUCTION OPTION)
(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.
*This paper consists of **EIGHT** questions in **TWO** sections; A and B.*
*Answer **FIVE** questions taking at least **TWO** questions from each section.*
Maximum marks for each part of a question are shown.
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.

Turn over

SECTION A: STRENGTH OF MATERIALS

Answer at least TWO questions from this section.

1. (a) State **three** factors which affect the maximum stress developed in a cylindrical pressure vessel. (3 marks)

(b) A cylindrical pressure vessel has a diameter of 1.2 m and the shell thickness is 3.6 mm. The vessel stores a gas at a pressure of 400 kN/m^2. From first principles, determine the following:

(i) circumferential stress in the vessel;

(ii) longitudinal strain in the vessel;

(iii) efficiency of the circumferential joint if the maximum permissible stress at the joint is 40 MN/m^2.

Take E = 210 GN/m^2. (17 marks)

2. (a) Define the following terms:

(i) Poisson's ratio;

(ii) modulus of rigidity. (4 marks)

(b) **Figure 1** shows a steel cantilever beam, made from a solid circular bar of 120 mm diameter. Determine the following:

(i) shear force at point A;

(ii) bending moments at point A;

(iii) maximum bending stress. (10 marks)

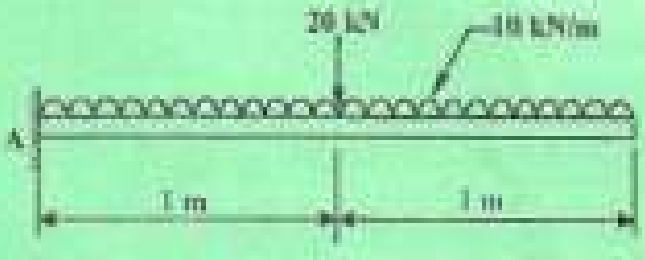

Fig. 1

7. (a) State **two** conditions which must be fulfilled for complete balance of a system of rotating masses. (2 marks)

(b) **Table 1** shows the eccentricities and angular dispositions of masses P, Q, R and S on a rotating shaft. The system is to be balanced by fixing two balance masses each at an eccentricity of 500 mm. One mass is to be attached to the plane of Q and the other to the plane of R. The distances of the planes of masses Q, R and S from P are 100 mm, 200 mm and 400 mm respectively. Determine the magnitudes and angular dispositions of the balance masses. (16 marks)

Table 1

Plane	Mass (Kg)	Eccentricity (mm)	Angle (°)
P	10	50	0
Q	8	100	60
R	5	120	90
S	2	80	180

8. A vehicle has a mass of 20 tonnes and road wheels of 700 mm diameter. The track resistance is 150 N/tonne. The engine produces 72 kW of power at its maximum speed of 2,800 rev/min, and drives the axle through a gear box. The engine torque is constant. Determine the following:

(a) time taken to reach full speed from rest on level track when the gear ratio is 12:1 and the transmission efficiency is 90%. (15 marks)

(b) gear ratio required to produce an acceleration of 0.12 m/s² on an up gradient of 1 in 100, assuming a gearing efficiency of 92%. (5 marks)

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SECTION B: MECHANICS OF MACHINES

Answer at least TWO questions from this section.

5. (a) State **four** factors which determine the maximum power transmitted by a belt drive. (4 marks)

(b) An open belt drive has pulley diameters of 400 mm and 600 mm, with their centres 1,200 mm apart. The drive uses two flat belts each of cross sectional area 8 mm^2. The maximum permissible stress in the belt material is 15 MN/m^2, and the coefficient of friction between the belts and pulleys is 0.55. The 400 mm diameter pulley runs at 1,200 rev/min. Determine the power transmitted by the drive. (16 marks)

6. (a) State **three** types of gear trains used in mechanical systems. (3 marks)

(b) **Figure 2** shows a gear train. The input shaft P transmits 80 kW at 2,400 rev/min. The numbers of teeth on the gear wheels are A=40, B=100, C=50, D=120, E=60 and F=150.

If the efficiency of the gear train is 92% , determine the following:

(i) speed of the output shaft Q;

(ii) power output;

(iii) torque required to fix the gear casing. (17 marks)

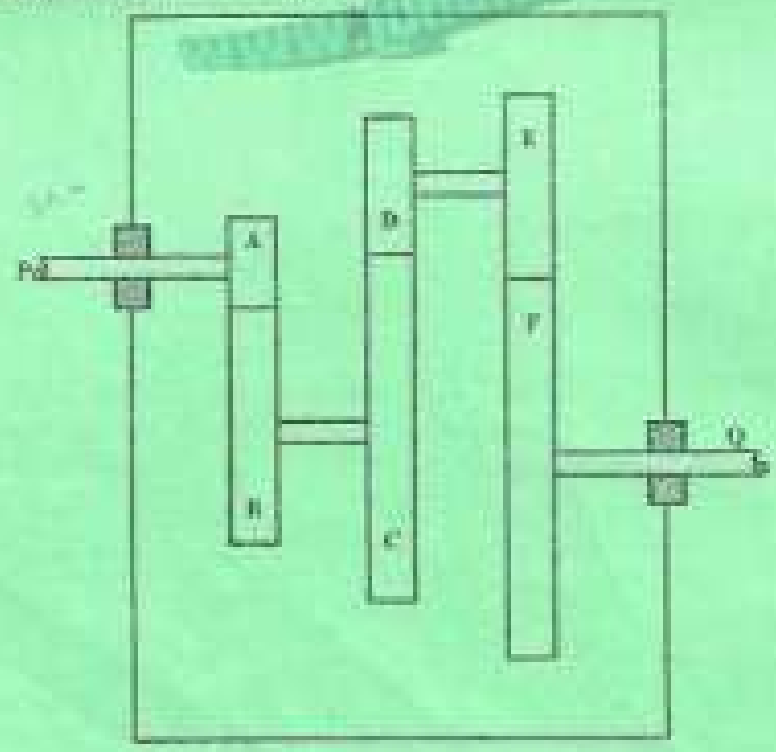

Fig. 2

(c) A uniform cantilever beam, 800 mm long, is subjected to a concentrated load of 5 kN at its free end. The deflection of the beam at the free end was found to be 0.85 mm. Given that the second moment of area of the section is 5.02×10^{-6} m^4 about its central axis, determine the modulus of elasticity of the material. (6 marks)

3. (a) State **three** parameters which affect the angular twist of a shaft when transmitting power. (3 marks)

(b) Working from first principles, show that for a solid shaft transmitting power:

$T/J = \tau/r$

Where:
T = torque transmitted.
τ = maximum shear stress
J = polar second moment of area.
r = shaft radius. (7 marks)

(c) A solid circular steel shaft, 1.5 m long, has its diameter turned down from 45 mm to 35 mm diameter, over a length of 0.5 m. It is used to transmit 80 kW of power at 2,400 rev/min. Determine the following:

(i) maximum stress developed in the 45 mm diameter section;

(ii) total angular twist in degrees.

Take G = 80 GN/m^2. (10 marks)

4. (a) With the aid of sketches, distinguish between:

(i) close coiled and open coiled helical springs;

(ii) semi elliptic and quarter elliptic leaf springs. (8 marks)

(b) Three helical springs X, Y and Z have spring rates of 2, 4 and 6 kN/m respectively. Working from first principles, determine the spring rate of the composite spring formed by arranging the three springs in:

(i) series;

(ii) parallel. (12 marks)