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**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.**

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**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  $400 \text{ kN/m}^2$ . 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  $40 \text{ MN/m}^2$ .

Take  $E = 210 \text{ GN/m}^2$ .

(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)

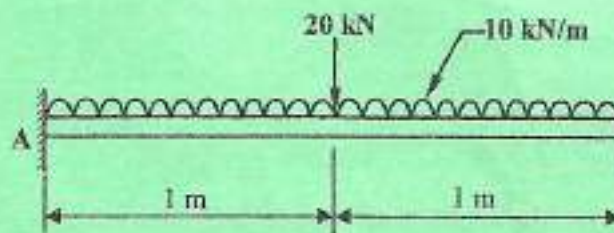


Fig. 1

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- (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  $5.02 \times 10^{-7} \text{ m}^4$  about its neutral 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.  
 $\tau$  = 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 1,400 rev/min. Determine the following: *G/N*
- (i) maximum stress developed in the 45 mm diameter section;
- (ii) total angular twist in degrees.
- Take  $G = 80 \text{ GN/m}^2$ . (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)



## 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  $8 \text{ mm}^2$ . The maximum permissible stress in the belt material is  $15 \text{ MN/m}^2$ , 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)

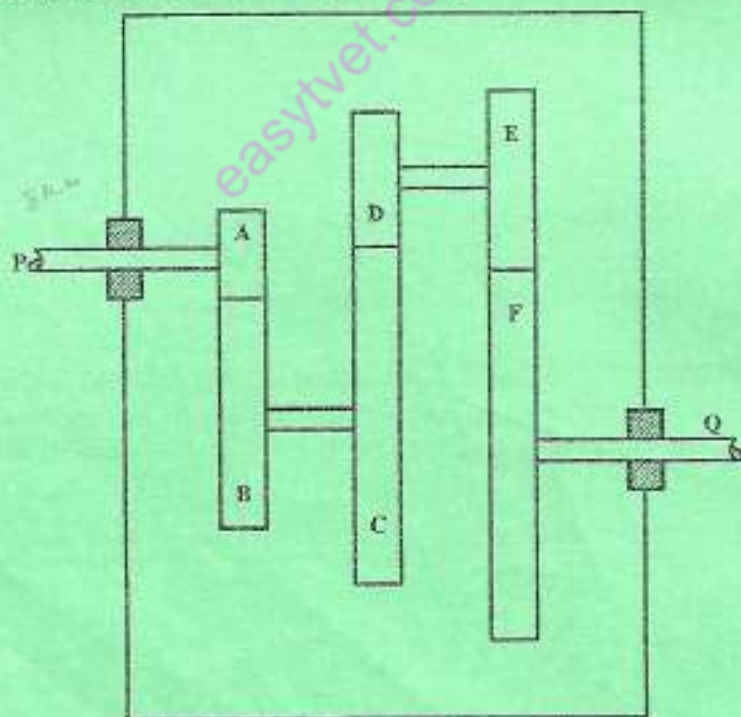


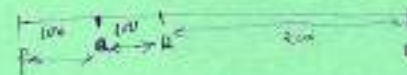
Fig. 2



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. (18 marks)

**Table 1**

Plane	Mass (Kg)	Eccentricity (mm)	Angle ( $^{\circ}$ )
P	10	50	0
Q	8	100	60
R	5	120	90
S	2	50	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  $0.12 \text{ m/s}^2$  on an up gradient of 1 in 100, assuming a gearing efficiency of 94%. (5 marks)

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