2501/202 2503/202 2509/202
2502/202 2508/202
STRENGTH OF MATERIALS AND
MECHANICS OF MACHINES
Oct./Nov. 2021
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;
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.

Turn over

SECTION A: STRENGTH OF MATERIALS

Answer at least TWO questions from this section.

1. (a) Define bending moment at a section of a beam and state its S.I units. (2 marks)

(b) A beam of length L is simply supported at its two ends and carries a uniformly distributed load of intensity W per metre over its full span. Show that the maximum deflection of the beam, y_{max} is given by:

$$y_{max} = \frac{5WL^4}{384EI}$$

Where EI = flexural rigidity (10 marks)

(c) Figure 1 shows a simply supported beam. Determine the:

(i) reactions at the supports P and Q;
(ii) shear force at point R;
(iii) bending moment at point R.

(8 marks)

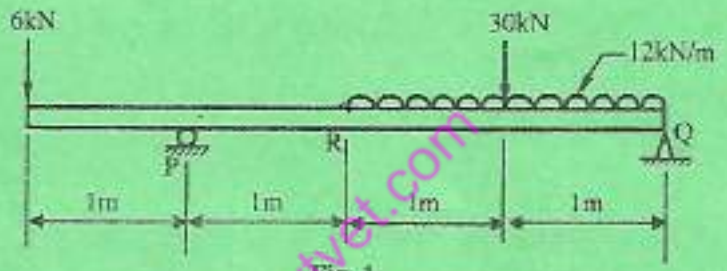

Fig. 1

2. (a) Distinguish between stress and strain as applied to engineering materials. (2 marks)

(b) A cylindrical pressure vessel is required to store 2400 litres of methane gas at a pressure of 600 kN/m^2. The efficiencies of the circumferential and longitudinal joints are to be 90% and 85% respectively. The ultimate strength of the shell plate is 400 MN/m^2 and a factor of safety of 8 is recommended. The cylinder length is to be 1.8 times the diameter. Determine the required:

(i) cylinder diameter;
(ii) cylinder length;
(iii) shell plate thickness.

(11 marks)

(c) A solid rectangular bar has cross sectional dimensions of 10 mm x 8 mm. The 1.5 m long bar is subjected to a tensile load of 4 kN. The modulus of elasticity of the material is 185 GN/m² and the Poisson's ratio is 0.36. Determine the change in the:

(i) length of the bar;
(ii) dimension of the 10 mm side.

(7 marks)

3. (a) A solid circular shaft of diameter d transmits a torque T. Show that the maximum shear stress (τ) in the shaft is given by:

$$(\tau) = \frac{16T}{\pi d^3}$$

(10 marks)

(b) A solid circular shaft is to be designed to transmit 80 kW at a speed of 1400 rev/min. The shear stress in the shaft is not to exceed 50 MN/m² and the angular twist is not to exceed 1.2° per metre length. Determine the minimum shaft diameter required. Take modulus of rigidity G = 80 GN/m². (10 marks)

4. (a) (i) Define a spring as applies to mechanical systems.

(ii) With the aid of sketches, state **three** classes of springs used in mechanical systems.

(8 marks)

(b) Figure 2 shows a cantilever ABC, fixed at A and carrying a vertical load of 50 N at the free end C. The cantilever is made from a 10 mm diameter rod of modulus of elasticity 200 GN/m². Determine the vertical deflection at the free end C. (12 marks)

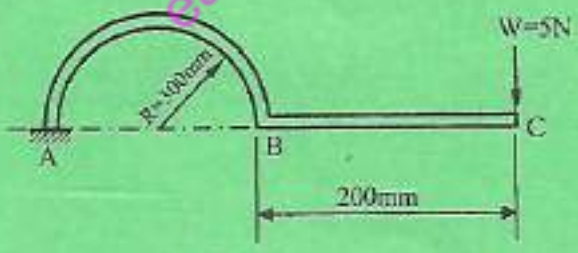

Fig. 2

SECTION B: MECHANICS OF MACHINES

Answer at least TWO questions from this section.

5. (a) With the aid of a diagram, name the elements of a simple epicyclic gear train.

(3 marks)

(b) Figure 3 shows an overdrive type gear box in which, X is the input shaft and Y is the output shaft. The input shaft X transmits 90 kW at 1500 rev/min, while the output shaft runs at 468.75 rev/min. The numbers of teeth on the wheels are P 30, Q 60 and U 40. If the overall efficiency of the gear train is 90%, determine the:

(i) numbers of teeth on wheels R, S and W;

(ii) torque required to fix the gear housing.

(17 marks)

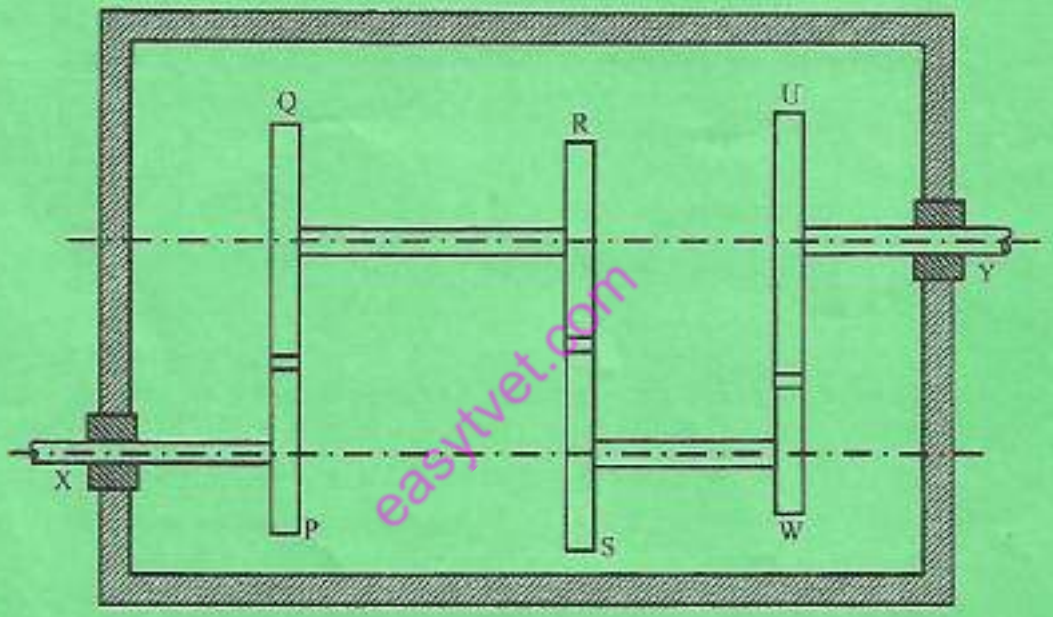

Fig. 3

6. (a) State **three** factors which affect each of the following:

(i) angle of lap of a belt drive;

(ii) torque transmitted by a plate clutch assembly.

(6 marks)

(b) An open flat belt drive is to be designed to transmit 78 kW of power from an electric motor running at 1600 rev/min to a coffee mill, running at 800 rev/min. A 300 mm diameter pulley is to be used on the motor shaft and the centre distance between the shafts is to be 1500 mm. The tension in the tight side of the belt is to be 2.5 kN and the mass of the belts is 0.8 kg/m. If the coefficient of belt friction is 0.52, determine the number of belts required. (14 marks)

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

(ii) Show that for a body in linear motion, the force F applied to the body equals the rate of change of its linear momentum.

(7 marks)

(b) An engine fly wheel has a mass of 40 kg and a radius of gyration of 320 mm. When the engine fuel supply is cut off, the flywheel retards to rest from a speed of 3600 rev/min. In 400 revolutions. Determine the:

(i) angular retardation;

(ii) retarding torque. (11 marks)

(c) The propeller of a light aircraft rotates at 90 rev/min. If its moment of inertia is 200 kgm^2, determine the angular momentum. (2 marks)

8. (a) Distinguish between static and dynamic balancing and give **one** example in each case. (4 marks)

(b) A truck of mass 20 tonnes has road wheels of 720 mm diameter. The total resistance to the motion of the truck is 120 N. The engine develops a power of 80 kW at its maximum speed of 300 rev/min and drives the axle through a gearing system. Determine the:

(i) time taken to reach full speed from rest on level track if the gear ratio is 15/1, transmission efficiency is 92% and the engine torque is constant.

(ii) gear ratio required to produce an acceleration of 0.25 m/s^2 up an incline of 1 in 50 at a transmission efficiency of 88%.

(16 marks)

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