2506/205
AIRCRAFT MECHANICAL TECHNOLOGY I
Oct./Nov. 2019
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING (AIRFRAMES AND ENGINES OPTION)

MODULE II

AIRCRAFT MECHANICAL TECHNOLOGY I

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Non programmable scientific calculator;
Drawing instruments.
*This paper consists of **EIGHT** questions in **TWO** sections; **A** and **B**.*
*Answer **FIVE** questions by choosing 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.

SECTION A: STRENGTH OF MATERIALS

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

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

(i) modulus of elasticity;

(ii) ultimate tensile strength.

(4 marks)

(b) A solid steel bar has a length of 350 mm and a diameter of 18 mm. The bar is subjected to a tensile load of 1 kN. The modulus of elasticity of the steel is 200 GN/m^2 and Poisson's ratio is 0.35. Determine the:

(i) change in the length and diameter of the bar;
(ii) energy stored in the bar.

(8 marks)

(c) A tie bar for an airframe is to be designed to carry a load of 10 kN. An alloy of ultimate strength 400 MN/m^2 is to be used and a factor of safety of 10 is recommended. Determine the required diameters of the tie bar if:

(i) a solid circular section is to be used;

(ii) a hollow section whose outside diameter is 2.5 times the inside diameter is to be used.

(8 marks)

2. (a) Outline **four** assumptions made in the derivation of the theory of pure bending.

(4 marks)

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

(i) reactions at the supports;
(ii) shear force and bending moment at a point midway between A and D.

(8 marks)

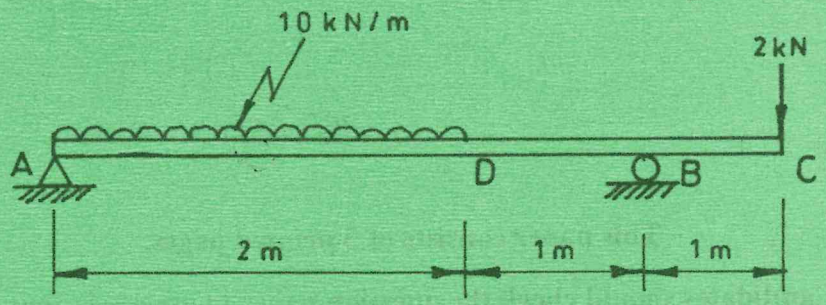

Fig. 1

(c) Figure 2 shows a loaded bent cantilever constructed from a 5 mm diameter rod. Determine the horizontal deflection at B.
Take $E = 204\,GN/m^2$. (8 marks)

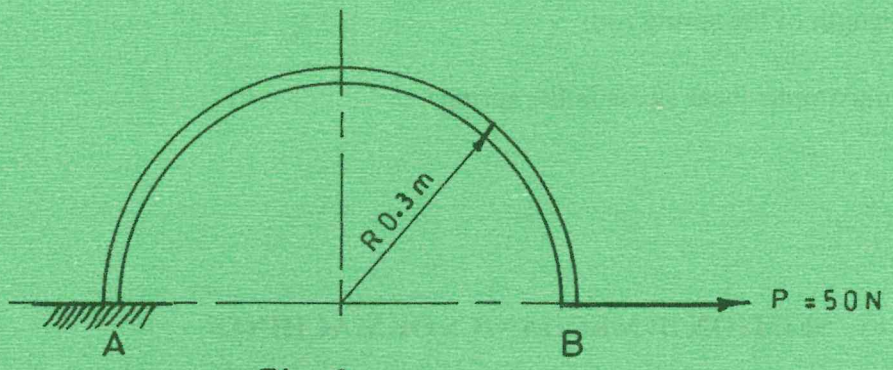

Fig. 2

3. (a) Show that the maximum shear stress τ developed in a solid shaft of diameter d is given by:

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

Where T is the torque. (10 marks)

(b) An aircraft load shaft is to be designed to transmit 100 kW at 1,800 rev/min. The maximum stress in the shaft is not to exceed $60\,MN/m^2$ and the angular twist is not to exceed 1.5° per metre length. If the modulus of rigidity of the shaft materials is $80\,GN/m^2$, determine the minimum permissible diameter of the solid shaft. (10 marks)

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

(i) open and closed coiled helical;
(ii) semi and quarter elliptic leaf.

(8 marks)

(b) Show that the maximum stress τ developed in a close coiled helical spring carrying an axial load W is given by:

$$\tau = \frac{8WD}{\pi d^3}$$

Where: W= axial load
D = coil diameter
d = wire diameter

(6 marks)

(c) A close coiled spring has a coil diameter of 100 mm. The spring rod diameter is 5 mm and the number of coils is 12. The spring carries an axial load of 10 kg. Determine the following:

(i) length of the spring rod;

(ii) maximum shear stress in the spring.

(6 marks)

SECTION B: MECHANICS OF MACHINES

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

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

I. momentum;
II. impulse.

(ii) State the law of conservation of linear momentum.

(6 marks)

(b) A shaft is supported in two bearings 2.4 m apart and projects 0.6 m beyond the bearings at each end. The shaft carries three pulleys; one at each end and one at the middle of its length. The end pulleys have masses of 90 kg and 50 kg and their centres of masses are 3.75 mm and 5 mm from the shaft axis respectively. The centre pulley has a mass of 70 kg and its centre of mass is 6.25 mm from the axis of the shaft. If the pulleys are arranged so as to give static balance:

(i) determine the angular displacement of the pulleys;

(ii) sketch the end view of this arrangement.

(14 marks)

6. (a) Show that the mass moment of inertia I of a thin rod of length L and mass m rotating about the centre is given by:

$$I = \frac{mL^2}{12}$$

(8 marks)

(b) A flywheel of mass 80 kg has a radius of gyration of 100 mm. The flywheel is accelerated from an initial speed of 300 rev/min in a time of 20 seconds. If the torque needed to overcome bearing friction is 2.0 Nm, determine the:

(i) total torque applied;
(ii) work done;
(iii) average input power from the driving motor.

(12 marks)

7. (a) Outline **two** applications of each of the following types of clutches:

(i) multi-plate clutch;

(ii) centrifugal clutch.

(4 marks)

(b) A belt drive consists of two V-belts running on grooved pulleys of the same size. The angle of the groove is 32°. The cross sectional area of each belt is 720 mm^2 and the coefficient of friction, $\mu = 0.15$. The density of the belt material is 1,200 kg/m^3 and the maximum safe stress in the material is 8 MPa. Determine the:

(i) power transmitted between the two pulleys of 300 mm diameter rotating at 1,000 rev/min;

(ii) shaft speed in rev/min at which the power transmitted would be a maximum.

(16 marks)

8. (a) Illustrate a simple epicyclic gear train. (5 marks)

(b) A gear train having 20 teeth of involute form with 6.5 mm module and an angle of obliquity of 20° drives another wheel of the same dimensions. The addendum of the gears is 6.5 mm. Determine the:

(i) length of the arc of contact;

(ii) addendum required if the arc of contact was altered to be maximum.

(15 marks)

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