2506/205
AIRCRAFT MECHANICAL TECHNOLOGY I
June/July 2018
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;
Mathematical tables/Non-programmable scientific calculator;
Drawing instruments.

This paper consists of ***EIGHT*** *questions in* ***TWO*** *sections; A and B.*
Answer ***FIVE*** *questions in total taking at least* ***TWO*** *questions from each section.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.
Candidates should answer the questions in English.

This paper consists of 6 printed pages.

Candidates should check the question paper to ascertain that all 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) (i) Define the following terms as applied to materials:

I. tensile strength;
II. spring stiffness;
III. Poisson's ratio.

(ii) List **two** factors that determine the choice of factor of safety of a component.

(iii) State Hooke's law. (6 marks)

(b) Figure 1 shows a tie rod made of two parts connected by a bolt. The rods are to carry a tensile load of 200 kN. The ultimate shear and tensile stress for the bolt and rod are 70 MN/m^2 and 250 MN/m^2 respectively. Allowing a factor of safety of 6 for both bolt and rod, determine suitable diameters for the:

(i) connecting bolt;
(ii) rod. (6 marks)

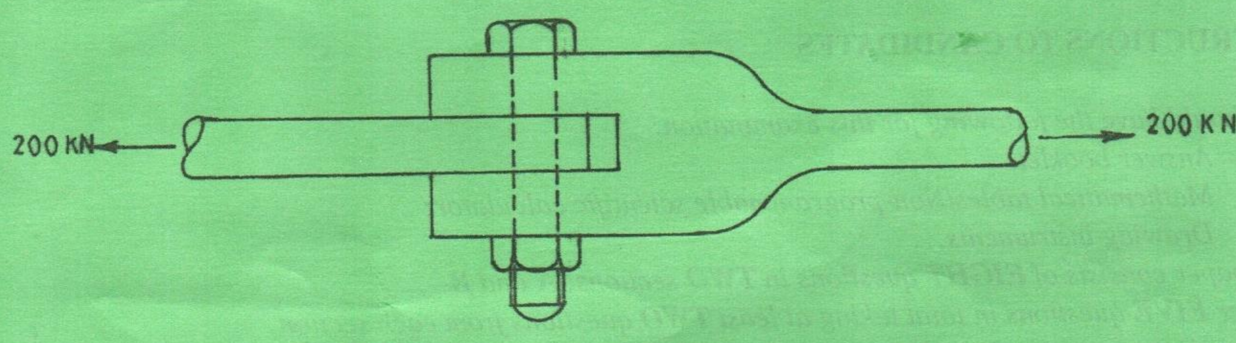

Fig. 1

(c) A cylindrical mild steel bar of 50 mm diameter and 150 mm long is enclosed by a bronze tube of the same length having an outside diameter of 70 mm and inside diameter of 50 mm. The compound strut formed is subjected to an axial compressive load of 150 kW. Determine the:

(i) stress in the steel rod and bronze tube;
(ii) shortening of the strut.

Take:

$E_{steel} = 200\ MN/m^2$;
$E_{bronze} = 100\ MN/m^2$. (8 marks)

Stress

2. (a) Define the following terms as applied to thin cylinders:

(i) diametral strain;
(ii) bulk modulus. (4 marks)

(b) From first principles, show that for a thin cylinder subjected to internal pressure, the hoop stress σ_H is given by the equation:

$$\sigma_H = \frac{pd}{2t}.$$

Where: p = internal pressure;
d = diameter of the cylinder;
t = cylinder thickness. (6 marks)

(c) A thin cylinder of 80 mm internal diameter, 240 mm long with walls 3.5 mm thick is subjected to an internal pressure of 9 MN/m^2. Determine the:

(i) change in internal diameter;
(ii) hoop stress;
(iii) longitudinal stress;
(iv) change in internal volume;
(v) circumferential stress if the joint efficiency is 54%.

Take: $E = 210\,GN/m^2$;
$\nu = 0.4$. (10 marks)

3. (a) Define strain energy. Total strain Stress energy stored in a body (2 marks)

(b) From first principles, show that for a bar of uniform cross-sectional area, subjected to a tensile force, the resilience is given by the expression:

Resilience = $\frac{1}{2}$ × strain × stress. (9 marks)

(c) A beam of 50 mm diameter, 4 M long is simply supported at the ends and carries a uniformly distributed load of 30 N/m for the whole of its length. Using Castigliano's first theorem, determine the deflection at the centre of the beam.

Take: $E = 208GN/m^2$. (9 marks)

4. (a) State **two** assumptions made in the simple torsion theory. (2 marks)

(b) A composite shaft is used to transmit 400 kW at a speed of 750 rev/min. The composite shaft is made by passing a solid cylindrical steel shaft of 70 mm diameter and 2 m long through the centre of a hollow cylindrical brass shaft 2 m long, 70 mm and 90 mm internal and external diameters respectively. The two shafts are then rigidly joined together at their ends. Determine the:

(i) maximum and minimum stresses in the two shafts;
(ii) angle of twist in degrees;
(iii) total strain energy stored.

Take: $G\ for\ brass = 35\ GN/m^3$;
$G\ for\ steel = 78\ GN/m^3$. (18 marks)

SECTION B: MECHANICS OF MACHINES

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

5. (a) State **two** conditions necessary for complete dynamic balance for a rotating shaft carrying several masses. (2 marks)

(b) Four masses A, B, C and D are carried on a shaft with their centres of mass 140 mm, 180 mm, 80 mm and 50 mm respectively. The massess are A = 10 kg, B = 20 kg, C = 22 kg and D = 16 kg. The distance of the planes of rotation measured from mass A are B = 4 m, C = 5 m and D = 7 m. Two balance masses are fitted as follows: One midway between A and B whose centre of mass from the shaft axis is 10 mm and the other midway between C and D whose centre of mass from the shaft axis is 70 mm. Determine the:

(i) balance masses;
(ii) angular position of the masses with respect to A. (18 marks)

6. (a) Figure 2 shows a simple gear train. Show that the velocity ratio between the driver A and the driven B is impended of the number of teeth on the idler gear wheel. (5 marks)

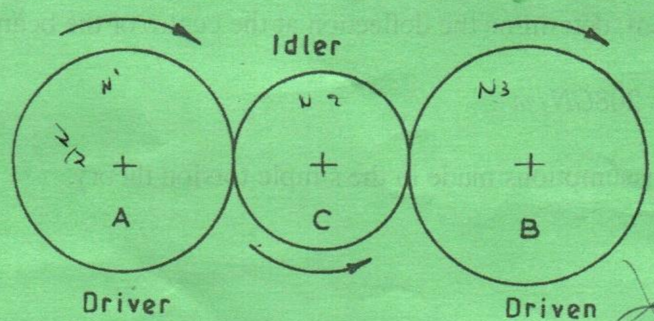

Fig. 2

(b) Figure 3 shows two shafts A and B in the same straight line geared together through an intermediate parallel shaft C. The wheel and pinion connecting A and C have a module of 4, those connecting C and B have a module of 7. The speed of B is to be about, but less than $\frac{1}{10}$ that of A. If the two pinions have each 24 teeth, determine the:

Axial force.

(i) suitable number of teeth for each wheel;
(ii) actual gear ratio;
(iii) centre distance between shaft A and C. (15 marks)

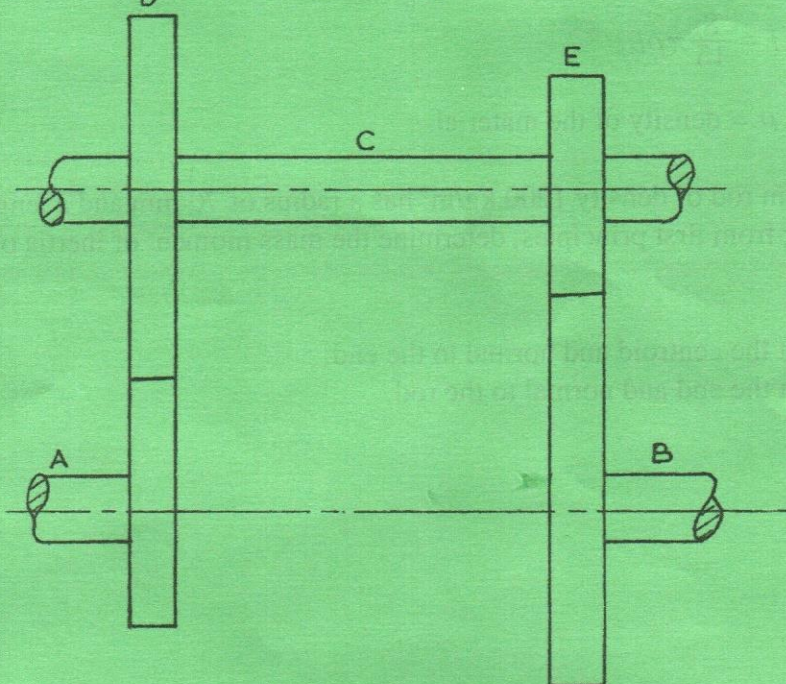

Fig. 3

7. (a) Assuming uniform wear, show that the torque T transmitted by a plate clutch is given by the equation:

$T = \mu WR$

Where:

μ = coefficient of friction;
W = axial thrust;
R = mean radii of faces on contact. (12 marks)

(b) A thrust of 40 kN along the axis of a shaft is taken by a cone clutch. The outer and inner diameters are 240 mm and 130 mm respectively. The semi-angle of the cone is $50°$ and the coefficient of function $\mu = 0.2$. Assuming that the intensity of pressure is uniform over the surfaces of the cone clutch, determine the:

(i) intensity of pressure; 7

(ii) power absorbed in friction if the shaft speed is 300 rev/min. (8 marks)

8. (a) Show that the mass moment of inertia of a solid sphere of radius R about the diametral axis is given by the expression:

$$I = \frac{8}{15}\pi\rho R^5$$

Where: ρ = density of the material. (10 marks)

(b) A uniform rod of density 1200 kg/m^3 has a radius of 70 mm and a length of 3 m. Working from first principles, determine the mass moment of inertia of the rod about an axis:

(i) at the centroid and normal to the end;

(ii) at the end and normal to the rod. (10 marks)

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