2506/205
AIRCRAFT MECHANICAL
TECHNOLOGY I
Oct./Nov. 2023
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 indicated.
All dimensions are in millimetres unless stated otherwise.
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) Explain the following terms as applied to torsion and state their S.I units:

(i) modulus of rigidity;
(ii) polar second moment of area.

(6 marks)

(b) A solid circular shaft of diameter d and length L transmits power. Show that the maximum shear stress τ induced in the shaft is given by $\tau = \frac{G\theta d}{2L}$.

Where: G = modulus of rigidity;
θ = angular twist.

(6 marks)

(c) A solid stepped shaft of length 1. 5 m has a diameter of 30 mm over a length of 0.8 m and a diameter of 40 mm over its remaining length of 0.7 m. The shaft transmits a power of 80 kW at a rotational speed of 1500 rev/min. If the total angular twist of the shaft is $4.7°$, determine the modulus of rigidity of the material. (8 marks)

2. (a) A straight elastic bar of length L is subjected to a bending moment M. Show that the strain energy $\cup$ stored in the bar is given by $\cup = \frac{M^2 L}{2EI}$.

Where EI = flexural rigidity of the bar. (7 marks)

(b) A cylindrical pressure vessel has a diameter of 2.4 m and a shell thickness of 4 mm. The vessel stores a gaseous fuel at a pressure of 600 kN/m². Working from first principles, determine the strain in the vessel along the:

(i) circumferential direction;
(ii) axial direction.

Take modulus of elasticity $E = 200\,GN/m^2$. (13 marks)

3. (a) Figure 1 shows the loading and cross section of a cantilever timber beam. The modulus of elasticity of the timber is 40 GN/m² and the maximum deflection of the beam is not to exceed 5 mm. From first principles, determine the maximum permissible uniformly distributed load which the beam can carry. (13 marks)

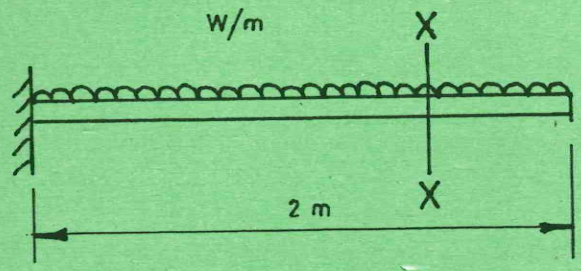
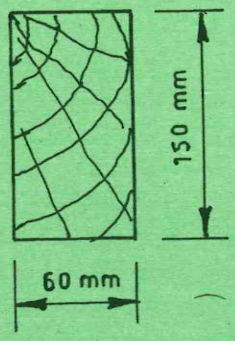


Fig. 1



Section X–X

(b) An alloy pipe has a length of 0.2 m, an internal diameter of 25 mm and a thickness of 4 mm. When subjected to a compressive load P, the pipe thickness increases by 0.005 mm. The modulus of elasticity of the alloy is 160 GN/m² and Poisson's ratio is 0.28. Determine the:

(i) reduction in length of the pipe;
(ii) applied load P.

(7 marks)

4. (a) With the aid of sketches, distinguish between a spiral spring and a helical spring.

(4 marks)

(b) A close coiled helical spring carries an axial load W. Show that its angular twist θ is given by $\theta = \frac{16WD^2n}{Gd^4}$.

Where: D = coil diameter;
n = number of coils;
G = modulus of rigidity;
d = wire diameter.

(7 marks)

(c) The following data refers to an open coiled helical spring carrying an axial load:

free length of the spring = 300 mm;
number of coils = 5;
axial load carried = 40 N;
rod diameter = 10 mm;
coil diameter = 100 mm.

Determine the:

(i) helix angle α;
(ii) maximum bending stress in the spring.

(9 marks)

SECTION B: MECHANICS OF MACHINES

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

5. (a) With the aid of sketches, distinguish between a simple and a compound spur gear train. (4 marks)

(b) A simple epicyclic gear train has a sun wheel with 50 teeth and three planet wheels each having 25 teeth. The input shaft is integral with the sun wheel and it transmits 60 kW at 300 rev/min. The annular wheel is fixed and the output shaft is integral with the planet carrier. The overall efficiency of the gear train is 80%.
Draw a labelled diagram of the gear train and hence, determine the:

(i) rotational speed of the driven shaft;
(ii) fixing torque required for the annulus. (16 marks)

6. (a) With the aid of a labelled diagram, describe the construction of a cone clutch. (6 marks)

(b) Assuming uniform pressure over the friction surfaces, show that the torque T, transmitted by a plate clutch is given by:

$$T = \frac{2}{3}\mu W \frac{(r_2^3 - r_1^3)}{(r_2^2 - r_1^2)}.$$

Where: $r_2 r_1$ = outside and inside radii of the friction surfaces;
μ = coefficient of friction;
W = axial spring load. (9 marks)

(c) The following data refers to a place clutch assembly:

outside diameter of friction ring = 320 mm;
inside diameter of friction ring = 160 mm;
coefficient of friction $\mu = 0.45$;
number of pairs of friction surfaces = 2;
axial spring load pressing the surfaces = 1. 5 kN;
rotational speed = 1800 rev/min.

Assuming uniform pressure, determine the power transmitted by the assembly. (5 marks)

7. A shaft of length 6 m carries three eccentric pulleys A, B and C. Pulley A is fitted at one end of the shaft, pulley C is at the other end and pulley B is located 2 m away from A.
Table I shows the masses, eccentricities and angular dispositions of the pulleys.

Table I

Pulley	A	B	C
Mass m (kg)	2.0	1.0	0.5
Eccentricity r (mm)	200	200	200
Angular position (°)	0	60	120

In order to restore complete dynamic balance, a mass P is to be fitted midway between the planes of A and B and a second balance mass Q is to be fitted midway between the planes of B and C. Both balance masses are to be fixed at an eccentricity of 200 mm.
Determine the required magnitude and angular disposition of:

(a) mass Q; (11 marks)

(b) mass P. (9 marks)

8. (a) (i) Explain the term linear momentum and state its S.I units.

(ii) Show that for a body moving linearly, the accelerating force F equals the rate of change of its linear momentum.

(7 marks)

(b) The flywheel of an engine has a moment of inertia of 5 kgm^2. The flywheel accelerates from rest to a speed of 3000 rev/min in 380 revolutions. If the friction torque at the bearings is 3.25 Nm, determine the:

(i) angular acceleration;
(ii) time taken;
(iii) accelerating torque.

(10 marks)

(c) A light aircraft has a propeller of mass 50 kg and a radius of gyration of 1800 mm. Determine angular momentum of the propeller at an instant when it rotates at 300 rev/min. (3 marks)

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