2506/205
AIRCRAFT MECHANICAL TECHNOLOGY I
Oct./Nov. 2021
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 all by choosing at least **TWO** questions from each section.*
All questions carry equal marks.
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.

This paper consists of 6 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) (i) State **three** assumptions made in the theory of torsion.

(ii) Derive the pure torsion equation.

(13 marks)

(b) A solid steel shaft is required to transmit 90 kW at 3000 rev/min. Taking the allowable shear stress as 80 N/mm², determine the suitable diameter of the shaft, if the maximum torque transmitted exceeds the mean torque by 25%.

(7 marks)

2. (a) Show that for an open coiled helical spring subjected to an axial load W, the deflection δ is given by the equation:

$$\delta = 2\pi nWR^3 \sec\alpha\left[\frac{\cos^2\alpha}{GJ} + \frac{\sin^2\alpha}{EI}\right].$$

Where:

α	=	helix angle;
n	=	number of coils;
R	=	mean radius of the coil;
G	=	Modulus of rigidity of the spring material;
E	=	Modulus of elasticity of the spring material.

(10 marks)

(b) An open coiled helical spring consists of 12 coils each of 40 mm mean diameter, 8 mm wire diameter and 20° angle of helix. If the spring is subjected to an axial load of 400 N, determine the:

(i) linear deflection;
(ii) angular deflection.

Take: E = 200 GN/m²;
G= 82 GN/m².

(10 marks)

3. (a) Define each of the following terms as applied to beams:

(i) shear force;
(ii) bending moment.

(2 marks)

(b) A load of 40 kN is suspended by a steel pipe of 30 mm external diameter. If the ultimate tensile strength of steel is 400 N/mm² and the factor of safety is 4, determine the thickness of the pipe.
Take E = 200 kN/mm²

(8 marks)

(c) A timber beam 20 cm wide and 40 cm deep is simply supported over a length of 8 m. It carries a uniformly distributed load of 2.5 kN/m over the whole length and three point loads each 'W' N placed at mid length and quarter length from each end. If the maximum permissible bending stress is not to exceed 9 MN/m², determine the maximum value of W. (10 marks)

4. (a) Derive expressions for the circumferential stress and longitudinal stress in a thin walled pressure vessel.

(10 marks)

(b) A hollow cylindrical shell of inner diameter 600 mm, thickness 6 mm and length 5 m is subjected to an internal pressure of 7 N/mm². Determine the change in the volume.
Take: E= 200 MN/m²;
$\upsilon = 0.3$.

Where υ is the Poisson's ratio.

(10 marks)

SECTION B: MECHANICS OF MACHINES

Answer at least TWO questions form this section.

5. (a) Assuming uniform pressure, show that the torque T transmitted by a cone clutch is given by:

$$T = \frac{2}{3}\mu W\left[\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}\right]\text{cosec}\,\beta \ .$$

Where: W = axial thrust;
μ = coefficient of friction;
r_1 = maximum radius of clutch;
r_2 = minimum radius of clutch;
β = half the included angle of the clutch.

(12 marks)

(b) A cone clutch has a bearing surface with a mean diameter of 400 mm and a cone angle of 40°. The coefficient of friction is 0.3 and the axial width of the conical bearing surface is 120 mm. The maximum normal pressure is 40 kN/m². Assuming constant wear condition, determine the maximum power that can be transmitted at 10 rev/s without the clutch slipping. (8 marks)

6. (a) With the aid of sketches, describe the construction of each of the following types of gear drives:

(i) simple gear train;
(ii) simple epicyclic gear train.

(6 marks)

(b) Derive the expression for the overall velocity ratio of the compound gear train shown in figure 1 in terms of the number of teeth on the gear wheels. (5 marks)

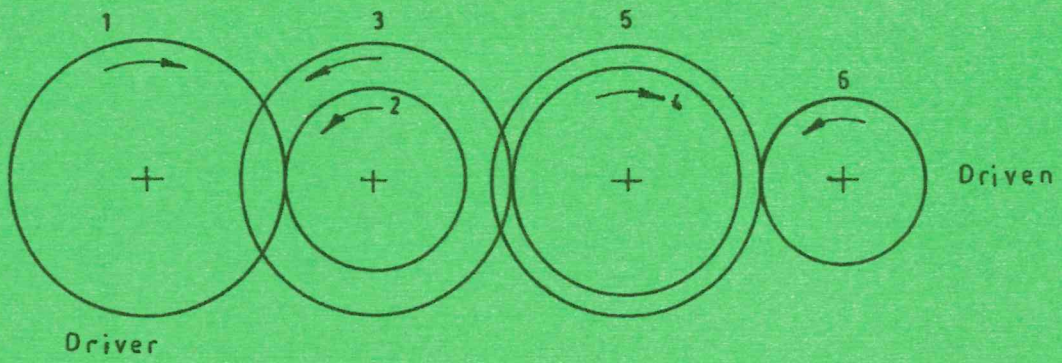

Fig.1

(c) In an epicyclic gear train, an arm carries two gears A and B having 36 and 45 teeth respectively. If the arm rotates at 150 rev/min in the anticlockwise direction about the centre of the gear A. Determine the speed of gear B when:

(i) A, is fixed;
(ii) A, rotates at 300 rev/min in the clockwise direction.

(9 marks)

7. (a) Define each of the following terms as applied to kinematics:

(i) angular velocity;
(ii) linear acceleration.

(2 marks)

(b) Show that the centripetal acceleration 'a' for a body moving round a circular track of radius 'r' with an angular velocity 'ω' is given by the equation; $a = r\omega^2$. (7 marks)

(c) The motion of a body is given by $a = t^3 - 3t^2 + 5$, where 'a' is the acceleration in m/s^2 and 't' is the time in seconds. The velocity of the body at $t = 2$ seconds in 6 m/s, and displacement is 9 metres.

Determine the:

(i) displacement at $t = 4$ seconds;
(ii) velocity at $t = 4$ seconds.

(11 marks)

8. (a) (i) Define the term 'area moment of inertia'.

(ii) State the perpendicular axes theorem.

(4 marks)

(b) Show that the second moment of area I_{xx} of a solid circular section of radius R is given by the equation:

$$I_{xx} = \frac{\pi R^4}{4} .$$

Where, X-X is an axis through the centroid.

(7 marks)

(c) The moment of inertia of a rectangular section about XX and YY axes passing through centroid are $310 \times 10^6\,mm^4$ and $45.6 \times 10^6\,mm^4$ respectively. Determine the dimensions of the section.

(9 marks)

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