2506/205
AIRCRAFT MECHANICAL TECHNOLOGY I
June/July 2017
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING (AIRFRAMES AND ENGINE 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 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 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) Define the following terms:

(I) stress;
(II) strain.

(ii) Distinguish between direct stress and sheer stress. (4 marks)

(b) A rod 800 mm long, 50 mm diameter has a hole drilled out along its length. The hole is 35 mm diameter and 150 mm long. If a tensile load of 200 kN is applied at its ends, determine the:

(i) stress in each part of the rod;

(ii) total extension of the rod.

Take $E = 80\ GN/m^2$. (16 marks)

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

(b) Derive the simple torsion theory equation. (9 marks)

(c) A solid shaft of 120 mm diameter and length 300 mm transmits 90 kW at 280 rev/min. Determine the:

(i) maximum sheer stress set up in the shaft;

(ii) angle of twist in degrees. (7 marks)

(d) If the shaft in 2 (c) was now bored in order to reduce it's weight to produce a tube of 120 mm outside diameter and 80 mm inside diameter, determine the torque that would be carried if the same maximum sheer stress is not to be exceeded.

Take $E = 80\ GN/m^2$ (2 marks)

3. (a) Show that for an open coiled helical spring subjected to an axial load W, the spring stiffness is give by the equation:

$$S = \frac{\cos \alpha}{2\pi nR^3 \left\{ \frac{\cos^2 \alpha}{GJ} + \frac{\sin^2 \alpha}{EI} \right\}}$$

Where: S = Spring stiffness;
α = Helical angle of the wire;
n = Number of coils;
E = Young's modulus of elasticity;
G = Young's modulus of rigidity;
I = Second moment of area;
J = Polar second moment of area;
R = Radius of coil.

(11 marks)

(b) The maximum stresses due to twisting and bending in an open coiled helical spring subjected to an axial torque are 125 MN/m^2 and 155 MN/m^2 respectively. The spring has the following specifications:

Number of coils = 10;
Mean spring diameter = 12 d;
Wire diameter = d.

Determine the angular twist at the end of the spring.

Take: $E = 208\ GN/m^2$
$G = 80\ GN/m^2$

(9 marks)

4. (a) Define the following terms:

(i) strain energy;
(ii) resilience.

(2 marks)

(b) State Castigliano's first theorem for deflection. (2 marks)

(c) Figure 1 shows a cantilever of 60 mm diameter loaded with a vertical force, 800 N. Considering the strain energy resulting from bending only, determine the vertical deflection of point A.

Take: E = $200\ GN/m^2$

(16 marks)

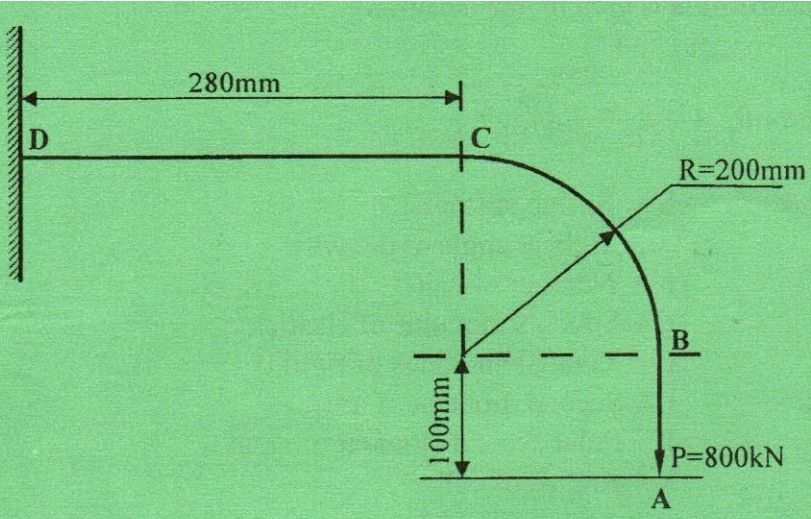

Fig. 1

SECTION B: MECHANICS OF MACHINES

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

5. (a) Show that for a cone clutch and assuming constant pressure over the contact area, the torque transmitted is given by the equation:

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

Where:
- W = axial force;
- μ = Coefficient of friction;
- r_1 = Outer mean radius;
- r_2 = Inner mean radius;
- β = Angle of the conical surface;
- P = Normal pressure between the surfaces;
- T = Torque transmitted.

(9 marks)

(b) An open belt drive connects two pulleys 1.4 m and 0.8 m diameter on parallel shafts 4 m apart. The belt has a mass of 0.7 kg/m length, and the maximum tension in it is not to exceed 3 kN. The 1.4 m diameter pulley runs at 250 rev/min. If $\mu = 0.5$ and due to slip, the velocity of the driven shaft is only 380 rev/min. Determine the:

(i) torque on each of the two shafts;
(ii) power transmitted;
(iii) power lost due to friction;
(iv) efficiency of the drive. (11 marks)

6. (a) (i) Define velocity ratio as applied to geared systems.

(ii) With the aid of a diagram, distinguish between a simple gear train and a compound gear train.

(4 marks)

(b) Figure 2 shows an epicyclic gear train in which the gear wheel D is held stationary by the shaft A and the arm B is rotated at 300 rev/min. The gear wheel E and F are fixed together and rotate freely on the pin carried by the arm. The gear wheel G is rigidly attached to the shaft C. The number of teeth in each wheel are:

E = 25, F = 50, G = 35. Determine the:

(i) speed of the shaft C, stating the direction of rotation relative to that of B;

(ii) torque required to hold the shaft A stationary if the gear system transmit 8 kW. Neglect friction losses.

(16 marks)

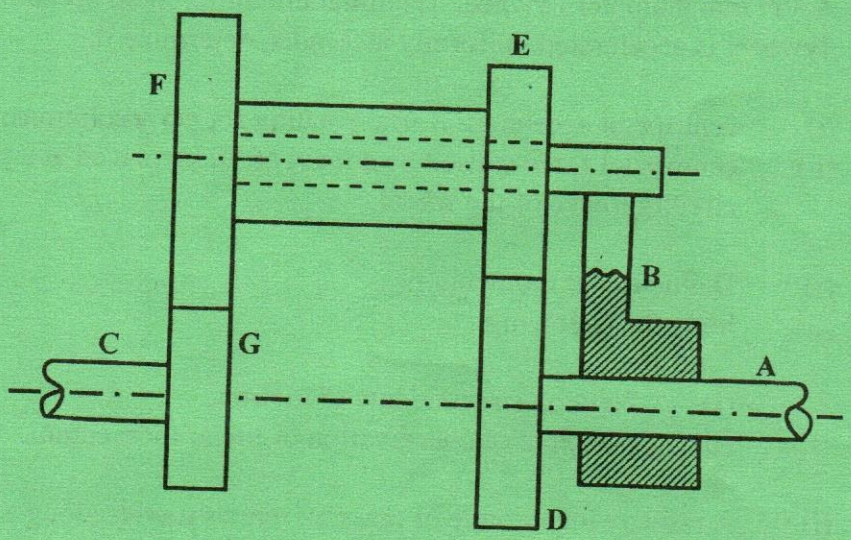

Fig. 2

7. (a) Define the following terms as applied to motion:

(i) linear velocity;

(ii) angular acceleration.

(2 marks)

(b) A motorist stops at two stations 8.5 km apart. Between the stations, he takes 70 seconds to accelerate uniformly to a speed of 30 m/s and then travels at this speed for a time T seconds before decelerating uniformly for the final 0.9 km. Sketch the velocity time graph for the journey and hence determine the:

(i) deceleration and acceleration;
(ii) value of T;
(iii) average velocity for the journey. (7 marks)

(c) A point on wheel tread of a vehicle tyre 0.8 m in diameter is uniformly accelerated to 34 m/s in 25 seconds. Determine the:

(i) initial and final angular velocity of the tyre in rev/min;
(ii) angular acceleration;
(iii) total number of revolutions made. (6 marks)

(d) A 360 mm diameter flywheel has initial circumferential speed of 4 m/s. If the flywheel is accelerated uniformly at 2 rad/s, determine the:

(i) centripetal acceleration after rotating for 60 revolutions;
(ii) centripetal force caused by a mass of 50 kg placed at a point on the circumference of the wheel. (5 marks)

8. (a) (i) Define linear momentum.
(ii) State the following:

(I) Newton's second law of motion;
(II) principle of conservation of linear momentum. (5 marks)

(b) (i) A railway locomotive of mass 50 tonnes travels along a level track at 24 km/h and collides with another locomotive of mass 15 tonnes travelling in the opposite direction at 30 km/h. After impact, the 50 tonne wagon travels in the same direction as before with a speed of 2 km/h. Determine the speed and direction of the second wagon.

(ii) A shell is fired from a gun at 800 m/s at an angle of 30° to the horizontal. If the shell's mass is 15 kg and the velocity of recoil of the gun is to be limited to 1.4 m/s, determine the mass of gun required. (10 marks)

(c) A disc of moment of inertia $8 \times 10^{-4} kgm^2$ is rotating freely about an axis through the centre at 60 rev/min. Determine the new revolutions per minute if some wax of mass 0.004 kg is dropped gently on to the disc 0.08 m from it's axis.

(5 marks)

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