2506/205
AIRCRAFT MECHANICAL TECHNOLOGY I
June/July 2022
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 taking 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 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 form this section.*

1. (a) Define the following terms as applied in strength and properties of materials:

(i) strain;
(ii) Young's modulus of elasticity;
(iii) Poisson's ratio. (3 marks)

(b) For a circular bar of diameter 'd' and Length 'L', show that the volumetric strain ε_{vol} is given by:

$$\varepsilon_{vol} = \varepsilon_x(1-2\upsilon).$$

Where: ε_x = longitudinal strain;
υ = Poisson's ratio.

(7 marks)

(c) A cylindrical air compressor reeiver has a diameter of 2 m with a thickness of 12. 5 mm. The efficiency of longitudinal and circumferential joints are 80% and 60% respectively, and the stress is limited to 100 MN/m^2. Working from first principles, determine the safe working pressure. (10 marks)

2. (a) (i) State the pure torsion equation and define the parameters involved.
(ii) List **four** factors which the torque transmitted by a shaft depends on.

(7 marks)

(b) Show that the strain energy U stored in a solid shaft subjected to a torque τ is given by:

$$U = \frac{\tau^2}{4G} \times Volume.$$ (6 marks)

(c) A solid shaft of length 2. 5 m and diameter 125 mm transmits power of 110 kW at a speed of 320 rev/min.
Determine the:
(i) maximum shear stress;
(ii) angular twist;
(iii) strain energy stored.
Take: G = 80 GN/m^2. (7 marks)

3. (a) State the Castigliano's theorem for linear deflection. (2 marks)

(b) Figure 1 shows a cantilever beam AB of length L, supporting a uniformly distributed load W N/m. Show that the deflection δ at the free end A is given by:

$$\delta = \frac{WL^4}{8EI}.$$

Where EI = flexural rigidity. (7 marks)

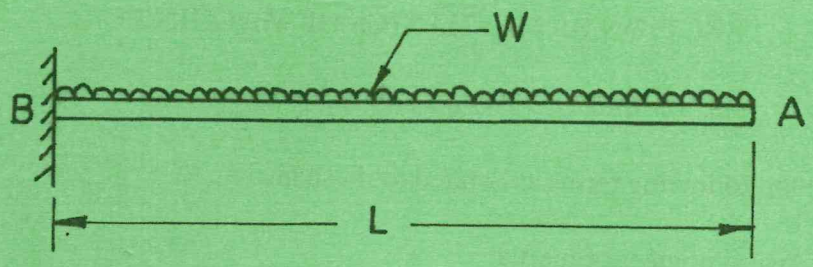

Fig.1

(c) Figure 2 shows a bend cantilever beam ABC. Determine the vertical deflection at point A. Take flexural rigidity EI = 26 kNm². (11 marks)

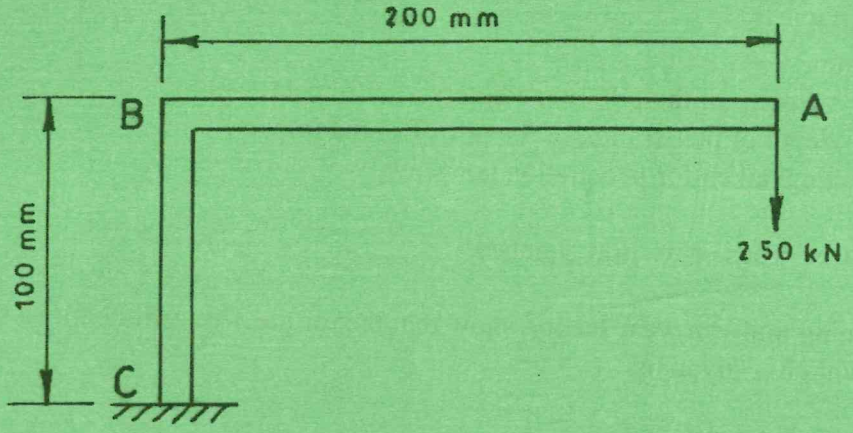

Fig.2

4. (a) List **two** engineering applications of springs. (2 marks)

(b) For **two** coil springs connected in series, show that the composite stiffness Kc is given by:

$$Kc = \frac{K_1 K_2}{K_1 + K_2} .$$

Where K_1 and K_2 = stiffness of spring 1 and spring 2 respectively.

(7 marks)

(c) The following data refers to a close-coiled helical spring required to absorb 2.25 kJ of energy:

- maximum shear stress = 400 MN/m²;
- maximum deflection = 250 mm;
- mean diameter = 8 × wire diameter;
- modulus of rigidity G = 70 GN/m².

Determine the:

(i) diameter of the wire;
(ii) number of coils required.

(11 marks)

SECTION B: MECHANICS OF MACHINES

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

5. (a) Define the following terms as applied to mechanics:

(i) mass moment of inertia;
(ii) radius of gyration. (4 marks)

(b) A pile driver of mass 300 kg is used to drive a pile of mass 500 kg vertically into the ground. The pile drives falls freely through a height of 4 m. The ground resistance is 230 kN and the coefficient of restitution between the driver and the pile is 0.8.
Determine the:
(i) velocity of the pile immediately after impact;
(ii) depth of penetration of the pile after the impact;
(iii) time taken for penetration per blow. (16 marks)

6. (a) List **three** types of friction clutches. (3 marks)

(b) Assuming uniform wear theory, show that the torque T transmitted by a single plate clutch is given by

$$T = \mu W\left(\frac{r_1 + r_2}{2}\right).$$

Where: r_1 and r_2 = outer and inner radii of friction surfaces respectively;
W = axial force;
μ = coefficient of friction. (7 marks)

(c) Two co-axial rotors A and B are connected by single plate clutch of 300 mm and 220 mm external and internal diameters respectively. The axial load on the clutch is 700 N. The masses and radii of gyration of A and B are 1100 kg, 200 mm, and 800kg, 350 mm respectively, with a coefficient of friction of 0.3. The rotor A runs at 1200 rev/min, while B is stationary when the clutch is suddenly engaged.
Assume uniform wear, determine the:

(i) time taken by rotors A and B to reach the same speed;
(ii) kinetic energy lost during the clutch slip. (10 marks)

7. (a) List **two** conditions necessary for complete dynamic balance of rotating masses. (2 marks)

(b) With the aid of a sketch, explain the construction of an epicyclic gear train. (6 marks)

(c) Figure 3 shows a turbine rotor which is out of balance to the extent of 1.5 kg at 0.45m radius in the planes AA and 2 kg at 0.6 m radius in the plane BB, the angular position of BB from AA is 125°. To balance the masses, two masses are

fitted to planes XX and YY at radii of 0. 525 m and 0.45 m respectively. Determine the:

(i) magnitude of the masses;
(ii) angular positions of the masses relative to plane AA.

(12 marks)

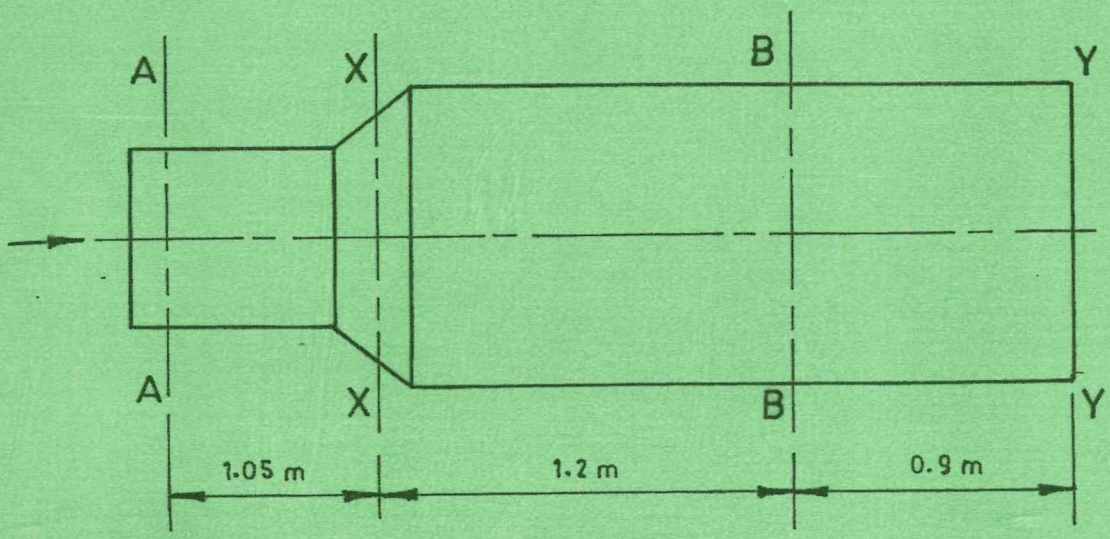

Fig.3

8. (a) List **three** advantages of belt drives over gear drives. (3 marks)

(b) An accelerated geared system has two wheels A and B having moments of inertia of 1_A and I_B respectively, and mesh with a speed ratio of 'n'. Show that the equivalent moment of inertia of the system referred to wheel A is given by

$$I_{equiv} = I_A + n^2 I_B.$$

Where I_{equiv} = Equivalent inertia referred to gear A. (7 marks)

(c) The following data relate to a v-belt drive:

- speed of motor pulley = 960 rev/min;
- speed reduction ratio = 2. 5:1;
- centre distance = 750 mm;
- diameter of motor pulley = 400 mm;
- cross-sectional area of belt = 475 mm^2;
- yield stress for belt material = 240 MN/m^2;
- factor of safety = 6;
- density of belt material = 110kg/m^3;
- groove angle = 36°.

Taking friction coefficient as 0.3, determine the number of belts required to transmit 10kW. (10 marks)

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