

B.E DEGREE EXAMINATIONS: APRIL 2015

(Regulation 2009)

Seventh Semester

AERONAUTICAL ENGINEERING

AER141: Vibration & Aeroelasticity

Time: Three Hours**Maximum Marks: 100****Answer all the Questions:-
PART A (10 x 1 = 10 Marks)**

1. The natural frequency of a spring with stiffness k and self mass of m_s
 - a) Infinite
 - b) $\sqrt{k/m_s}$
 - c) $\sqrt{k/3m_s}$
 - d) $\sqrt{3k/m_s}$
2. If the spring with stiffness k cut into two equal parts and connected in parallel, then equivalent stiffness will be
 - a) $4k$
 - b) k
 - c) $k/4$
 - d) $8k$
3. The reduction of the amplitude ratio in the presence of damping is very significant when the frequency ratio is
 - a) 0.5
 - b) 0.707
 - c) 1.0
 - d) 1.414
4. Equivalent damping for Coulomb damped system when the system is undergoing a harmonic vibration is
 - a) $\alpha / (\pi\omega)$
 - b) $4F_d / (\pi\omega X_0)$
 - c) $4\alpha / (\pi\omega)$
 - d) $2F_d / (\pi\omega X_0)$
5. Normal modes are
 - a) Orthogonal to each other
 - b) Orthogonal through mass matrix
 - c) Orthogonal through stiffness matrix
 - d) Orthogonal through mass and stiffness matrices
6. First six natural frequencies of flexible model of an aircraft are
 - a) Distinct
 - b) Infinite
 - c) Zero
 - d) Equal but not zero
7. The normalized mode shape of pinned-pinned beam is
 - a) $\cos(\pi nx/l)$
 - b) $\sin(\pi nx/l)$

c) $\cos\left(\frac{(2n+1)\pi x}{2l}\right)$ d) $\sin\left(\frac{(2n+1)\pi x}{2l}\right)$

8. The frequency equation of a continuous system is
 a) partial differential equation b) ordinary differential equation
 c) polynomial equation d) transcendental equation
9. The study deals with interaction of aerodynamics and elasticity is termed as
 a) Static aero-elasticity b) Dynamic aero-elasticity
 c) Flutter d) Buffeting
10. Divergence can be avoided if
 a) Aerodynamic center is aft of elastic axis b) Elastic axis is aft of aerodynamic center
 c) Aerodynamic center is aft of centre of mass d) Centre of mass is aft of aerodynamic center

PART B (10 x 2 = 20 Marks)

11. A cantilever beam of negligible mass is 0.6 m long. It has rectangular cross-section of width 8 mm and thickness 6 mm and carries a tip mass of 1.4 kg. If the natural frequency of the system is 10 rad/sec., determine the Young's modulus of the beam.
12. The following data are given for a system with viscous damping: mass, $m = 4\text{kg}$, spring constant, $k = 5\text{kN/m}$, and the amplitude decreases to 0.25 of the initial value of 1 after consecutive cycles. Find the damping coefficient of the damper.
13. A damped single degree of freedom system is vibrating under a harmonic excitation with amplitude ratio of 2.5 at resonance. Find the damping ratio of the system.
14. When an exhaust fan of mass 200 kg is supported on springs with negligible damping, the resulting static deflection is found to be 98.1 mm. If the fan has a rotating unbalance of 0.15 kg-m, find the amplitude of vibration at 1750 rpm.
15. What is dynamic coupling? Is the nature of the coupling dependent on the coordinates used?
16. What is an unrestrained system? Give two examples of physical systems that are unrestrained.
17. Write the boundary conditions for the torsional vibration of a bar having (i) both ends free (ii) both ends fixed.
18. Write the boundary conditions for the following beam

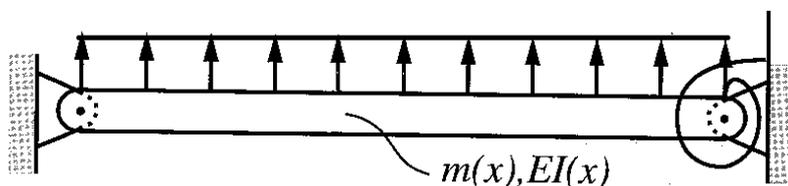


Fig. 1

19. Define the terms: (i) Divergence speed and (ii) Aileron reversal
20. List out the factors influencing the phenomena of flutter.

PART C (5 x 14 = 70 Marks)

21. a) Does the orientation of the system influence the natural frequency? Justify your answer with examples.

(OR)

- b) A mass m of 10 kg traveling with the velocity $v = 50$ m/s strikes and becomes embedded in a massless board supported by a spring of stiffness $k = 6.4 \times 10^4$ N/m in parallel with a dashpot with the coefficient of viscous damping $c = 400$ N.s/m (Fig. 2). Determine the time required for the board to reach the maximum displacement and the value of the maximum displacement.

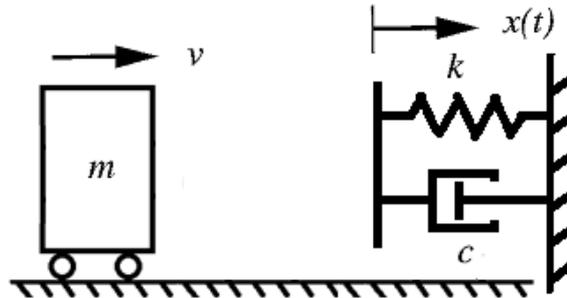


Fig. 2

22. a) A machine part of mass 5 kg vibrates as a standard SDOF oscillator in a viscous medium. A harmonic exciting force of amplitude 50 N and period 0.2 s applied to the mass produces a resonant amplitude of 2 cm. If the machine part is excited by a harmonic force of frequency 4 cycles per second, what will be the percentage change in the amplitude of forced oscillations when the viscous medium is drained?

(OR)

- b) One of the tail rotor blades of a helicopter has an unbalanced mass of $m = 0.5$ kg at a distance of $e = 0.15$ m from the axis of rotation, as shown in Fig. 3. The tail section has a length of 4 m, a mass of 240 kg, a flexural stiffness (EI) of 2.5 MN- m^2 , and a damping ratio of 0.15. The mass of the tail rotor blades, including their drive system, is 20 kg. Determine the forced response of the tail section when the blades rotate at 1500 rpm. (Hint: Idealize the tail section as a uniform beam fixed to the fuselage)

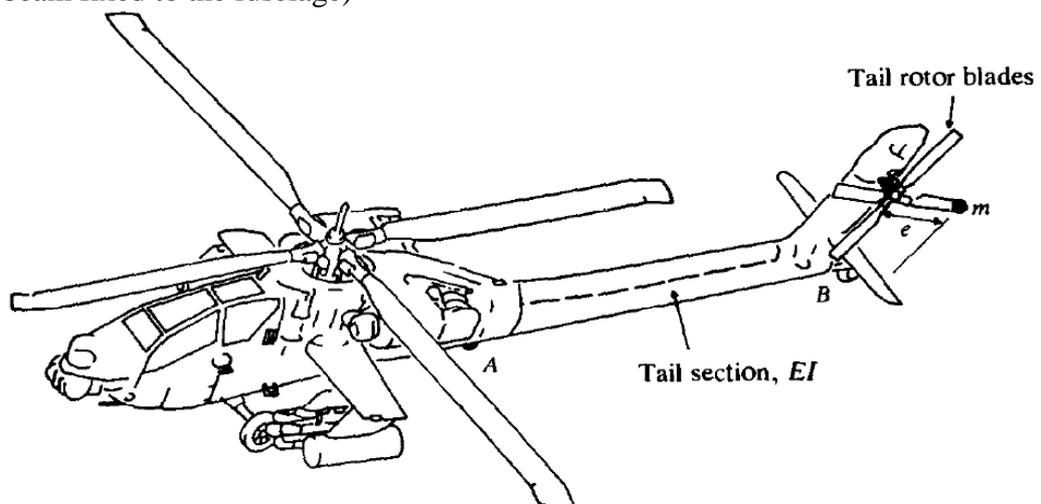


Fig. 3

23. a) A machine tool, having a mass $m = 1000$ kg and a mass moment of inertia of $J_0 = 300$ kg- m^2 , is supported on elastic supports, as shown in Fig. 4. If the stiffness of the supports are given by $k_1 = 3000$ N/mm, and $k_2 = 2000$ N/mm, and the supports are located $l_1 = 0.5$ m, and $l_2 = 0.8$ m, find the natural frequencies and

mode shapes of the machine tool.

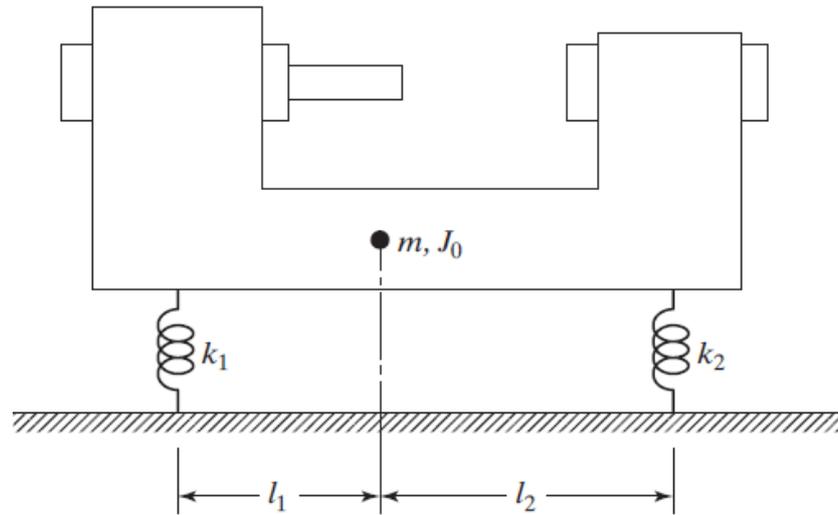


Fig. 4

(OR)

- b) i) Consider the system shown in Fig. 5 and derive the matrix equation of motion and determine the natural frequencies and normal modes of the system (10)
- ii) Find the natural frequencies of the system (Fig. 5) without actually solving the characteristic equation (Hint: from the definition of node) (4)

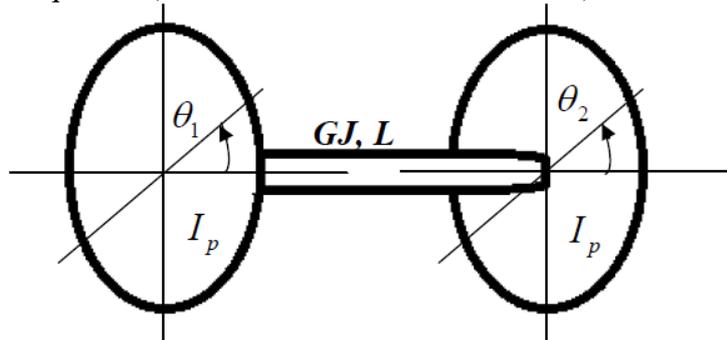


Fig. 5

24. a) i) Derive the equation of motion for longitudinal vibration of a rod. (6)
- ii) Find the expression for natural frequency and mode shapes of longitudinal vibration of a rod with one end fixed and other end is free. (8)

(OR)

- b) Derive the equation of motion for transverse vibration of a beam and obtain the generalized solution for a free vibration system.

25. a) Derive the equation for divergence for a straight wing and obtain divergence speed and elastic twist.

(OR)

- b) Explain the concept of aileron reversal using airfoil – tab model.
