Code No: M2121 **R07** **Set No.1**

IV B.Tech I Semester Supplementary Examinations, February/March 2011

VIBRATIONS AND STRUCTURAL DYNAMICS

(Aeronautical Engineering)

Time : 3 hours **Max. Marks: 80**

Answer any FIVE Questions

All Questions carry equal marks

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1. (a) Explain the following:
   - (i) Resonance
   - (ii) Simple harmonic motion [6]

   (b) Differentiate between damped and undamped oscillations. [5]

   (c) Determine equivalent viscous damping coefficient for a coulomb damping system? [5]

2. The static deflection of the vibrometer is 15 mm. The instrument when attached to a machine vibrating with a frequency of 140 cycles per minute records relative amplitude of 0.03 cm. Find out for the machine (a) the amplitude of vibration (b) the maximum velocity of vibration and (c) the maximum acceleration. [16]

3. (a) Find the principal coordinates, for the system shown in Fig. 1. [10]

   (b) Show that the Eigen vectors of a system are orthogonal with respect to the mass and stiffness matrices. [6]

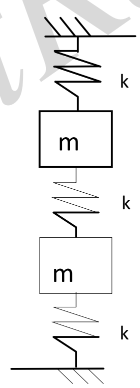

Fig. 1

4. Determine the natural frequencies of a uniform simply supported beam of length L, elastic modulus E, density ρ, area A and moment of inertia I. [16]

5. A rotor of mass 10 Kg is mounted on a shaft of stiffness 4000 N/m at the rotor. The equivalent damping coefficient of the system is 220N-sec/m. When the shaft rotates at 600 rpm, the power dissipated is 9 watts. Determine the eccentricity of the rotor. [16]

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6. Determine the two lowest natural frequencies approximately for the torsional system shown in Fig. 2 using Rayleigh-Ritz method. Take cubic polynomials as trial functions. Take rigidity modulus G = 80 x 10^9 N/m^2, Polar moment of inertia, J= 1 x10^{-5} m^4 and torsional stiffness of the spring k_t= 4 x 10^6 N-m/rad. [16]

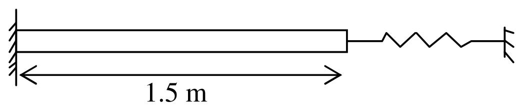

Fig. 2

7. Use modal analysis to determine the steady state response of the system shown in Fig. 3 when the mass 2m is subjected to a force of $F_o \sin 1.5\sqrt{k/\ }\ t$. [16]

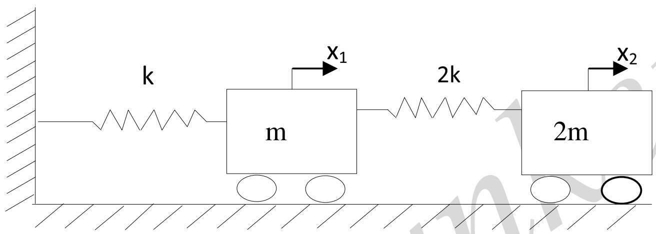

Fig. 3

8. A one degree of freedom system is initially at rest in equilibrium and subject to a force of $F(t) = F_o\, t\, e^{-t/2}$. Use Duhamel's integral to determine the response of the system. [16]

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Time : 3 hours **Max. Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
*****

1. (a) What are different mechanisms of damping? Explain. [8]
   (b) Explain D'Alembert's Principle. [4]
   (c) Explain degrees of freedom. [4]

2. A commercial vibration pick-up has a damped natural frequency of 4.5 Hz and a damping ratio of 0.5. What is the range of impressed frequency of at which the amplitude can be read directly from the pick-up with an error not exceeding 2% of the actual amplitude? [16]

3. For the system shown in Fig. 1, assuming small displacement in the plane of the paper,
   (a) Write differential equations of motion
   (b) Obtain the frequency equation.
   The pendulum rod is stiff and is pivoted at point O. [16]

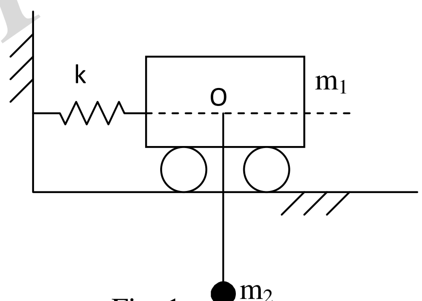

Fig. 1

4. Obtain the general solution for the free vibration of a string tightly stretched between two fixed supports. [16]

5. (a) Obtain an expression for whirl amplitude of a light shaft having a single disc with damping. [8]

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(b) A rotor of mass 5 Kg is mounted midway on a 1 cm diameter shaft supported at the ends by two bearings. The bearing span is 50 cm. The centre of gravity of the disc is 0.02 mm away from the geometric centre of the rotor. If the system rotates at 2500 r.p.m, determine the amplitude of steady state vibrations. Neglect damping. Take young's modulus of elasticity as 2 x 10^{11} N/m^2. [8]

6. Use Rayleigh's quotient to approximate the lowest natural frequency of a simply supported beam with a concentrated mass m at its midspan. Take trial function as $\phi = sin\frac{\pi x}{L}$. [16]

7. For the damped two degree of freedom system shown in Fig. 2, determine the vibrartory response of the masses for the initial conditions: $x_1 = 1.5$ and $x_2 = 1$ at time t = 0 and $x_1 = x_2 = 0$ at time t = 0. Use modal analysis with proportional damping. [16]

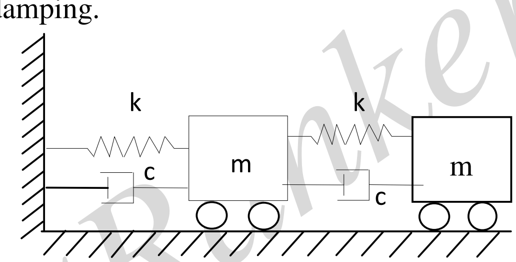

Fig. 2

8. Use Duhamel's integral to determine the response of an under damped one degree of freedom system of mass ***m*** and natural frequency ***ω_n*** when the excitation force is unit step function, ***u(t)***. [16]

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VIBRATIONS AND STRUCTURAL DYNAMICS

(Aeronautical Engineering)

Time : 3 hours **Max. Marks: 80**

Answer any Five Questions
All Questions carry equal marks
*****

1. (a) Define degrees of freedom. Differentiate between discrete and continuous systems with respect to degrees of freedom. [5]
   (b) Determine equivalent viscous damping coefficient for a hysteretic damping system. [6]
   (c) Find the amplitude of the sum of the two harmonic motions [5]
   $x_1 = 1.5 \sin(t+2)$ $x_2 = 2 \sin(t-1.0)$

2. (a) Derive an expression for the steady state amplitude in forced vibrations. [6]
   (b) A 1200 Kg machine is placed on a vibration isolator of stiffness 1×10^6. The machine is given an initial displacement of 5 cm and released. The amplitude of the machine is 1 cm after 10 cycles. Determine the damping coefficient of the system. [10]

3. A mild steel shaft of 12 mm diameter is built into walls at both ends. It carries two flywheels, each at 0.25 m from a wall and also 0.25 m from each other. The flywheel is of 0.3 m diameter and 50 mm thick. Find the two natural frequencies in torsion. [16]

4. Determine the natural frequencies and mode shapes for the slender rod shown in Fig. 1. Use x and θ as the generalised coordinates. [16]

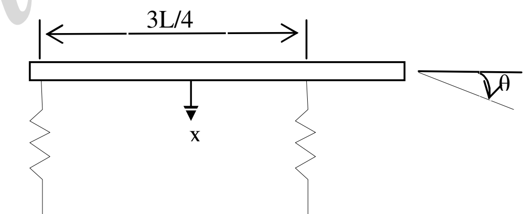

Fig. 1

5. A disc of mass 6 kg is mounted midway between bearings which may be assumed to be simple supports. The bearings span is 56 cm. The steel shaft which is horizontal is 9 mm in diameter. The CG of the disc is displaced 3mm from the geometric center. The equivalent viscous damping at the centre of the disc-shaft may be taken as 49 N-sec/m. If the shaft rotates at 800 rpm, find the maximum stress in the shaft. [16]

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6. Use Rayleigh's quotient to approximate the lowest natural frequency of a cantilever beam with a concentrated mass $\boldsymbol{m}$ at its end. Take trial function as $\phi = sin\frac{\pi x}{2L}$. [16]

7. Show that the mode shapes of the system shown in Fig. 2 are orthogonal. [16]

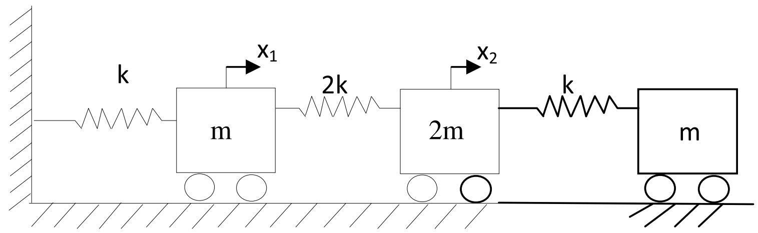

Fig. 3

8. Use Duhamel's integral to determine the response of an under damped one degree of freedom system of natural frequency ω_n and damping ratio ζ when subjected to a harmonic excitation of $F_o \sin \omega t$. [16]

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VIBRATIONS AND STRUCTURAL DYNAMICS
(Aeronautical Engineering)

Time : 3 hours **Max. Marks: 80**

Answer any Five Questions
All Questions carry equal marks
*****

1. (a) Explain hysteretic damping. [6]
   (b) Find the amplitude of the sum of the two harmonic motions [5]
   $x_1 = 5 \sin(1.5{*}t-1)$ $x_2 = 2\sin(1.5{*}t+3)$
   (c) Differentiate between Newton's second law of motion and D'Alembert's principle. [5]

2. (a) A machine of 100 Kg is mounted on an elastic foundation of stiffness 2 x 10^6 N/m. The machine is subjected to a harmonic force of magnitude 1200 N at an operating frequency of 180 rad/s. If the steady state amplitude of the machine is measured as 2.1 mm, find the damping ratio of the foundation. [10]
   (b) Derive expression for logarithmic decrement in damped free oscillations. [6]

3. A torsional system has an inertia of 1.2 kg-m^2 and a torsional stiffness 200 N-m/rad. It is acted upon by a torsional excitation at 120 r.p.m. Determine the parameter of the absorber to be fixed to the main system if it is desired to keep the natural frequency at least 20% away from the impressed frequency. [16]

4. Solve the eigen value problem for a uniform string fixed at both ends and plot the first two eigen functions. [16]

5. A rotor having a mass 10 kg is mounted on a 10 mm horizontal steel shaft midway between the bearings that are 0.8 m apart. The centre of gravity of the disc is 5 mm from its geometric centre. If the damping factor in the system is 0.1, find the maximum stress at the operating speed of 600 r.p.m. [16]

6. Determine the lowest natural frequency of a uniform simply supported beam using Rayleigh Ritz method. Use the trial functions as
   $\phi_1 = L^3x - 2Lx^3 + x^4,$ $\phi_2 = \frac{7}{3}L^4x - \frac{10}{3}L^2x^3 + x^5$ [16]

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7. Use modal analysis to determine the steady state response of the system shown in Fig. 1 when the mass m is subjected to a force of $100\, Sin\, 2t$. [16]

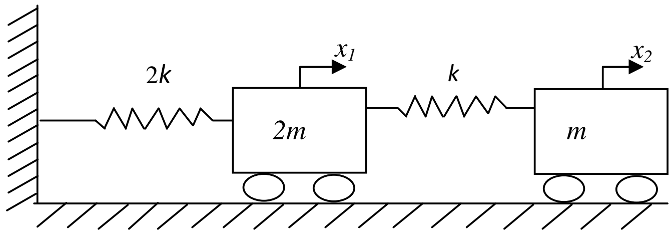

Fig. 1

8. A press of mass $\boldsymbol{m}$ is mounted on an elastic foundation of stiffness $\boldsymbol{k}$. During operation the force applied to the press builds up to its final value F_o in a time t_o as shown in Fig. 2. Determine the response of the press for (a) $t < t_o$ (b) $t > t_o$. [16]

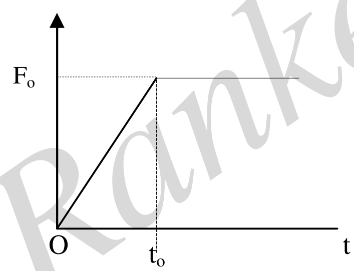

Fig. 2