Question Paper Code : 20116

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2012.

Seventh Semester

Aeronautical Engineering

AE 2403/AE 73 — VIBRATIONS AND ELEMENTS OF AEROELASTICITY

(Common to AE 1006 Vibration and Aero Elasticity)

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. A circular steel bar of length 2 meters and diameter 1 cm is fixed at one end and attached with a mass of 20 kg at the other end. Find its longitudinal natural frequency. E = 200 GPa.

2. A simple harmonic motion is represented by $x(t) = 5\sin 2t$ meters. Find its (a) rms amplitude, (b) average amplitude and (c) frequency in Hz.

3. What is meant by logarithmic decrement? If the logarithmic decrement is zero what does it mean?

4. Write down the expression for transmissibility and explain all the terms clearly. What is the value of the frequency ratio interms of the damping factor corresponding to the maximum value of the transmissibility?

5. Explain with necessary equations, how does a vibrometer function also as an accelerometer.

6. What are static and dynamic couplings?

7. Write down the Lagrange's equation and explain its use with a simple spring mass system as an example.

8. What are normalized eigen vectors?

9. Draw the first four mode shapes of a stretched string and also indicate the corresponding frequency values.

10. What is meant by aileron reversal?

PART B — (5 × 16 = 80 marks)

11. (a) For the systems shown in Figures 11(a) (i) and 11(a) (ii), find the natural frequencies. Assume K = 4 KN/m, m = 10 kg, L = 100 cm. (8 + 8)

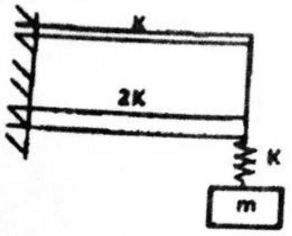


Fig. 11(a) (i)

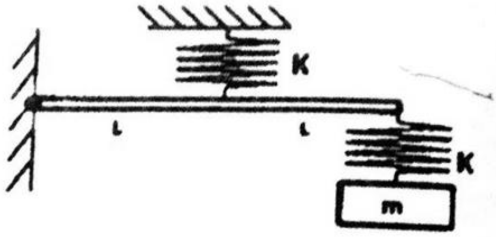


Fig. 11(a) (ii)

Or

(b) The pendulum shown in Figure 11(b) is pivoted at O. Find the natural frequency if m = 1 kg, l = 1 m, l_1 = 0.3 m, l_2 = 0.2 m, C = 100 N sec/m, g = 9.81 m/sec², K = 10 kN/m. (16)

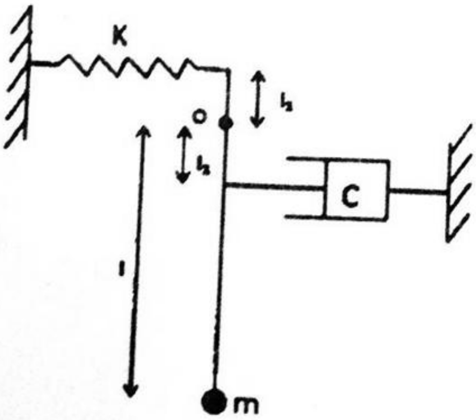


Fig. 11(b)

12. (a) (i) Derive the expression for the response of a single degree of freedom system subjected to base excitation. (8)

(ii) The static deflection of an automobile on its springs is 8 cm. Find the critical speed of the vehicle when it is travelling on a road which is approximated as a sine wave of 6 cm amplitude and a wave length of 10 m. Assume a damping factor of $\zeta = 0.1$. Also determine the amplitude of vibration when the speed of the vehicle is 60 kmph. (8)

Or

(b) (i) An accelerometer has a natural frequency of 5 Hz and a damping factor of $\zeta = 0.2$. Determine the highest forcing frequencies at which the measured acceleration has accuracies with 1% and 3% errors. (10)

(ii) If the above instrument is to used as a vibrometer what is lowest forcing frequency at which the accuracy is less than 2%. (6)

13. (a) (i) Derive the equation of motion for the three rotor system shown in Figure 13(a) (i). (8)

(ii) If the node for the system shown in Figure 13(a)(ii) is at the middle portion of CD, find the weight of the rotor D and also the natural frequency. G =70 GPa. (8)

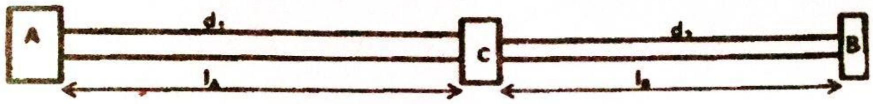


Fig. 13 (a) (i)

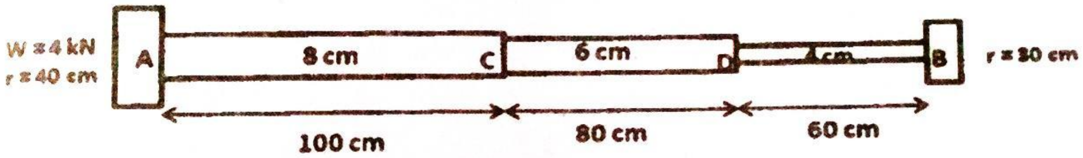


Fig. 13 (a) (ii)

Or

(b) (i) Derive the equation of motion for the system shown in Figure 13(b). (6)

(ii) Find the natural frequencies and the eigen vectors for the above system if m = 10 kg and K = 1 kN/m. (10)

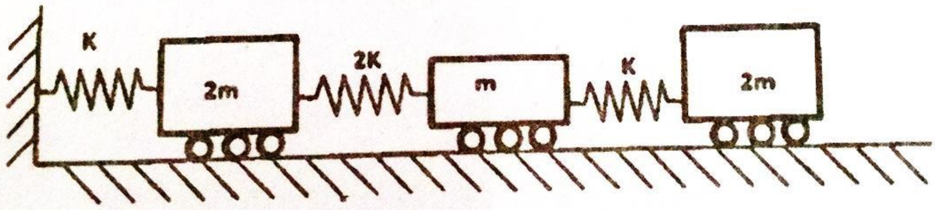


Fig. 13 (b)

14. (a) (i) Using Lagrange's equation derive the equation of motion for a double pendulum. (8)

(ii) If $m_1 = m_2 = m$ and $l_1 = l_2 = l$ find the natural frequencies and the mode shapes of the double pendulum. (8)

Or

(b) (i) Derive the equation of motion for the transverse vibration of a beam. (8)

(ii) Also find the first three natural frequencies of a cantilever beam and draw the corresponding mode shapes. (8)

15. (a) (i) Explain how Holzer method is employed in getting natural frequencies of semi-definite systems? (6)

(ii) Using Holzer method, find the natural frequencies of the three rotor system shown in Figure 13(a)(i). Assume $W_A = 2\text{kN}$, $W_B = 4\text{ kN}$, $W_C = 3\text{ kN}$, $r_A = 40\text{ cm}$, $r_B = 50\text{ cm}$, $r_C = 60\text{ cm}$, $l_A = 50\text{ cm}$, $l_B = 75\text{ cm}$, $d_1 = 2\text{ cm}$, $d_2 = 3\text{ cm}$. (10)

Or

(b) Using Aerelastic Collar's triangle, explain all the aeroelastic problems in detail. (16)

Question Paper Code : C 1524

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2010.

Seventh Semester

Aeronautical Engineering

AE 1006 — VIBRATION AND AERO ELASTICITY

(Regulation 2004)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. A spring having a spring constant 'k' is suspended vertically. When a 2 kg mass is attached to the spring, the extension is 3 mm. What is the natural frequency of the system?

2. Define the coefficient of viscous damping and state its S.I. units.

3. The amplitude of oscillations of a damped system decreases by 50% after 8 cycles. Calculate the associated damping factor.

4. A spring-mass system having a natural frequency w_n is subject to a harmonic excitation of frequency w. The response will be in-phase with the input when ————————. (Fill in the blanks)

5. Briefly explain the working of Frahm's reed tachometer.

6. Sketch and label the parts of a piezoelectric accelerometer.

7. Define static coupling.

8. What are 'normal modes' of vibration?

9. Define the stiffness influence coefficient.

10. Aeroelasticity is the study of ————————. (Fill in the blanks)

PART B — (5 × 16 = 80 marks)

11. (a) (i) Using the energy method, obtain the equation governing free vibrations for a simple pendulum system. Deduce the natural frequency of the same. (10)

(ii) Obtain the natural frequency of the system indicated in Fig. 1. (6)

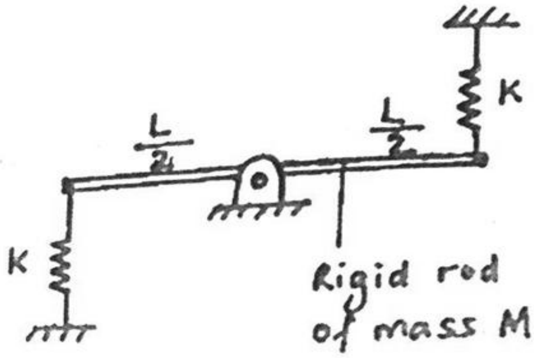


Fig. 1

Or

(b) (i) Refer Fig. 2. The mass M is subject to a periodic force as indicated. Obtain the general solution for the displacement of the mass. (10)

(ii) With the example of the system shown in Fig. 2, discuss resonance. Sketch the frequency response curve of the system. If a viscous damping unit is now added to the system, how would it change the frequency response of the system? (6)

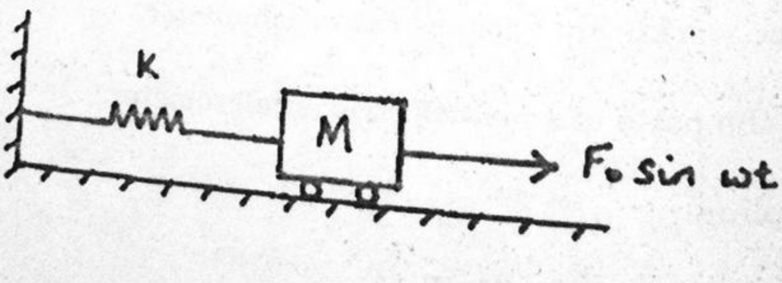


Fig. 2

12. (a) (i) The 30 kg electric motor shown in Fig. 3 is supported by 4 springs, each having a spring constant of 200 N/m. The rotor R is unbalanced and the effect of unbalance is equivalent to a 4 kg mass located 4 mm from the axis of rotation. The damping factor of the system is 0.15. Determine the amplitude of vibration when the rotor is rotating at $\omega = 10$ rad/s. (10)

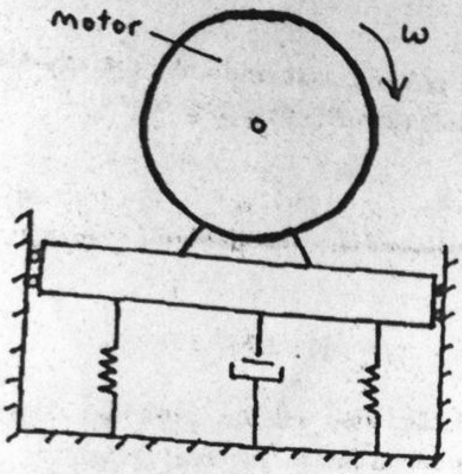


Fig. 3

(ii) Explain the working principle of Frahms reed tachometer. (6)

Or

(b) Discuss the design of a dynamic vibration absorber unit.

13. (a) (i) Using an example of your choice, explain the application of Lagrange's equations in vibrations. (10)

(ii) Consider a bar undergoing free axial vibrations. Derive and obtain the governing differential equation. (6)

Or

(b) Derive and obtain the governing differential equation for a beam undergoing free bending vibrations. Solve the same in order to the obtain the natural frequencies and mode shapes of a simply-supported beam.

14. (a) Obtain the natural frequencies and modes shapes of the system indicated in Fig. 4. $M_1 = 10$ kg $= M_2$. $K_1 = 300$ N/cm and $K_2 = 200$ N/cm.

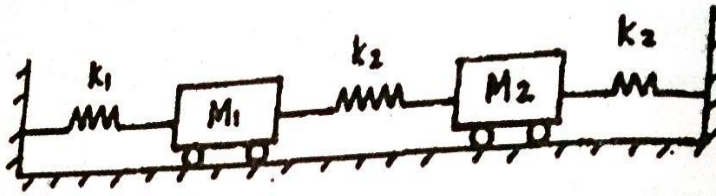


Fig. 4

Or

(b) Using Rayleigh's method, estimate the fundamental frequency of the lumped mass system shown in Fig. 5.

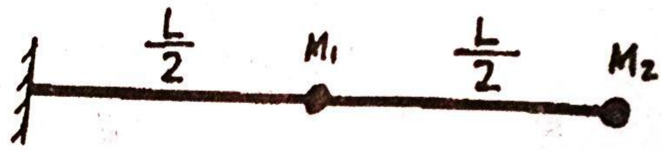


Fig. 5

15. (a) Consider a 2-D wing with aileron attached. Derive and obtain an expression for the aileron control reversal speed.

Or

(b) (i) With the help of Collar's triangle, give an account of the different aeroelastic phenomena. (10)

(ii) Briefly discuss the different methods of flutter prevention. (6)

———————

Seventh Semester

Aeronautical Engineering

AE 2403/AE 73/AE 1006/080180050 – VIBRATIONS AND ELEMENTS OF AEROELASTICITY

(Common to AE 1006 Vibration and Aero Elasticity)

(Regulation 2008)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define inertia force.

2. State TRUE or FALSE.

   (a) Transient vibrations are also known as free vibrations.

   (b) Transient vibrations do not depend upon initial conditions.

3. What are the degrees of freedom of a vibrating system?

4. Why is vibration isolation necessary?

5. What is a semi-definite system?

6. What are natural modes of vibration?

7. Sketch the first three modes shapes of transverse vibrations of a simply-supported beam.

8. Briefly explain the physical principle behind Rayleigh's method.

9. Name two methods of increasing the divergence speed of an aircraft wing.

10. Name the forces that interact during the bending-torsion flutter phenomena.

11. (a) (i) Explain the difference between periodic motion and simple harmonic motion. (4)

(ii) Obtain the natural frequency of a simple pendulum undergoing small angular planar oscillations. (6)

(iii) Refer Fig. 1. Determine the frequency of oscillation when the compound pendulum shown in the figure freely oscillates about pivot point O due to its own weight acting at the center of gravity G. (6)

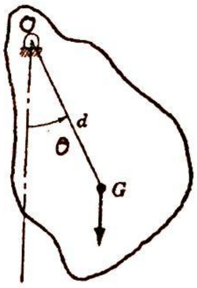


Fig. 1

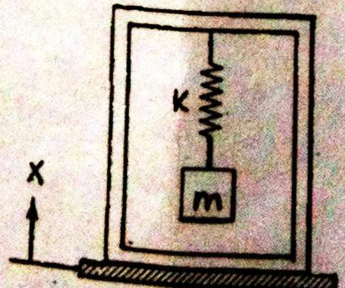
Or

(b) (i) When does resonance occur? State the effect of damping during resonance. (4)

(ii) Derive and obtain the response of a SDOF spring – mass system subject to a single frequency sinusoidal excitation. (12)

(a) (i) Briefly explain the working principle of a vibrometer. (4)

(ii) Refer Fig.2 where the given mass (m = 2 kg) is suspended in a box by a vertical spring whose spring constant k = 40 N/cm. The box is placed on top of a shake table for which the motion due to vibration is given by $x = 0.03 \sin(3t)$ where t is in seconds and x is in meters. Find the absolute motion of the mass. (12)



(b) Refer Fig.3 where the given masses m_1 and m_2 are attached to a string having high tension T. Frame the governing equations and find the natural frequencies of the system for small vertical oscillations of the masses. Assume that the tension in the string remains constant during the motion.

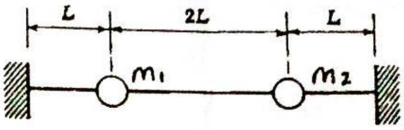


Fig. 3

13. (a) Refer Fig.4 where $k_1 = k_2 = k_3 = 25$ N/cm while $m_1 = m_2 = 0.8$ kg. Determine the natural frequencies and mode shapes of the given system. Write the equation of motion for the masses if masses m_1 and m_2 are both given an initial downward displacement equal to 2 cm and then released.

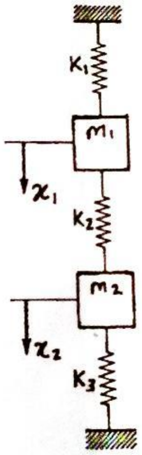


Fig. 4

Or

(b) (i) Refer Fig.5. The circular disc having mass moment of inertia 'J' is attached to the lower end of an elastic vertical shaft whose mass may be neglected. The torsional stiffness of the shaft is 'k'. Determine the natural frequency of torsional vibrations of the given system. (4)

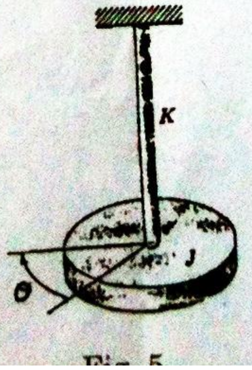


Fig. 5

(ii) A uniform bar of length L undergoes free axial vibrations. Derive and obtain the governing differential equation for the system. If both the ends of the bar are kept free, what would be the natural frequencies of the system? (12)

14. (a) Describe Rayleigh's method using an example of your choice.

Or

(b) Illustrate the use of the Holzer method using the example of the system shown in Fig.6.

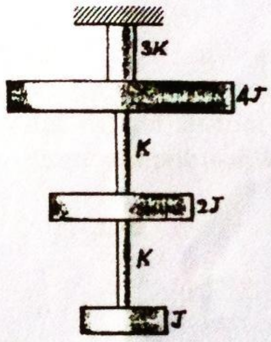


Fig. 6

15. (a) (i) With the help of Collar's triangle, list out the various types of aeroelastic phenomena. (4)

(ii) What is mass balancing? (4)

(iii) Explain the physics of bending-torsion flutter. (8)

Or

(b) Consider a 2-D wing with aileron attached. Derive and obtain an expression for the aileron control reversal speed.

Seventh Semester

Aeronautical Engineering

AE 2403/AE 73/AE 1006/080180050 — VIBRATIONS AND ELEMENTS OF AEROELASTICITY

(Common to AE 1006 Vibration and Aero Elasticity)

(Regulation 2008)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. The natural frequency and the maximum acceleration of a simple harmonic motion are five Hz and 20 m/sec^2 respectively. Find the amplitude and the r.m.s values of the motion.

2. A motion is represented by sum of two simple harmonic motions and is expressed by $x(t) = 4\cos(\pi/2)t + 2\sin(\pi/2)t$. Is $x(t)$ periodic? If it is periodic what is the periodicity?

3. Using energy method, find the natural frequency of a simple spring mass system.

4. Distinguish between free, damped and forced vibrations.

5. What are orthogonal conditions of normalized Eigen vectors?

6. Distinguish between longitudinal, lateral and torsional oscillations.

7. Explain briefly the basis of Holzer method.

8. How do you represent the behavior of discrete and continuous systems?

9. What is meant by vibration isolation? Explain with necessary equation and diagram.

10. What is collar's aeroelastic triangle?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Find the torsional natural frequency of the stepped shaft shown in Figure. 11(a) (i). G = 70 GPa.

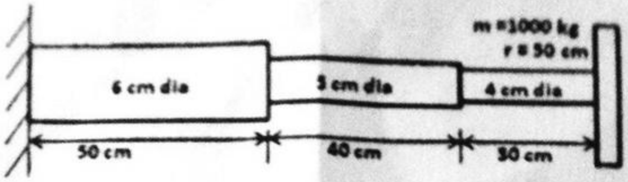


Figure. 11(a)(i)

(ii) A mass is supported by a weightless bar and two springs as shown in figure. 11(a)(ii). Find the natural frequency of the system if K = 5 kN/m, m = 10kg and L = 50cm.

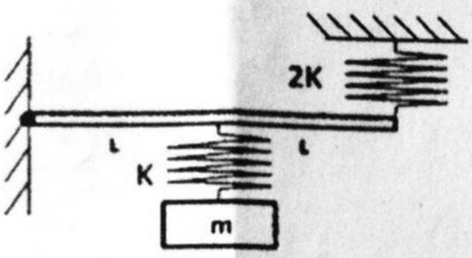


Figure. 11(a)(ii)

Or

(b) (i) Derive the equation of motion for the system shown in Figure.11(b)(i).

(ii) Find the natural and damped natural frequencies of the system if the parameter values are as given. m = 5kg, K = 2 kN/m, C = 0.1 kN sec/m, a = 60cm and b = 40cm.

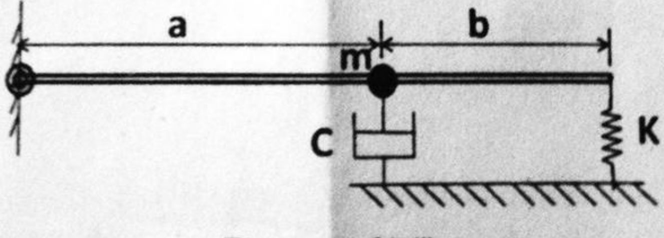


Figure.11 (b) (i)

12. (a) (i) Derive the frequency response relation for a single degree of freedom system subjected to harmonic excitation. Also plot the frequency response diagram. (8)

(ii) The damped natural frequency of a system is 10.5 Hz. When the system is subjected to a harmonic excitation the maximum amplitude of oscillations occurs at 9.5 Hz. Find the amplitude ratio when it is excited at 15 Hz frequency?

Or

(b) (i) Derive the expression for transmissibility.

(ii) A machine of mass 1000 kg is subjected to an external force of 2500 N at a frequency of 1800 rpm. To reduce the effect of vibration, an isolation rubber having a static deflection of 2 mm under the machine load with a damping factor of 0.15 is used. Determine the transmissibility and the force transmitted. If the frequency is increased to 2000 rpm what is the force transmitted? (8)

13. (a) (i) Explain the working of seismic instrument with necessary equations. (8)

(ii) A commercial type vibration pickup has a natural frequency of 5 Hz with a damping factor of 0.6. What is the lowest natural frequency beyond which the amplitude can be measured with 2% and 4% accuracies?

Or

(b) (i) Derive the equations of motion for a two rotor system and frequency is evaluated from those equations. (6)

(ii) Find the natural frequency of the two rotor system shown in Fig.13 (b) (ii) also locate the position of the node with respect to the rotor A. G = 70 GPa.

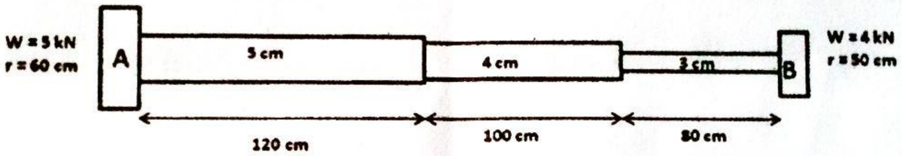


Figure.13 (b)(ii)

14. (a) (i) Derive the equation of motion for the system shown in Figure.14 (a) (i). (8)

(ii) If the values of the system parameters are $K_1 = 2K_2 = K_3 = 2K$ and $m_1 = 2m_2 = 2m$ find the natural frequencies and the normalized eigen vectors.

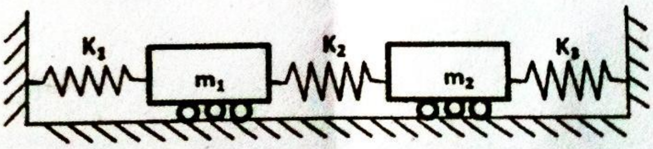


Figure.14 (a)(i)

Or

(b) (i) Derive the equation of for the transverse vibration of a stretched string. (8)

(ii) Using the mode shapes, prove that the orthogonal conditions of eigen vectors are also valid for continuous systems.

15. (a) (i) Explain how Rayleigh's method is employed to get the fundamental frequency of a discrete system.

(ii) An uniform simply supported beam with mass density m per unit length supports two masses of magnitude 2m and m as shown in figure.15(a) (ii). Using Rayleigh's method, find the fundamental frequency of the system.

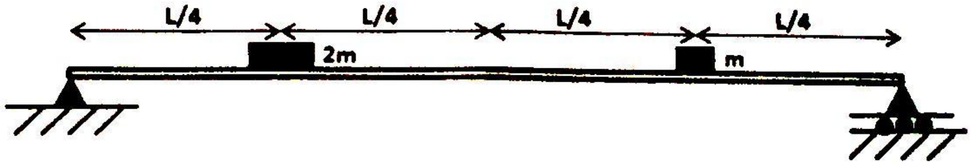


Figure.15 (a)(ii)

Or

(b) Explain the following in detail :

(i) Wing divergence

(ii) Aileron reversal and

(iii) Flutter and

(iv) Prevention of (i), (ii) and (iii).

Question Paper Code : 31036

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2013.

Seventh Semester

Aeronautical Engineering

AE 2403/AE 73/AE 1006/080180050/10122 AE 704 – VIBRATIONS AND ELEMENTS OF AERO ELASTICITY

(Regulation 2008/2010)

Time : Three hours — Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Distinguish between periodic and simple harmonic motion.

2. State D'Alembert's principle.

3. What are the main causes of vibration and the methods to reduce them?

4. What is meant by free vibration and forced vibration?

5. Explain Coordinate Coupling in a multi degree of freedom system.

6. Define synchronous motion for a multi degree of freedom system.

7. What do you understand by Rayleigh's stationary principle?

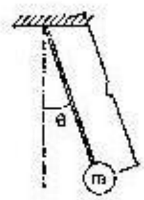
8. What is the difference between Rayleigh's and Holzer methods to find natural frequencies?

9. How do you avoid tail plane buffeting?

10. What is flutter and how to prevent it?

PART B — (5 × 16 = 80 marks)

11. (a) A simple pendulum is shown in fig below, Determine the natural frequency of the swing, (i) if the mass of the rod is small compared to the mass at the end, (ii) if the mass of the rod is not negligible. (16)



Or

(b) The cylinder of mass m and radius r rolls without slipping on a circular surface of radius R. Determine the frequency of oscillation when the cylinder is displaced slightly from its equilibrium position. Use the Energy method.

12. (a) Show that the mass of an over damped system will pass through the static equilibrium-position. (16)

(i) If it is given an initial displacement only

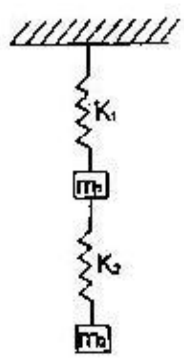
(ii) If it is given an initial velocity only.

Or

(b) (i) A simply supported beam has a concentrated mass 'M' acting on the mid span. Find the natural frequency of the system if the mass of the beam is 'm'. (8)

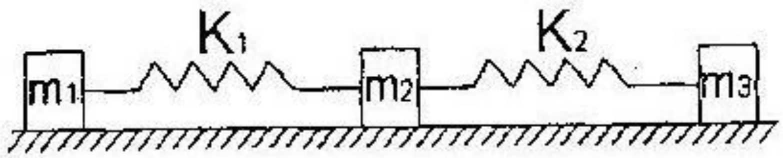
(ii) A vibrometer having a natural frequency of 31.4 rad/sec is employed to measure the amplitude of a machine part. If it gives a reading of 1.5 mm, what is the amplitude of vibration of the machine part? (8)

13. (a) Determine the equations of motion and the natural frequencies of the two degree freedom spring-mass system shown in figure below. (16)



Or

(b) Three wooden blocks of equal unit mass, connected by springs of stiffness 1 N/mm as shown in fig below, are resting on a frictionless surface. If block m_3 is given an initial displacement of 10 mm, determine the resulting motion of the system. (16)

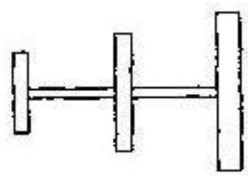


14. (a) Determine the fundamental frequency of the uniform cantilever beam using the simple curve, $y = cx^2$.

Or

(b) Determine the natural frequency and mode shapes of the system shown in figure

$$K_1 = 0.10 \times 10^6, K_2 = 0.20 \times 10^6 \, Nm/rad$$



$$J_1 = 5,\ J_2 = 11,\ J_3 = 22\, Kg - m^2$$

15. (a) Write short notes on the following topics :

(i) Stall flutter. (5)

(ii) Mass balancing. (5)

(iii) Wing torsional divergence. (6)

Or

(b) Derive an expression for the aileron control reversal speed for a 2-D wing with aileron attached.

Question Paper Code : 51036

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2014.

Seventh Semester

Aeronautical Engineering

AE 2403/AE 73/AE 1006/080180050/10122 AE 704 — VIBRATIONS AND ELEMENTS OF AERO ELASTICITY/VIBRATIONS AND AERO ELASTICITY

(Regulation 2008/2010)

Time : Three hours　　　　Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. A circular steel bar of length 1 meter, diameter 2 cms is fixed at one end and attached with a disc of mass 50 kg and radius of gyration 25 cms at the other end. Find the ratio between lateral and torsional natural frequency. E = 3 G.

2. Two simple harmonic motions represented by $x_1(t) = 3\sin 5t$ and $x_2(t) - 4\cos 5t$ are superposed one over the other. What are the frequency and amplitude values of the resultant motion $x(t)$.

3. Define free, damped and forces vibrations.

4. What is meant by isolation in forced vibration?

5. What are the characteristics of mass and stiffness matrices?

6. What are principal co-ordinates?

7. "Rayleigh's method always over estimates the natural frequency". Justify this statement.

8. What is the concept behind Holzer method?

9. What is meant by bending torsion coupling in aeroelasticity?

10. What is meant by critical speed of rotating shaft?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Using energy method, find the natural frequency of a small cylinder of radius r oscillating with in another big cylinder of radius R as shown in Figure 11(a) (i). (8)

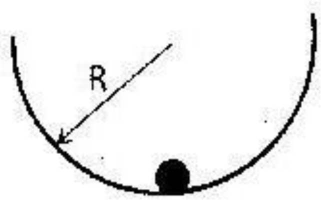


Figure 11(a) (i)

(ii) Using energy method, find the natural frequency of a simple spring mass system including the effect of the mass of the spring. (8)

Or

(b) (i) A mass m attached with a massless rigid bar hinged at O is as shown in figure 11(b) (i). Derive the equation of motion for the system. (6)

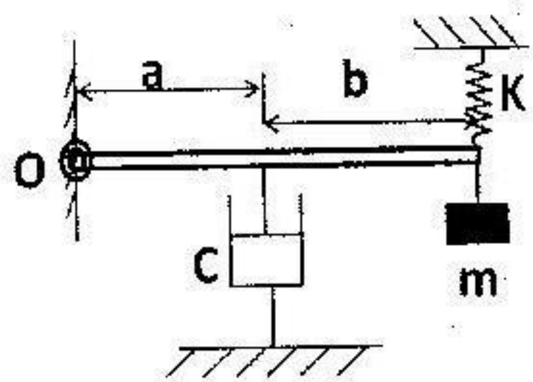


Figure 11(b) (i)

(ii) Find the undamped and damped natural frequencies if $m = 5kg$, $C = 2$ Nsec/cm, $K = 20N/cm$, $a = 15cm$ and $b = 20cm$. (10)

12. (a) (i) Derive the expression for transmissibility and plot the diagram. (6)

(ii) A machine weighing 2500 N is supported on four springs of stiffness 25N/cm each and is subjected to a force $F(t) = 1000\cos 5t\ N$. The damping factor is 0.2. Find the transmissibility and the force transmitted to the ground. Find also the excitation frequency at which the force transmitted to the ground is maximum. (10)

Or

(b) (i) Explain with necessary equations, how vibration measuring instruments are characterised as vibrometer and accelerometer. (6)

(ii) A vibrometer has a natural frequency of 10 Hz and a damping factor of $\zeta = 0.15$. Determine the lowest frequencies at which the measured displacement has accuracies with 1% and 3% errors. (6)

(iii) If the above instrument is to be used as an accelerometer what is highest forcing frequency at which the accuracy is less than 2%. (4)

13. (a) (i) Derive the equation of motion for the system shown in Figure 13(a) (i). (8)

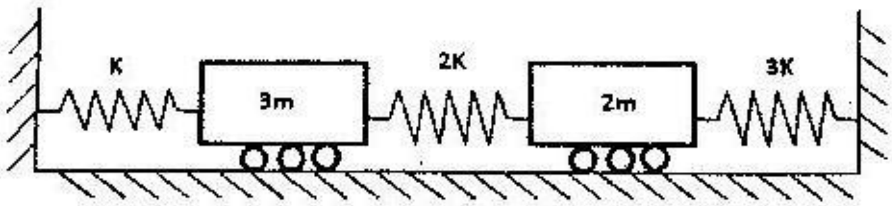


Figure 13(a) (i)

(ii) If the values of the system parameters are K = 1000N/m and m = 10 kg find the natural frequencies and the normalized eigen vectors. (8)

Or

(b) (i) Derive the equation of motion for a two rotor system and explain how the natural frequency is obtained. (8)

(ii) If the node for the system shown in Figure 13(b) (ii) is at the middle of the portion of BC, find the diameter of the portion BC and also the natural frequency. G =70 GPa. (8)

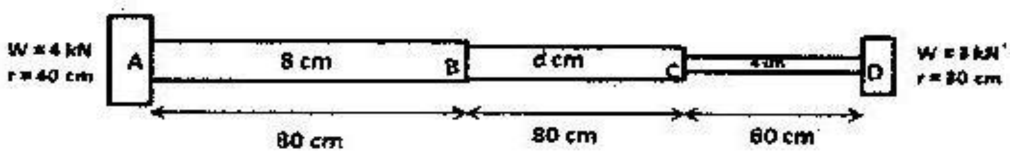


Figure 13(b) (ii)

14. (a) (i) Explain with necessary equations how does a secondary system absorbs the oscillations of a primary system subjected to harmonic excitation. (8)

(ii) A small reciprocating machine of 20 kg mass runs at a constant speed of 5000 rpm. After installation it was found that the forcing frequency is too close to the natural frequency of the system. Design an absorber so that the natural frequencies are at least 20% away from the excitation frequency. (8)

Or

(b) (i) Derive the Lagrange's equation. (10)

(ii) Using Lagrange's equation derive the equation of motion for the system shown in Figure 13(a) (i). (6)

15. (a) Using Rayleigh's method find the fundamental frequency of a uniform cantilever beam with two additional masses as shown in Figure 15(a). Mass density of the beam is m/L per unit length and bending rigidity = EI.

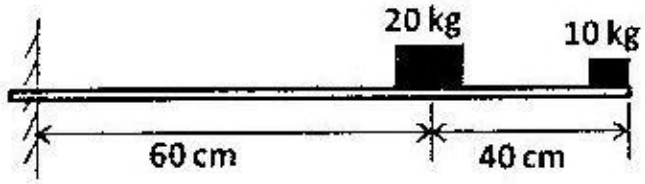


Figure 15(a)

Or

(b) Using Aeroelastic Collars triangle, Explain all the aeroelastic problems in detail.