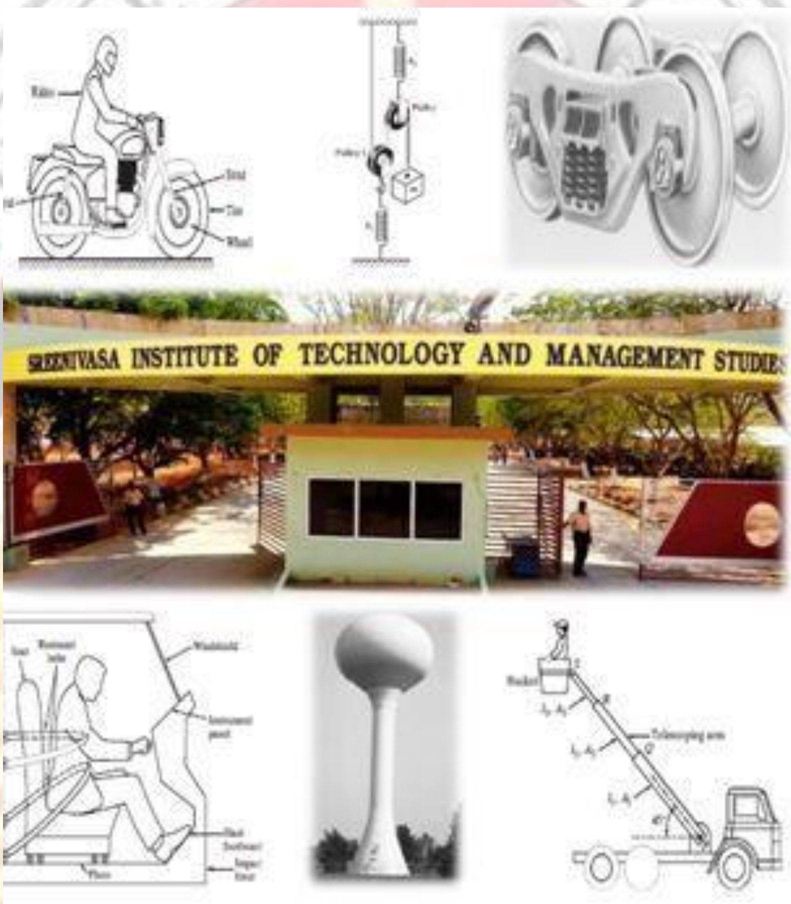
Class: Final year I Semester **BRANCH:** Mechanical



18MEC412 Fundamentals of Vibrations

QUESTION BANK

(Updated on Nov 2021)

Prepared by
Dr. K. Vimalanathan,
Professor
Department of Mechanical Engineering,
SITAMS, Chittoor

UNIT I

Name of the Faculty	:	Dr. K. Vimalanathan	Design./Dept.	:	Prof./Mech.
Subject Code	:	18MEC412	Branch	:	Mechanical
Subject Name	:	Fundamentals of Vibrations	Year/Sem.	:	IV/I

PART-A (2 Marks)

1. Give two examples each of the bad and the good effects of vibration. **(BT4)**
2. Define Single degree of freedom **(BT2)**
3. How to classify vibration **(BT1)**
4. Define damped vibration **(BT2)**
5. What is deterministic vibration? **(BT2)**
6. Write the procedure of vibration analysis **(BT3)**
7. Define Viscous Damping **(BT2)**
8. Define Dry-Friction Damping **(BT2)**
9. Define Hysteretic Damping **(BT2)**
10. Define these terms: cycle **(BT2)**
11. Define: amplitude **(BT2)**
12. Define: phase angle **(BT2)**
13. Define: linear frequency **(BT2)**
14. Define: period **(BT2)**
15. Define: natural frequency **(BT2)**
16. What are the three elementary parts of a vibrating system? **(BT3)**
17. Define the number of degrees of freedom of a vibrating system. **(BT2)**
18. What is the difference between a discrete and a continuous system? Is it possible to solve any vibration problem as a discrete one? **(BT4)**
19. In vibration analysis, can damping always be disregarded? **(BT5)**
20. Can a nonlinear vibration problem be identified by looking at its governing differential equation? **(BT5)**
21. What is the difference between deterministic and random vibration? Give two practical examples of each. **(BT4)**
22. What methods are available for solving the governing equations in vibration problem? **(BT3)**
23. How do you connect several springs to increase the overall stiffness? **(BT5)**
24. Define spring stiffness and damping constant. **(BT2)**

25. What are the common types of damping? **(BT1)**

26. State three different ways of expressing a periodic function in terms of its harmonics. **(BT3)**

27. How can we obtain the frequency, phase, and amplitude of a harmonic motion from the corresponding rotating vector? **(BT4)**

28. How do you add two harmonic motions having different frequencies? **(BT6)**

29. What are beats? **(BT1)**

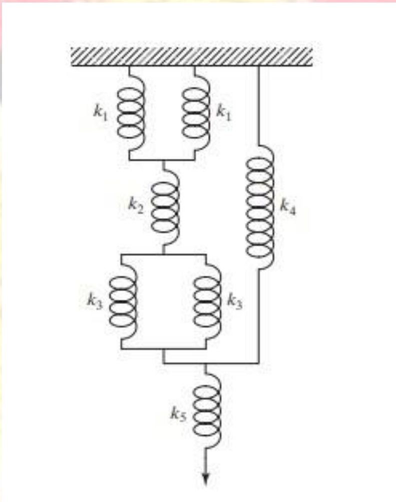
30. Define the terms decibel and octave. **(BT2)**

31. Explain Gibbs phenomenon. **(BT2)**

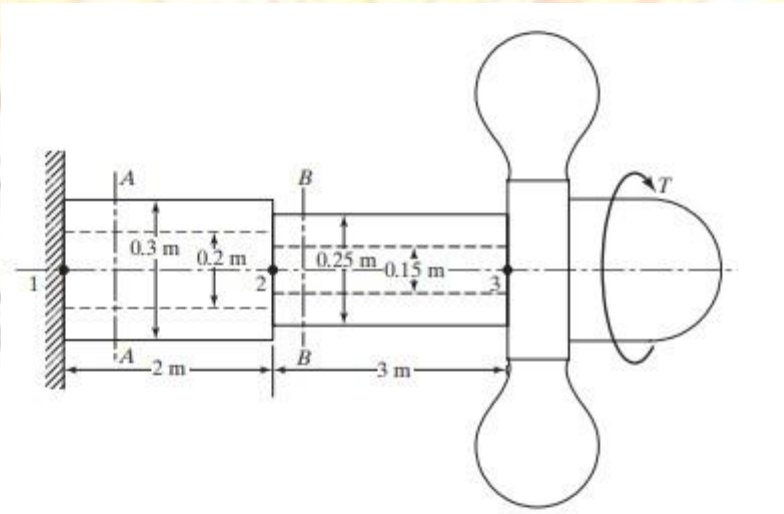
32. What are half-range expansions? **(BT2)**

PART-B

1. Determine the equivalent spring constant of the system shown in Fig. below **(BT4)**



2. Determine the torsional spring constant of the steel propeller shaft shown in Fig. below **(BT5)**

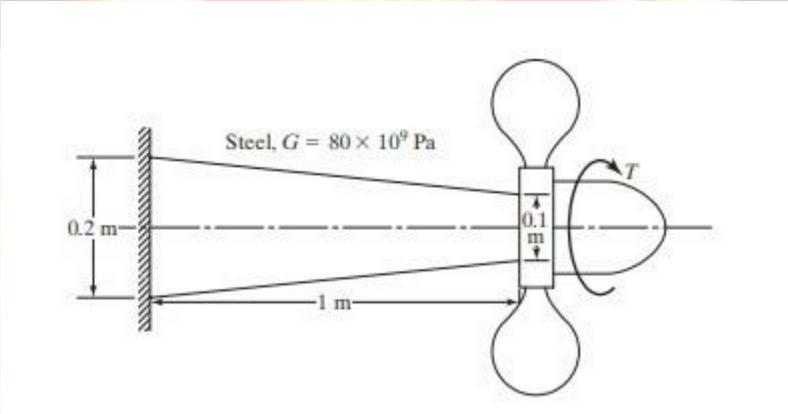


3. One end of a helical spring is fixed and the other end is subjected to five different tensile forces. The lengths of the spring measured at various values of the tensile forces are given below:

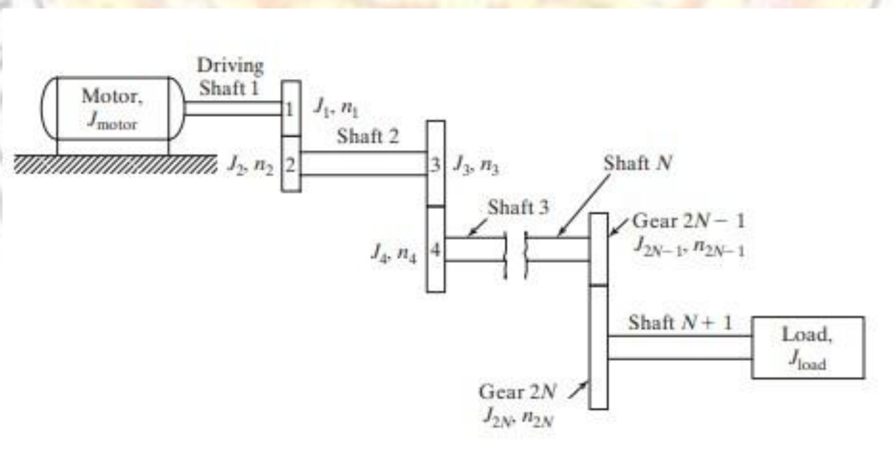
Tensile force F (N)	0	100	250	330	480	570
Total length of the spring (mm)	150	163	183	194	214	226

Determine the force-deflection relation of the helical spring **(BT5).**

4. A tapered solid steel propeller shaft is shown in Fig in below. Determine the torsional spring constant of the shaft **(BT6)**



5. Find the equivalent mass moment of inertia of the gear train shown in Fig. below with reference to the driving shaft. In Fig. 1.97, and denote the mass moment of inertia and the number of teeth, respectively, of gear i, i = 1, 2, …. 2N. **(BT5)**



6. Consider two nonlinear dampers with the same force-velocity relationship given by $F = 1000v + 400v^2 + 20v$ with F in newtons and v in meters/second. Find the linearized damping constant of the dampers at an operating velocity of 10 m/s. **(BT3)**

7. If the linearized dampers of $F = 1000v + 400v^2 + 20v$ are connected in parallel, determine the resulting equivalent damping constant. **(BT3)**

8. If the linearized dampers of (above) F = 1000v + 400v2 + 20v are connected in series, determine the resulting equivalent damping constant. **(BT4)**

9. The experimental determination of damping force corresponding to several values of the velocity of the damper yielded the following results: **(BT5)**

Damping force (newtons)	**80**	**150**	**250**	**350**	**500**	**600**
Velocity of damper (meters/second)	**0.025**	**0.045**	**0.075**	**0.110**	**0.155**	**0.185**

Determine the damping constant of the damper.

10. The force (F)-velocity relationship of a nonlinear damper is given by where a and b are constants. $F = ax + bx^2$
Find the equivalent linear damping constant when the relative velocity is 5 m/s with N-s/m and b = 0.2 $N\text{-}s^2/m^2$; a = 5 . **(BT4)**

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UNIT II

Name of the Faculty	:	Dr. K. Vimalanathan	**Design./Dept.**	:	Prof./Mech.
Subject Code	:	18MEC412	**Branch**	:	Mechanical
Subject Name	:	Fundamentals of Vibrations	**Year/Sem.**	:	IV/I

PART-A (2 marks)

1. What is equivalent stiffness of a spring? **(BT2)**
2. Derive Newton's second equation of motion? **(BT2)**
3. Define Momentum **(BT2)**
4. State D-Alembert's Principle **(BT2)**
5. State the Principle of Virtual Displacements. **(BT2)**
6. State Equation of Motion of a Spring-Mass System in Vertical Position**(BT3)**
7. Define torsional vibration **(BT2)**
8. Write the application of shock observer in bike **(BT3)**
9. Suggest a method for determining the damping constant of a highly damped vibrating system that uses viscous damping. **(BT5)**
10. State the parameters corresponding to m, c, k, and x for a torsional system. **(BT2)**
11. What effect does a decrease in mass have on the frequency of a system? **(BT4)**
12. What effect does a decrease in the stiffness of the system have on the natural period **(BT5)**
13. Why does the amplitude of free vibration gradually diminish in practical systems **(BT6)**
14. Why is it important to find the natural frequency of a vibrating system **(BT6)**
15. How many arbitrary constants must a general solution to a second-order differential equation have? How are these constants determined **(BT4)**
16. Can the energy method be used to find the differential equation of motion of all single degree-of-freedom systems **(BT4)**
17. What assumptions are made in finding the natural frequency of a single-degree-of freedom system using the energy method **(BT2)**
18. Is the frequency of a damped free vibration smaller or greater than the natural frequency of the system **(BT4)**
19. What is the use of the logarithmic decrement **(BT2)**
20. Is hysteresis damping a function of the maximum stress **(BT5)**
21. What is critical damping, and what is its importance **(BT2)**

22. What happens to the energy dissipated by damping **(BT2)**

23. What is equivalent viscous damping? **(BT2)**

24. Is the equivalent viscous-damping factor a constant? **(BT6)**

25. What is the reason for studying the vibration of a single-degree-of-freedom system**(BT4)**

26. How can you find the natural frequency of a system by measuring its static deflection? **(BT5)**

27. Give two practical applications of a torsional pendulum. **(BT3)**

28. Define these terms: damping ratio, logarithmic decrement, loss coefficient, and specific damping capacity. **(BT2)**

29. In what ways is the response of a system with Coulomb damping different from that of systems with other types of damping? **(BT4)**

30. What is complex stiffness? **(BT2)**

31. Define the hysteresis damping constant. **(BT2)**

32. Give three practical applications of the concept of center of percussion.

33. Define the time constant. **(BT2)**

34. What is a root locus plot? **(BT2)**

35. What is a time-invariant system? **(BT2)**

PART-B

1. Graphical representation of the motion of a harmonic oscillator **(BT3)**

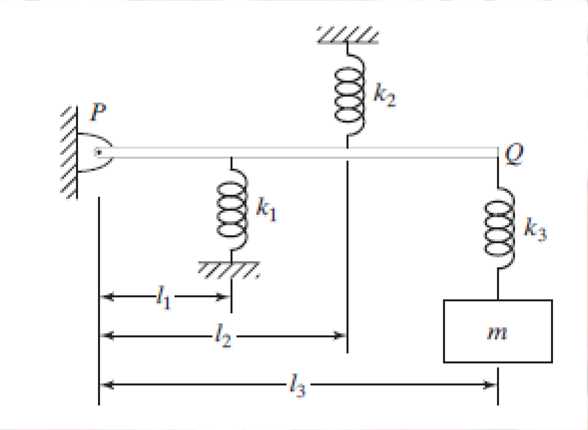
2. A helical spring, when fixed at one end and loaded at the other, requires a force of 100 N to produce an elongation of 10 mm. The ends of the spring are now rigidly fixed, one end vertically above the other, and a mass of 10 kg is attached at the middle point of its length. Determine the time taken to complete one vibration cycle when the mass is set vibrating in the vertical direction. **(BT4)**

3. An air-conditioning chiller unit weighing 2,000 lb is to be supported by four air springs. Design the air springs such that the natural frequency of vibration of the unit lies between 5 rad/s and 10 rad/s. **(BT4)**

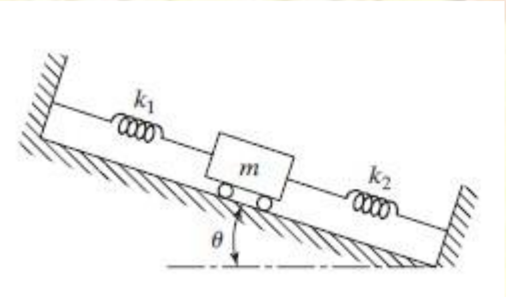
4. The maximum velocity attained by the mass of a simple harmonic oscillator is 10 cm/s, and the period of oscillation is 2 s. If the mass is released with an initial displacement of 2 cm, find (a) the amplitude, (b) the initial velocity, (c) the maximum acceleration, and (d) the phase angle **(BT4)**

5. An automobile having a mass of 2,000 kg deflects its suspension springs 0.02 m under static conditions. Determine the natural frequency of the automobile in the vertical direction by assuming damping to be negligible. **(BT4)**

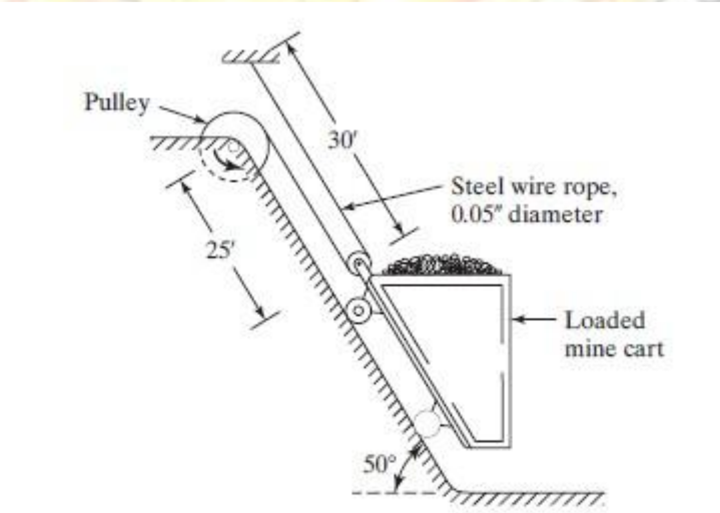
6. Three springs and a mass are attached to a rigid, weightless bar *PQ* as shown in Fig. below. Find the natural frequency of vibration of the system. **(BT5)**



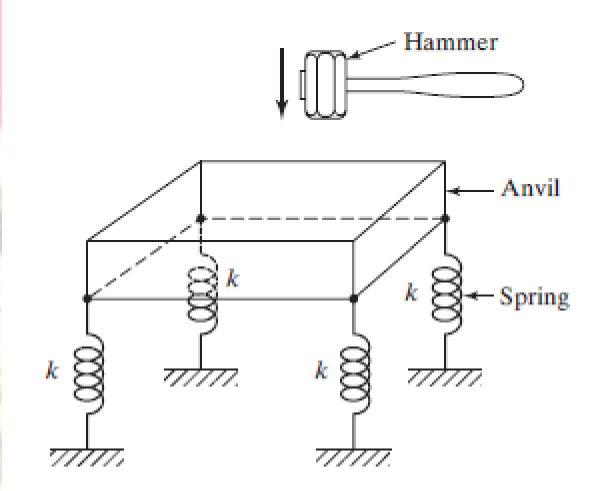
7. Find the natural frequency of vibration of a spring-mass system arranged on an inclined plane, as shown in Fig. below. **(BT6)**



8. A loaded mine cart, weighing 5,000 lb, is being lifted by a frictionless pulley and a wire rope, as shown in Fig. 2.53. Find the natural frequency of vibration of the cart in the given position **(BT5)**

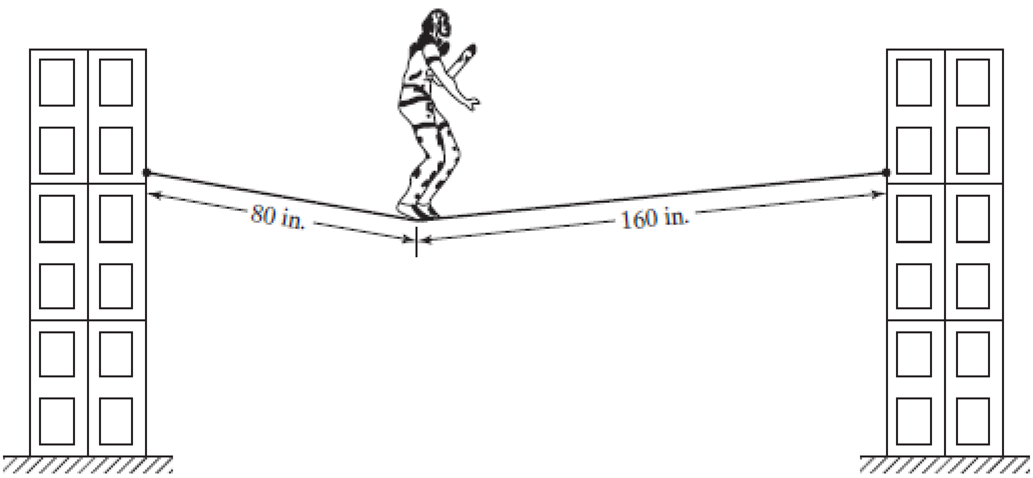


9. A sledgehammer strikes an anvil with a velocity of 50 ft/sec (Fig. below). The hammer and the anvil weigh 12 lb and 100 lb, respectively. The anvil is supported on four springs, each of stiffness k= 100 lp/in. Find the resulting motion of the anvil (a) if the hammer remains in contact with the anvil and (b) if the hammer does not remain in contact with the anvil after the initial impact. **(BT6)**



10. The natural frequency of a spring-mass system is found to be 2 Hz. When an additional mass of 1 kg is added to the original mass *m*, the natural frequency is reduced to 1 Hz. Find the spring constant *k* and the mass *m*. **(BT5)**

11. An acrobat weighing 120 lb walks on a tightrope, as shown in Fig. below. If the natural frequency of vibration in the given position, in vertical direction, is 10 rad/sec, find the tension in the rope. **(BT6)**



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UNIT III

Name of the Faculty	:	Dr. K. Vimalanathan	**Design./Dept.**	:	Prof./Mech.
Subject Code	:	18MEC412	**Branch**	:	Mechanical
Subject Name	:	Fundamentals of Vibrations	**Year/Sem.**	:	IV/I

PART-A (2 marks)

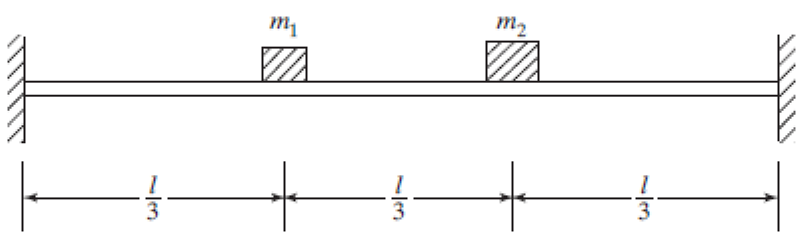
1. Name a few methods for finding the fundamental natural frequency of a multi degree-of freedom system. **(BT1)**
2. What is the basic assumption made in deriving Dunkerley s formula **(BT4)**
3. What is Rayleigh s principle **(BT2)**
4. State whether we get a lower bound or an upper bound to the fundamental natural frequency by using Dunkerley s formula **(BT4)**
5. State whether we get a lower bound or an upper bound to the fundamental natural frequency by using Rayleigh s method **(BT4)**
6. What is Rayleigh s quotient **(BT2)**
7. _________method is more extensively applied to torsional systems, although the method is equally applicable to linear systems. **(BT2)**
8. What is the basic principle used in Holzer's method **(BT2)**
9. What is the matrix iteration method **(BT2)**
10. Can we use any trial vector X vector in the matrix iteration method to find the largest natural frequency **(BT2)**
11. Holzer s method is basically a____________method. **(BT2)**
12. Using the matrix iteration method, how do you find the intermediate natural frequencies **(BT4)**
13. What is the difference between the matrix iteration method and Jacobi s method **(BT2)**
14. What is a rotation matrix? What is its purpose in Jacobi s method **(BT2)**
15. What is a standard Eigen value problem **(BT2)**
16. What is the role of Choleski decomposition in deriving a standard eigenvalue problem **(BT4)**
17. How do you find the inverse of an upper triangular matrix? **(BT4)**
18. The fundamental frequency in Durkerley's formula will always be larger than the exact value. Say True/False **(BT2)**

19. The fundamental frequency in Rayleigh s method will always be larger than the exact value. Say True/False **(BT2)**

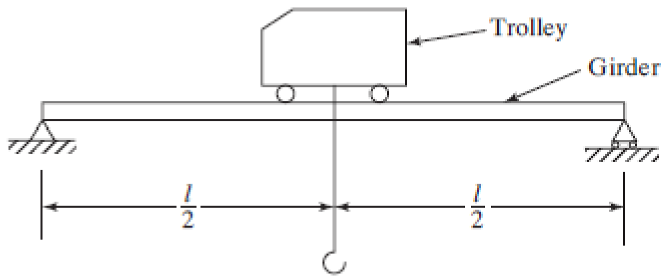
20. The computation of higher natural frequencies, based on the matrix iteration method, involves a process known as matrix______.**(BT2)**

PART-B

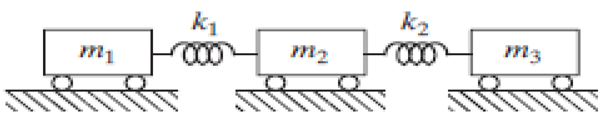
1. Prove that Rayleigh s quotient is never higher than the highest eigenvalue **(BT4)**
2. A uniform fixed-fixed beam carries two masses m_1 and m_2, with $m_1=m_2$ as shown in Fig. Find the fundamental natural frequency of the beam using Dunkerley s method. **(BT4)**



3. In an overhead crane (see Fig.) the trolley weighs ten times the weight of the girder. Using Dunkerley s formula, estimate the fundamental frequency of the system**(BT4)**



4. Using Holzer ‘s method, find the natural frequencies and mode shapes of the system shown in Fig. below, with m1=100kg, m2=20kg, m3=200kg, k1=8000 N/m and k2=4000N/m **(BT5)**



5. The stiffness and mass matrices of a vibrating system are given by

$$[k] = k\begin{bmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 3 \end{bmatrix}, \quad [m] = m\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{bmatrix}$$

Using Holzer s method, determine all the principal modes and the natural frequencies. **(BT5)**

6. The mass and stiffness matrices of a spring-mass system are known to be

$$[m] = m\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{bmatrix} \quad \text{and} \quad [k] = k\begin{bmatrix} 2 & -1 & 0 \\ -1 & 3 & -2 \\ 0 & -2 & 2 \end{bmatrix}$$

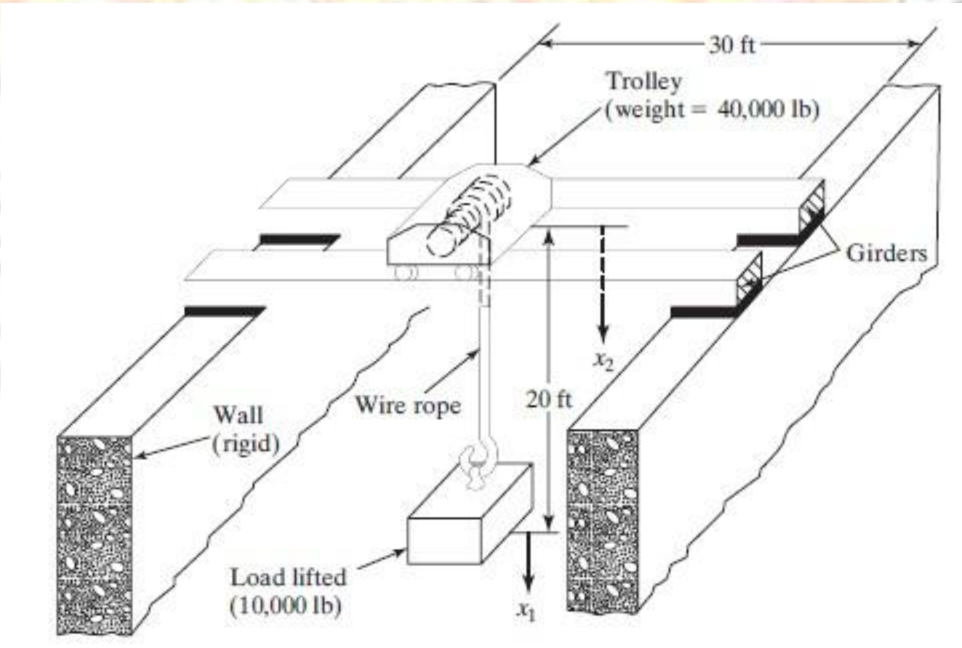
Using the matrix iteration method, find the natural frequencies and mode shapes of the system **(BT5)**

7. The mass and flexibility matrices of a three-degree-of-freedom system are given by

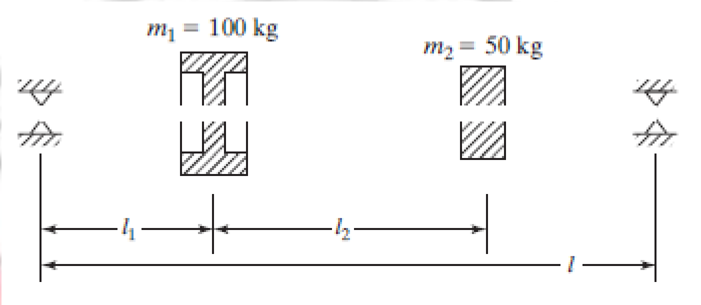
$$[m] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad \text{and} \quad [a] = [k]^{-1} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 2 \\ 1 & 2 & 3 \end{bmatrix}$$

Find the lowest natural frequency of vibration of the system using the matrix iteration method. **(BT5)**

8. A simplified diagram of an overhead traveling crane is shown in Fig. below. The girder, with square cross section, and the wire rope, with circular cross section, are made up of steel. Design the girders and the wire rope such that the natural frequencies of the system are greater than the operating speed, 1500 rpm, of an electric motor located in the trolley. **(BT6)**



9. A flywheel of mass m1 = 100 kg and a pulley of mass m2 = 50 kg are to be mounted on a shaft of length as shown in Fig below. Determine their locations and to maximize the fundamental frequency of vibration of the system. **(BT6)**



10. The largest eigenvalue of the matrix

$$[D] = \begin{bmatrix} 2.5 & -1 & 0 \\ -1 & 5 & -\sqrt{2} \\ 0 & -\sqrt{2} & 10 \end{bmatrix}$$

is given by $\lambda_1 = 10.38068$ Using the matrix iteration method, find the other eigenvalues and all the eigenvectors of the matrix. Assume [m] = [I]. **(BT4)**

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Unit-VI

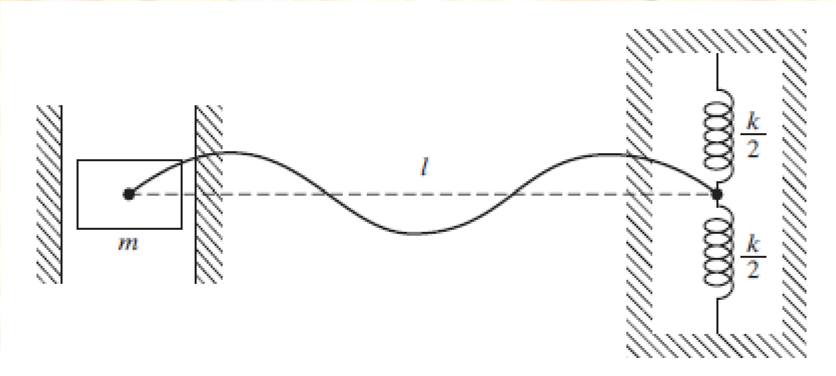
Name of the Faculty	:	Dr. K. Vimalanathan	**Design./Dept.**	:	Prof./Mech.
Subject Code	:	18MEC412	**Branch**	:	Mechanical
Subject Name	:	Fundamentals of Vibrations	**Year/Sem.**	:	IV/I

PART-A (2 marks)

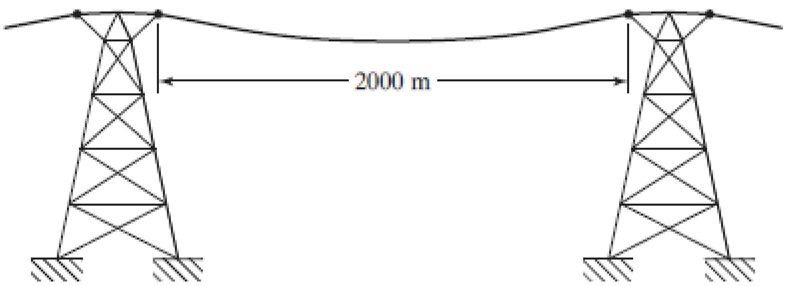
1. How does a continuous system differ from a discrete system in the nature of its equation of motion? **(BT4)**
2. How many natural frequencies does a continuous system have? **(BT4)**
3. Are the boundary conditions important in a discrete system? Why? **(BT6)**
4. What is a wave equation? What is a traveling-wave solution? **(BT2)**
5. What is the significance of wave velocity? **(BT2)**
6. State the boundary conditions to be specified at the simply supported end of a beam if (a) thin-beam theory is used and (b) Timoshenko beam theory is used. **(BT3)**
7. State the possible boundary conditions at the ends of a string. **(BT2)**
8. What is the main difference in the nature of the frequency equations of a discrete system and a continuous system? **(BT2)**
9. For a discrete system, the governing equations are______differential equations **(BT2)**
10. What is the effect of a tensile force on the natural frequencies of a beam? **(BT2)**
11. Under what circumstances does the frequency of vibration of a beam subjected to an axial load become zero? **(BT4)**
12. A drumhead can be considered as a______.**(BT2)**
13. Why does the natural frequency of a beam become lower if the effects of shear deformation and rotary inertia are considered? **(BT6)**
14. The free-vibration equation of a string is also called a______equation**(BT2)**
15. Give two practical examples of the vibration of membranes. **(BT2)**
16. What is the basic principle used in Rayleigh s method? **(BT2)**
17. The Timoshenko beam theory can be considered as______beam theory. **(BT2)**
18. Why is the natural frequency given by Rayleigh s method always larger than the true value of $\omega 1$? **(BT6)**
19. What is the difference between Rayleigh s method and the Rayleigh-Ritz method? **(BT4)**
20. What is Rayleigh s quotient? **(BT2)**

PART-B

1. Determine the velocity of wave propagation in a cable of mass ρ = 5 kg/m when stretched by a tension P = 4000 N. **(BT4)**
2. A steel wire of 2 mm diameter is fixed between two points located 2 m apart. The tensile force in the wire is 250 N. Determine (a) the fundamental frequency of vibration and (b) the velocity of wave propagation in the wire. **(BT5)**
3. A stretched cable of length 2 m has a fundamental frequency of 3000 Hz. Find the frequency of the third mode. How are the fundamental and third mode frequencies changed if the tension is increased by 20 percent? **(BT5)**
4. Find the time it takes for a transverse wave to travel along a transmission line from one tower to another one 300 m away. Assume the horizontal component of the cable tension as 30,000 N and the mass of the cable as 2 kg/m of length. **(BT5)**
5. A cable of length l and mass ρ per unit length is stretched under a tension P. One end of the cable is connected to a mass m, which can move in a frictionless slot, and the other end is fastened to a spring of stiffness k, as shown in Fig. below. Derive the frequency equation for the transverse vibration of the cable. **(BT6)**

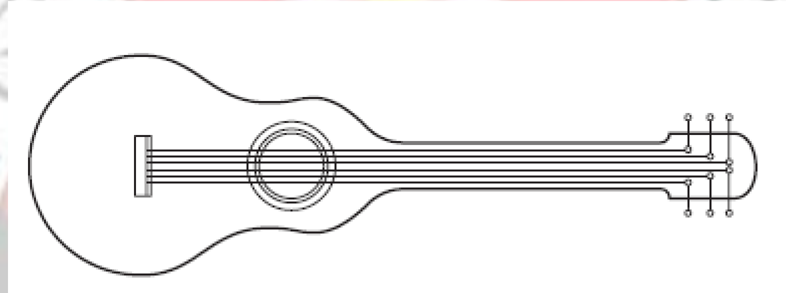


6. The cable between two electric transmission towers has a length of 2000 m. It is clamped at its ends under a tension P (Fig. 8.24). The density of the cable material 8890 kg/m^3 is If the first four natural frequencies are required to lie between 0 and 20 Hz, determine the necessary cross-sectional area of the cable and the initial tension. **(BT5)**



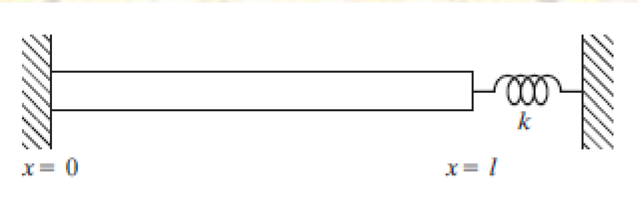
7. A cord of length l is made to vibrate in a viscous medium. Derive the equation of motion considering the viscous damping force **(BT4)**

8. The strings of a guitar (Fig. below) are made of music wire with diameter 0.05 mm, weight density 76.5 kN/m^3, and Young s modulus 207 GPa. If the lengths of two of the strings are given by 0.60 m and 0.65 m, determine the fundamental natural frequencies of the strings if the tension in each string is 5 X 10^4 N. **(BT5)**



9. Derive an equation for the principal modes of longitudinal vibration of a uniform bar having both ends free **(BT4)**

10. Show that the normal functions corresponding to the longitudinal vibration of the bar shown in Fig. below are orthogonal **(BT5)**



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UNIT V

Name of the Faculty	:	Dr. K. Vimalanathan	**Design./Dept.**	:	Prof./Mech.
Subject Code	:	18MEC412	**Branch**	:	Mechanical
Subject Name	:	Fundamentals of Vibrations	**Year/Sem.**	:	IV/I

PART-A (2 marks)

1. Name some sources of industrial vibration. **(BT1)**
2. What are the various methods available for vibration control? **(BT2)**
3. What is single-plane balancing? **(BT2)**
4. Describe the two-plane balancing procedure. **(BT2)**
5. What is whirling? **(BT2)**
6. What is the difference between stationary damping and rotary damping? **(BT4)**
7. How is the critical speed of a shaft determined? **(BT5)**
8. What causes instability in a rotor system? **(BT4)**
9. What considerations are to be taken into account for the balancing of a reciprocating engine? **(BT3)**
10. What is the function of a vibration isolator? **(BT2)**
11. What is a vibration absorber? **(BT2)**
12. What is the difference between a vibration isolator and a vibration absorber? **(BT4)**
13. Does spring mounting always reduce the vibration of the foundation of a machine? **(BT5)**
14. Is it better to use a soft spring in the flexible mounting of a machine? Why? **(BT6)**
15. Is the shaking force proportional to the square of the speed of a machine? **(BT6)**
16. Does the vibratory force transmitted to the foundation increase with the speed of the machine? **(BT4)**
17. Why does dynamic balancing imply static balancing? **(BT6)**
18. Explain why dynamic balancing can never be achieved by a static test alone. **(BT6)**
19. Why does a rotating shaft always vibrate? What is the source of the shaking force? **(BT6)**
20. Is it always advantageous to include a damper in the secondary system of a dynamic vibration absorber? **(BT6)**
21. What is active vibration isolation? **(BT2)**
22. Explain the difference between passive and active isolation. **(BT4)**
23. What is the importance of vibration measurement? **(BT2)**
24. What is the difference between a vibrometer and a vibrograph? **(BT4)**

25. What is a transducer? **(BT1)**
26. Discuss the basic principle on which a strain gage works. **(BT2)**
27. Define the gage factor of a strain gage. **(BT2)**
28. What is the difference between a transducer and a pickup? **(BT4)**
29. What is a piezoelectric material? Give two examples of such material. **(BT2)**
30. What is the working principle of an electrodynamic transducer? **(BT2)**
31. What is an LVDT? How does it work? **(BT2)**
32. What is a seismic instrument? **(BT2)**
33. What is the frequency range of a seismometer? **(BT2)**
34. What is an accelerometer? **(BT2)**
35. What is phase-shift error? When does it become important? **(BT2)**
36. Give two examples of a mechanical vibration exciter. **(BT2)**
37. What is an electromagnetic shaker? **(BT2)**
38. Discuss the advantage of using operational deflection shape measurement. **(BT3)**
39. What is the purpose of experimental modal analysis? **(BT4)**
40. Describe the use of the frequency-response function in modal analysis. **(BT4)**
41. Name two frequency-measuring instruments. **(BT2)**
42. State three methods of representing the frequency-response data. **(BT2)**
43. How are Bode plots used? **(BT2)**
44. How is a Nyquist diagram constructed? **(BT2)**
45. What is the principle of mode superposition? What is its use in modal analysis? **(BT2)**
46. State the three types of maintenance schemes used for machinery. **(BT2)**
47. How are orbits used in machine diagnosis? **(BT2)**
48. Define the terms kurtosis and cepstrum **(BT2)**

PART-B

1. A Rochelle salt crystal, having a voltage sensitivity of 0.098 V-m/N and thickness 2 mm, produced an output voltage of 200 volts under pressure. Find the pressure applied to the crystal. **(BT5)**
2. Determine the maximum percent error of a vibrometer in the frequency-ratio range $4 \leq r < \infty$ with a damping ratio of $\zeta = 0$ and $\zeta = 0.67$ **(BT5)**
3. A vibrometer is used to measure the vibration of an engine whose operating-speed range is from 500 to 2000 rpm. The vibration consists of two harmonics. The amplitude distortion must be less than 3 percent. Find the natural frequency of the vibrometer if (a) the damping is negligible and (b) the damping ratio is 0.6. **(BT5)**

4. A spring-mass system, having a static deflection of 10 mm and negligible damping, is used as a vibrometer. When mounted on a machine operating at 4000 rpm, the relative amplitude is recorded as 1 mm. Find the maximum values of displacement, velocity, and acceleration of the machine. **(BT5)**
5. A vibration pickup has a natural frequency of 5 Hz and a damping ratio of **ζ=0.5** Find the lowest frequency that can be measured with a 1 percent error. **(BT4)**
6. The cylinders of a four-cylinder in-line engine are placed at intervals of 12 in. in the axial direction. The cranks have the same length, 4 in., and their angular positions are given by 0°, 180°, 180°, and 0°. If the length of the connecting rod is 10 in. and the reciprocating weight is 2 lb for each cylinder, find the unbalanced forces and moments at a speed of 3000 rpm, using the center line through cylinder 1 as the reference plane. **(BT5)**
7. The armature of a variable-speed electric motor, of mass 200 kg, has an unbalance due to manufacturing errors. The motor is mounted on an isolator having a stiffness of 10 kN/m and a dashpot having a damping ratio of 0.15. (a) Find the speed range over which the amplitude of the fluctuating force transmitted to the foundation will be larger than the exciting force. (b) Find the speed range over which the transmitted force amplitude will be less than 10 percent of the exciting force amplitude **(BT5)**
8. A dishwashing machine weighing 150 lb operates at 300 rpm. Find the minimum static deflection of an isolator that provides 60 percent isolation. Assume that the damping in the isolator is negligible. **(BT6)**
9. A washing machine of mass 50 kg operates at 1200 rpm. Find the maximum stiffness of an isolator that provides 75 percent isolation. Assume that the damping ratio of the isolator is 7 percent. **(BT6)**
10. A shaft carries four rotating masses A, B, C and D which are completely balanced. The masses B, C and D are 50 kg, 80 kg and 70 kg respectively. The masses C and D make angles of 90° and 195° respectively with mass B in the same sense. The masses A, B, C and D are concentrated at radius 75 mm, 100 mm, 50 mm and 80 mm respectively. The plane of rotation of masses B and C are 250 mm apart. Determine (i) the magnitude of mass A and its angular position and (ii) the position planes A and D. **(BT5)**
11. A shaft is rotating at a uniform angular speed. Four masses m_1, m_2, and $m_3$and m_4 of magnitudes 300kg, 450kg, 360kg, 390kg respectively are attached rigidly to the shaft. The masses are rotating in the same plane. The corresponding radii of rotation are 200mm, 150mm, 250mm and 300mm respectively. The angle made by these masses with horizontal are 0°.45°, 120°and 255°respectively. Find, (i) the magnitude of balancing mass (ii) The position of balancing mass if its radius of rotation is 200mm. **(BT5)**

12. Four masses m_1, m_2, m_3, and m_4 are 200kg, 300kg, 240kg and 260kg respectively. The corresponding radii of rotation are 0.2m, 0.15m, 0.25m and 0.3m respectively and the angle between successive masses45°, 75°, and135°.Find the position and magnitude of balance mass required if its radius of rotation is 0.25m. **(BT5)**
13. A, B, C and D are four masses carried by a rotating shaft at radii 100mm,125mm,200mm and 150mm respectively. The planes in which the masses revolve are spaced 600mm apart and the masses of B,C and D are 10kg,5kg and 4kgrespectively.Find the required mass A and relative angular setting of the four masses so that the shaft be in complete balance. **(BT5)**

Notes :

Bloom's Taxonomy

Bloom's Level	Descriptions	Bloom's Level	Descriptions
BT 1	**Remember**	**BT 2**	**Understand**
BT 3	**Apply**	**BT 4**	**Analyze**
BT 5	**Evaluate**	**BT 6**	**Create**

Prepared by	Recommended by	Approved by
Dr. K. Vimalanathan, **Professor** Department of Mech. Engineering, Sreenivasa Institute of Technology& Management Studies, Chittoor	**Dr. S. Rajesh** **HOD/Mechanical** Sreenivasa Institute of Technology& Management Studies, Chittoor.	**Principal** **SITAMS,** Chittoor.