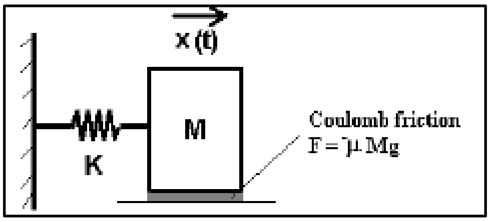
Unit 1- Introduction &Single Degree of Freedom Systems – Free Undamped and Damped Vibrations

Assignment Questions

Theory Questions:

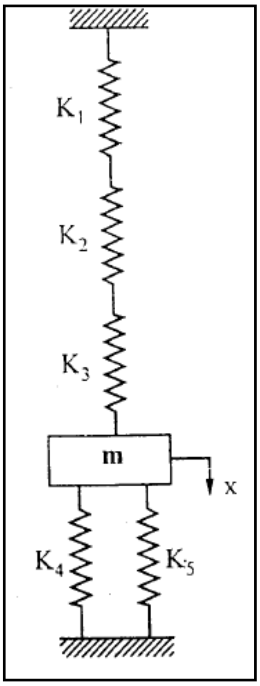
1. What do you meant by vibrations? Give various applications of vibrations.
2. Define following terms related to vibrations:
   - I. Damper
   - II. Time period (T)
   - III. Frequency (f)
   - IV. Natural frequency
   - V. Free Vibrations
   - VI. Forced Vibrations
   - VII. Damped Vibrations
   - VIII. Resonance
   - IX. Simple Harmonic Motion (S.H.M)
3. Define Transverse vibration, Longitudinal Vibration and torsional vibrations with neat sketch.
4. What are the basic elements of a vibrating system? Discuss degree of freedom in context with Vibration.
5. Give difference between Discrete vibrating system and continuous vibrating system
6. Prepare a mathematical model for the following vibrating system:
   I. A cantilever beam having modulus of elasticity 'E' , mass 'm' and cross section 'A'
   II. A Hammer Press
   III. Motor Vehicle
7. Discuss various methods of finding equation of motion for Free Undamped Vibration system.
8. Define : i) Dry Friction or Coulomb Damping and ii) Viscous or Linear Damping
9. Derive equation of motion for the following system shown in figure (Dry Friction Damping):



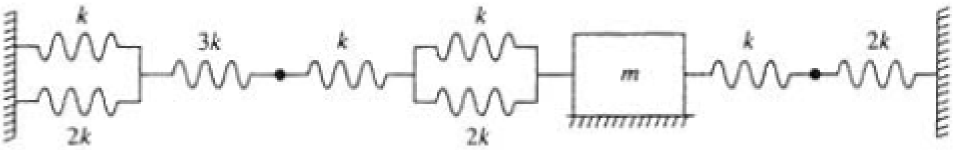
10. Draw the graph of Amplitude vs time for Coulomb friction damping and derive the equation for the Rate of Decay (Δ).
11. Discuss final rest position in coulomb damping.
12. Derive equation of motion for Viscous or Linear Damping.
13. Define Damping Factor and Discuss 3 cases for Linear damping : 1) Underdamped , 2) Critically Damped and 3) Overdamped. (Graph of amplitude vs time is necessary)

Problems/Examples:

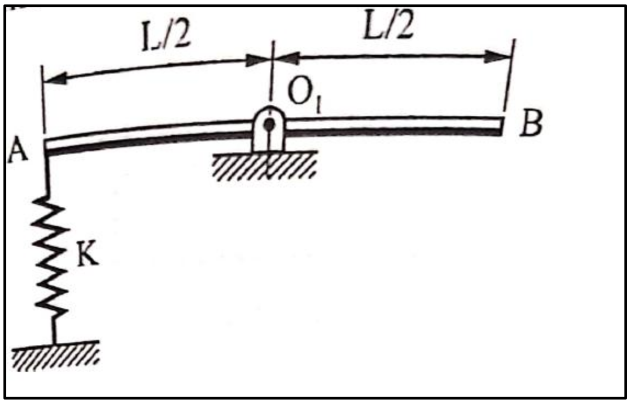
1. For the system shown in figure below: K_1 = 3000N/m, K_2=1500 N/m, K_3= 2000 N/m, K_4 =K_5 =500 N/m. Find mass 'm' such that the system has a natural frequency of 10 hz.



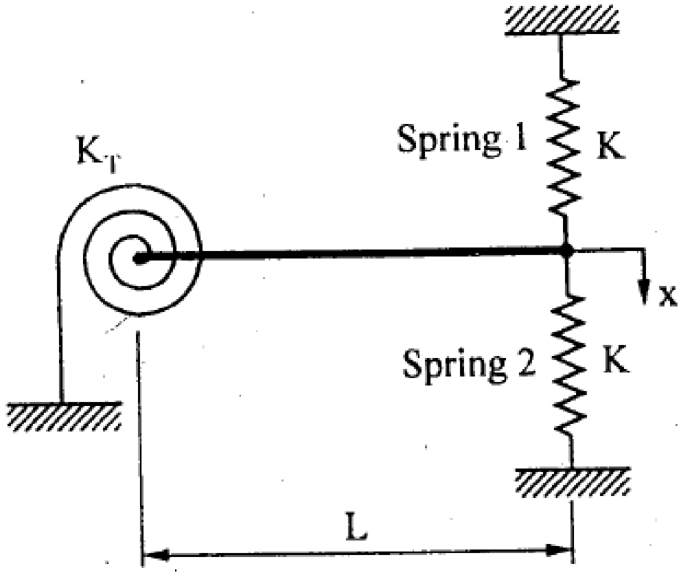
2. Find equivalent stiffness of the following block diagram.



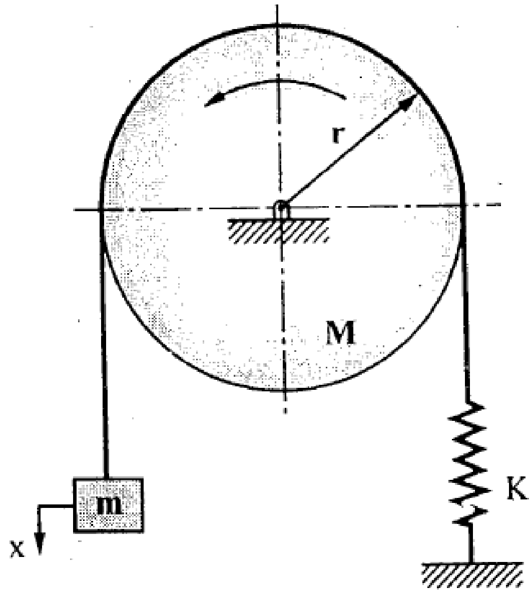
3. A uniform rod of mass '**m**' is suspended as shown in figure. Determine the frequency (**f_n)** of the resulting motion.



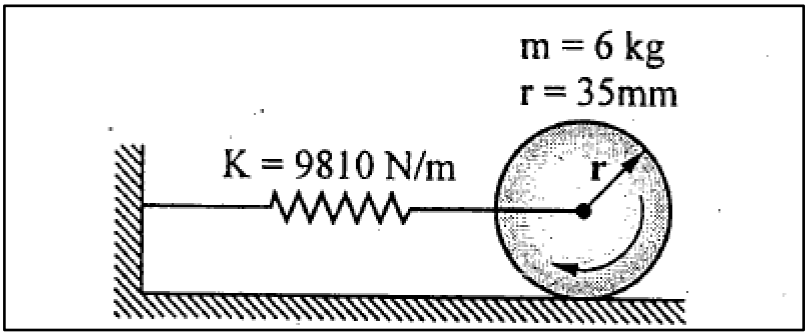
4. For the system shown in figure below, find equation of motion and also determine its natural frequency.



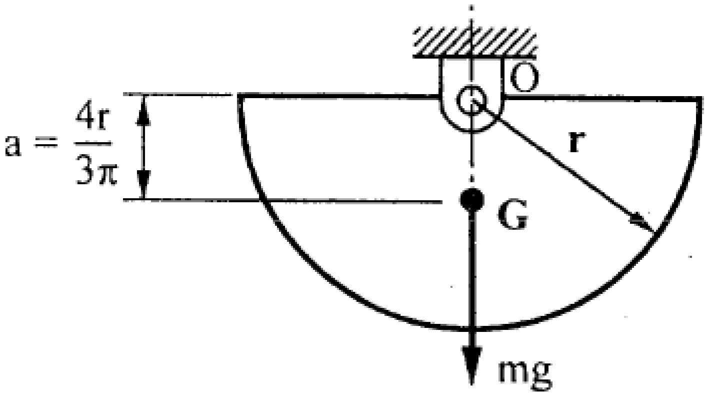
5. Write equation of motion for the system shown in figure below and find its natural frequency.



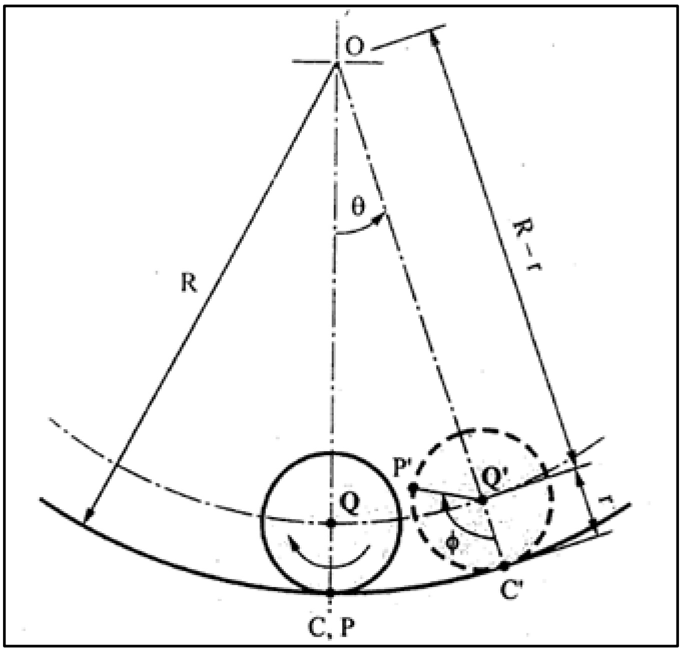
6. Find the frequency (f) of oscillation of the roller, if it rolls without slipping for the system as shown in figure below.



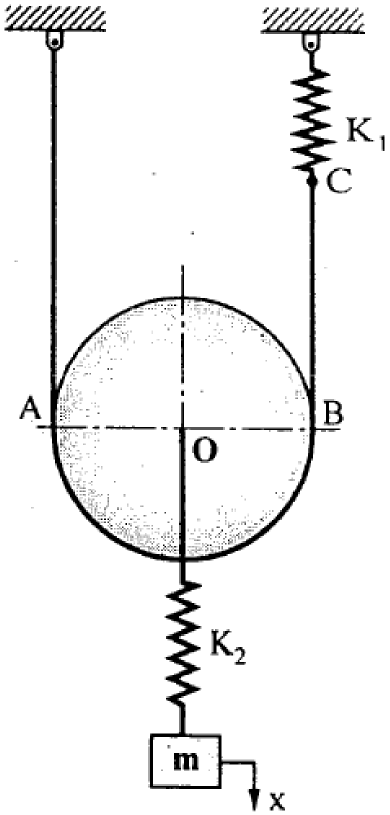
7. Find the natural frequency of half solid cylinder of mass ‘m’ and radius ‘r’ when it is slightly displaced from the equilibrium position and then released.



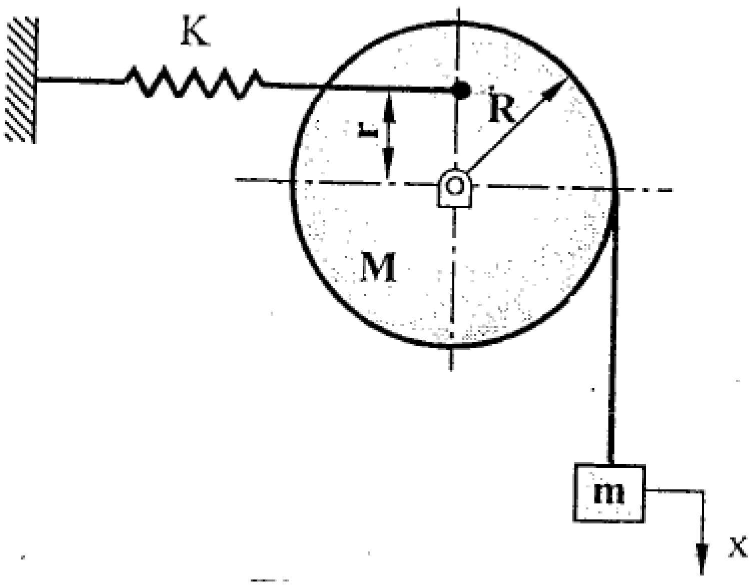
8. A cylinder with mass ‘m’ and radius ‘r’ rolls without slipping on a cylindrical surface of radius ‘R’. Find the natural frequency for small oscillations.



9. Find the natural frequency of following system.



10. Find the natural frequency of following system.



A. Based on Dry Friction or Coulomb Damping

1. A vibrating system having mass 50 kg and spring stiffness of 500 N/m is having dry friction damping with limiting frictional force (Fr = 6 N). If the mass is given initial displacement of 300 mm, find:
   a) Loss of amplitude per cycle
   b) Number of cycles before stopping
   c) Time elapsed before stopping

   d) Distance at which the mass stops from the mean position.

2. A weight of 1 kg is attached to a spring having stiffness 3900 N/m. The weight slides on a horizontal surface having a coefficient of friction 0.1. Find the frequency of the vibration of the system and the amplitude after one cycle; if the initial amplitude is 2.5 mm. determine the final rest position.
3. A body of mass 1 kg lies on a dry horizontal plane and is connected to a rigid support. The body is displaced from the unstressed position by amount equal to 0.255 m with the tension in the spring at this displacement equal to 49.05 N and then released with zero velocity. How long the body vibrate and at what distance from the unstressed position will it stop if the coefficient of friction is 0.25?
4. A mass if 20 kg is supported by a vertical spring of 4000 N/m stiffness. There is a friction force of 25 N which always resist the vertical upward or downward displacement. The mass is released from a position in which the total extension of the spring is 110 mm. Determine the frequency of vibration and the final extension of the spring in the position in which the system comes to rest.

B. <u>Based on Linear or Viscous Damping</u>

1. A machine weighs 18 kg and is supported on springs and dashpots. The total stiffness of the spring is 12 N/mm and damping is 0.2 N-sec/mm. The system is initially at rest and a velocity of 120 mm/sec is imparted to the mass. Determine:
   a) The displacement and velocity of mass as a function of time.
   b) The displacement and velocity after 0.4 sec.
2. A gun barrel, weighing 600 kg has a recoil spring of stiffness 345 N/mm. If the barrel recoils one meter on firing, find :
   a) The initial recoil velocity of the gun
   b) The critical damping coefficient which is engaged at the end of the recoil stroke. Assume no energy is lost in recoil of the barrel.
3. A flywheel of mass 10 kg and radius of gyration 0.3 m, makes a torsional rotations under a torsion spring of stiffness 5 N m /rad. A viscous damper is fitted and it is found that the amplitude is reduced by a factor 100 over any complete 2 cycles. Find:
   a) Damping Factor
   b) Damping Coefficient
   c) Periodic Time of damped oscillations
4. In a single degree viscous damped vibrating system, the suspended mass of 16 kg makes 45 oscillations in 27 seconds. The amplitude of the natural vibrations decreases to one fourth of the initial value after 5 oscillations. Determine:
   a) The logarithmic decrement
   b) The damping factor and damping coefficient
   c) The stiffness of the spring.