UNIT 4 - FORCED VIBRATION

UNIVERSITY QUESTIONS

1) A single-cylinder vertical petrol engine of total mass 400 kg is mounted upon a steel chassis frame and chases a vertical static deflection of 2.4 mm. The reciprocating parts of engine have a mass of 18 kg and move through a vertical stroke of 160 mm with SHM. A dashpot is pivoted, the damping resistance of which is directly proportional to the velocity and amounts to 2000 N/m/s. Determine: i) the speed of the driving shaft at which resonance will occur, and (ii) the amplitude of steady state forced vibrations when the driving shaft of the engine rotates at 540 r.p.m. ***May 2003***
2) A harmonic exciting force of 25 N is acting on a machine part which is having a mass of 2 kg and is vibrating in a viscous medium. This exciting force causes resonant amplitude of 12.5 mm with a period of a.2 sec. Determine the damping coefficient. ***Dec 2003***
3) A machine 100 kg mass has a 20 kg rotor with 0.5 mm eccentricity. The mounting springs have s = 85 x 103 N/m, ζ= 0.02. The operating speed is 600 r.p.m and the unit is constrained to move vertically. Find: (i) dynamic amplitude of the machine; and (ii) force transmitted to the supports. ***Dec 2004***
4) An industrial machine weighing 445 kg is supported on a spring with a statical deflection of 0.5 cm. If the machine has rotating imbalance of 25 kg-cm. Determine the force transmitted at 1200 r.p.m and the dynamic amplitude at that speed. ***Dec 2004***
5) A mass of 50 kg is supported by an elastic structure of total stiffness 20 kN/m. The damping ratio of the system is 0.2. A simple harmonic disturbing force acts on the mass and at any time t seconds, the force is 60 cos 10 t Newtons. Find the amplitude of the vibrations and phase angle caused by damping. ***May 2005***
6) A mass of 50 kg is supported by an elastic structure of total stiffness 20 kN/m. The damping ratio of the system is 0.2. A harmonic force 60 cos l0 t Newton acts on it. Find the amplitude of vibration and phase angle caused by the damping. ***Dec 2005***
7) Find the stiffness of each spring when a refrigerator unit having a mass of 30 kg is to be supported by three springs. The force transmitted to the supporting structure is only 10% of the impressed force. The refrigerator unit operates at 420 r.p.m. ***Dec 2005***
8) A single-cylinder vertical petrol engine has a mass of 200 kg and is mounted upon a steel chassis frame. The vertical static deflection of the frame is 2.4 mm due to the weight of the engine. The mass of the reciprocating parts is 9 kg and the stroke of the piston is 160 mm with simple harmonic motion. A dashpot of damping coefficient of 1 N/mm/sec is used to dampen the vibrations. Calculate at steady state: (i) the amplitude of forced vibration at 500 rpm engine speed, and (ii) the resonance speed. ***May 2006***
9) The body having a mass of 15 kg is suspended from a spring which deflects 12 mm under weight of the mass. Determine the frequency of the free vibration. What is the viscous damping force needed to make the motion a periodic at a speed of 1 mm/sec? If, when damped to this extent, a disturbing force having a maximum value of 100 N and vibrating at 6 Hz is made to act on the body determine the amplitude of the ultimate motion. ***May 2006***
10) A mass of 50 kg is supported by an elastic structure of stiffness 20 kN/m. A simple harmonic disturbing force in Newtons, expressed as 75 cos (12 t) acts on the mass. If 't' is expressed in seconds and the damping ratio is 0.25, find the amplitude of the vibrations and the phase angle caused by the damping. ***Dec 2006***
11) A single-cylinder reciprocating engine of total mass 250 kg is to be installed on an elastic support which permits vibratory motion only in vertical direction. The mass of piston is 3.75 kg and it reciprocates vertically with SHM with a stroke of 150 mm. The maximum vibratory force transmitted through the elastic support to the foundation must be limited to 500 N when the engine runs at 750 rpm and less than 500 N at all higher

speeds. i) Find the necessary stiffness of the elastic support and the amplitude of vibration at 800 rpm. (ii) If the engine speed is reduced below 750 rpm, at what speed will the transmitted force again becomes 500 N. ***Dec 2006***

12) A mass of 10 kg is suspended from one end of a helical spring, the other end being fixed. The stiffness of the spring is t0 N/mm. The viscous damping causes the amplitude to decrease to one tenth of the initial value in four complete oscillations. If a periodic force of 150 cos 50 t N is applied at the mass in the vertical direction, find the amplitude of the forced vibrations. What is its value at resonance? ***May 2007***
13) A machine supported symmetrically on four springs has a mass of 80 kg. The mass of the reciprocating parts is 2.2 kg which move through a vertical stroke of 100 mm with simple harmonic motion. Neglecting damping, determine the combined stiffness of the spring so that the force transmitted to foundation is $1/20^{th}$ of the impressed force. The machine crank shaft rotates at 800 rpm. If under working conditions, the damping reduces the amplitudes of successive vibrations by 30%, find (i) the force transmitted to the foundation at resonance and (ii) the amplitude of vibration at resonance. ***May 2007***
14) A single-cylinder engine has an out-of- balance force of 500 N at an engine speed of 300 rpm. The total mass of the engine is 150 kg and it is carried on a set of springs of total stiffness 300 N/cm. (i) Find the amplitude of the steady motion of the mass and the maximum oscillating force transmitted to the foundation. ii) If a viscous damping is interposed between the mass and the foundation, the damping force being 1000 N at 1 m/s of velocity, find the amplitude of the forced damped oscillation of the mass and its angle of lag with disturbing force. ***May 2007***
15) A mass of 10 kg is suspended from one end of a helical spring, the other end being fixed. The stiffness of the spring is 10 N/mm. The viscous damping causes the amplitude to decrease to one-tenth of the initial value in four complete oscillations. If a periodic force of 150 cos 50 t N is applied at the mass in the vertical direction, find the amplitude of the forced vibrations. What is its value of resonance? ***Dec 2007***
16) The mass of an electric motor is 120 kg and it runs at 1500 rpm. The armature mass is 35 kg and its C.G lies 0.5 mm from the axis of rotation. The motor is mounted on five springs of negligible damping so that the force transmitted is one-eleventh of the impressed force. Assume that the mass of the motor is equally distributed among the five springs. Determine: (i) Stiffness of each spring. (ii) Dynamic force transmitted to the base at the operating speed (iii) Natural frequency of the system. ***Dec 2007***
17) A mass of 500 kg is mounted on supports having a total stiffness of 100 kN/m and which provides viscous damping, the damping ratio being 0.4. The mass is constrained to move vertically and is subjected to a vertical disturbing force of the type F cos ωt. Determine the frequency at which resonance will occur and the maximum allowable value of F if the amplitude at resonance is to be restricted to 5 mm. ***May 2008***
18) A machine of mass 75 kg is mounted on springs of stiffness 1200 kN/m and with an assumed damping factor of 0.2. A piston within the machine of mass 2 kg has a reciprocating motion with a stroke of 80 mm and a speed of 3000 cycles/min. Assuming the motion to be simple harmonic, find (i) the amplitude of motion of the machine, (ii) its phase angle with respect to the existing force, (iii) the force transmitted to the foundation, and (iv) the phase angle of transmitted force with respect to the exciting force. ***May 2008***
19) A machine of mass 75 kg is mounted on springs of stiffness 1200 kN/m and with an assumed damping factor of 0.2. A piston within the machine of mass 2 kg has a reciprocating motion with a stroke of 80 mm and a speed of 3000 cycles/min. Assuming the motion to be simple harmonic, find: (i) The amplitude of motion of

the machine, (ii) The phase angle with respect to the existing force, (iii) The force transmitted to the foundation, and (iv) The phase angle of transmitted force with respect to the exciting force. ***Dec 2008***

20) A machine supported symmetrically on four springs has mass of 80 kg. The mass of the reciprocating parts is 2.2 kg which move through a vertical stroke of 100 mm with simple harmonic motion. Neglecting damping, determine the combined stiffness of the springs so that the force transmitted to the foundation is $1/20^{th}$ of the impressed force. The machine crankshaft rotates at 800 r.p.m. If, under actual working conditions, the damping reduces the amplitudes of successive vibrations by 30%find: (i) The force transmitted to the foundation at 800 r.p.m., (ii) The force transmitted to the foundation at resonance, and (iii) The amplitude of vibrations at resonance. ***Dec 2008***

21) A vibrating body is supported by six isolators each having stiffness 32000 N/m and 6 dashpots having damping factor as 400 N-sec/m. The vibrating body is to be isolated by a rotating device having an amplitude of 0.06 mm at 600 rpm. Take m = 30 kg. Determine: (i) amplitude of vibration of the body, and (ii) dynamic load on each isolator due to vibration. ***May 2009***

22) A machine supported symmetrically on four springs has a mass of 80 kg. The mass of the reciprocating part is 2.2 kg which move through a vertical stroke of 100 mm with simple harmonic motion. Neglecting damping, determine the combined stiffness of the springs so that the force transmitted to the foundation is $1/20^{th}$ of the impressed force. The machine crankshaft rotates at 800 rpm. If under actual working conditions, the damping reduces the amplitudes of successive vibrations by 30%, find: (i) the force transmitted to the foundation at 800 rpm, (ii) the force transmitted to the foundation at resonance, and (iii) the amplitude of the vibrations at resonance. **May 2009*, Dec 2009***

23) A harmonic exciting force of 25 N is acting on a machine part, which is having mass of 2 kg and is vibrating in a viscous medium. The exciting force causes resonant amplitude of 12.5 mm with a period of 0.20 seconds. Determine the damping coefficient. If the system is excited by a harmonic force of frequency 1 Hz, find the increase in amplitude of forced vibration when damper is removed. ***Dec 2009***

24) A machine of 100 kg mass is supported on a-spring of stiffness700 kN/m and has an unbalanced rotating element, which results in a disturbing force of 350 N at a speed of 3000 rpm. Assuming a damping factor of 0.20, determine its amplitude of motion due to unbalance the transmissibility, and the transmitted force. ***(Nov/Dec 2011)***

25) A machine of mass 1000 kg is acted upon by an external force of 2450N at a frequency of 1500 rpm. To reduce the effects of vibration, isolator of rubber having static deflection of 2 mm under the machine load and an estimated damping of 0.2 are used' Determine the force transmitted to the foundation, the amplitude of vibration and the Phase lag. ***(Nov/Dec 2011)***

26) An electric motor is supported on a spring and a dashpot. The spring has a stiffness of 6400 N/mm and the dashpot offers resistance of 500 N at 4 m/s. The unbalanced mass 0.5 kg rotates at 5 cm radius and the total mass of vibratory system is 20 kg. The motor runs at 400 rpm. Determine damping factor, amplitude of vibration and phase angle, resonant speed and resonant amplitude and force exerted by the spring and dashpot on the motor. ***April/May 2012.***

27) A vibrating body is supported by six isolators each having stiffness of 32000 N/m and six dashpots having damping factor as 400 N-sec/m. The vibrating body is to be isolated by a rotating device having amplitude of 0.06mm at 600 rpm. Take m = 30 kg. Determine the amplitude of vibration of the body and dynamic load on each isolator due to vibration. ***April/May 2012.***

28) A vibratory body of mass 150 kg supported on springs of total stiffness 1050 kN/m has a rotating unbalance force of 525 N at a speed of 6000 rpm. If the damping factor is determine: (i) the amplitude caused by the unbalance and its phase angle, (ii) the transmissibility, and (iii) the actual force transmitted and its phase angle. ***Nov/Dec 2012.***

29) What do you understand by transmissibility? Describe the method of finding the transmissibility ratio from unbalanced machine supported with foundation. ***Nov/Dec 2012.***

30) A mass of 10 kg is suspended from one end of a helical spring, the other end being fixed. The stiffness of the spring is l0 N/mm. The viscous damping causes the amplitude to decrease to one-tenth of the initial value in four complete oscillations. If a periodic force of 150 cos 50t N is applied at the mass in the vertical direction, find the amplitude of the forced vibrations. What is it value of resonance? ***April/May 2013.***

31) The mass of an electric motor is 120 kg and it runs at 1500 rpm. The armature mass is 35 kg and its C.G lies 0.5 mm from the axis of rotation. The motor is mounted on five springs of negligible damping so that the force transmitted is one-eleventh of the impressed force. Assume that the mass of the motor is equally distributed among the five springs. Determine: (i) Stiffness of each spring. (ii) Dynamic force transmitted to the base at the operating speed. (iii) Natural frequency of the system. ***April/May 2013.***