CLASS – 11

WORKSHEET- OSCILLATIONS

A. INTRODUCTION TO PERIODIC AND OSCILLATORY MOTION

(1 Marks Questions)

1. The equation of motion of a particle is $x = A \cos(\alpha t)^2$. The motion is
   (a) periodic but not oscillatory (b) periodic and oscillatory
   (c) oscillatory but not periodic (d) neither periodic nor oscillatory

2. Can a motion be periodic but not oscillatory?

(2 Marks Questions)

3. Describe the motion of a particle acted upon by force $F = -(x - 3)^3$.

B. SIMPLE HARMONIC MOTION

(1 Marks Questions)

1. The time period of simple harmonic motion depends upon
   (a) amplitude (b) energy (c) phase constant (d) mass

2. What is the (a) distance moved (b) displacement of a particle executing SHM in one vibration?

3. Simple Harmonic motion is the projection of uniform motion on
   (a) x-axis (b) y-axis (c) reference circle
   (d) any diameter of reference circle

4. A particle executing SHM. The phase difference between acceleration and displacement is
   (a) 0 (b) $\pi/2$ (c) π (d) $1/2\ \pi$

5. Can velocity and acceleration be in the same direction in a SHM?

6. What is phase relationship between displacement, velocity and acceleration in SHM?

7. The equation of motion in a simple harmonic motion is

(a) $\frac{d^2x}{dt^2} = -\omega^2 x$ (b) $\frac{d^2x}{dt^2} = -\omega^2 t$ (c) $\frac{d^2x}{dt^2} = -\omega x$ (d) $\frac{d^2x}{dt^2} = -\omega t$

8. Which of the following relationships between the acceleration a and the displacement x of a particle executing simple harmonic motion?

(a) $a = 2x^2$ (b) $a = -2x^2$ (c) $a = 2x$ (d) $a = -2x$

9. The total energy of a simple harmonic oscillator is proportional to

(a) amplitude (b) square of amplitude (c) frequency (d) velocity

10. The amplitude of a simple harmonic oscillator is doubled. How does this affect: (a) the period (b) the total energy (c) the maximum velocity of the oscillator?

11. Write an expression for PE of a harmonic oscillator at any point.

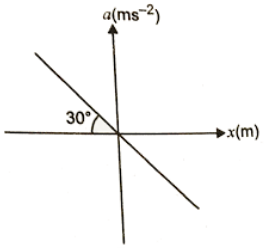
12. The girl sitting on swing stands up. What will be the effect on periodic time of swing?

13. What will be the time period of a second pendulum inside an artificial satellite?

(2 Marks Questions)

14. The displacement of particle in SHM may be given by a $y = a \sin(\omega t + \phi)$. Show that if the time t is increased by $2\pi/\omega$, the value of y remains the same.

15. Figure shows the acceleration displacement graph of a particle in SHM. Find the time period (in second).



16. Find the period of vibrating particle (SHM) which ahs acceleration of 45 cm s^{-1}, when displacement from mean position is 5cm.

17. Show that the acceleration of a particle in SHM is proportional to its displacement from the mean position.

18. A body is executing a simple harmonic motion such that its potential energy is U_1 at x and U_2 at y. When the displacement is x + y, calculate the potential energy.

19. A point particle of mass 0.1kg is executing SHM of amplitude 0.1m. When the particle passes through the mean position, its kinetic energy is 0.008J. If each is 45°, then what is the equation of motion of this particle?

20. A particle is moving on x-axis and has potential energy $U = 2 – 20x + 5x^2$ joule where x is position. The particle is released at x = - 3. If the mass of the particle is 0.1kg, then the maximum velocity (in m/s) of the particle is 25β.If the amplitude is 5m, find the value of β.

21. A 0.2 kg of mass hangs at the end of a spring. When 0.02 kg more mass is added to the end of the spring, it stretches 7cm more. If the 0.02kg mass is removed, what will be the period of vibration of the system?

(3 Marks Questions)

22. A particle executes simple harmonic oscillation with an amplitude a. The period of oscillation is T. What will be the minimum time taken by the particle to travel half of the amplitude from the equilibrium position?

23. A block is resting on a piston which is moving vertically with a SHM of period 1.0s. At what amplitude of vibration will the block and the piston separate? What is the maximum velocity of the piston at this amplitude?

24. A body is describing SHM has a maximum acceleration of 8π m/s^2 and maximum speed of 1.6m/s. Find the time period and the amplitude.

25. If the displacement x and velocity v of a particle executing SHM are related through the experiment $4v^2 = 25 – x^2$, then determine its time period.

26. What is Simple Harmonic Motion? What is phase difference between displacement and acceleration in SHM. A simple harmonic motion is described by a = -25x where a is acceleration (m/s) and x is displacement (m). What I the time period?

27. Show that the total energy of a particle executing SHM is directly proportional to the square of its amplitude and frequency.

28. A simple harmonic motion is described by $y = A \sin \omega t$. Find th time at which kinetic energy and potential energy of the simple harmonically oscillating particle are equal to each other.

29. Find the displacement of a simple harmonic oscillator at which its PE is half of the maximum energy of the oscillator.

30. A man of mass 60kg is standing on a platform executing SHM in vertical direction. The displacement from mean position of platform varies as $y = 0.5 \sin (2\pi\upsilon t)$. What will be the minimum value of υ, for which the man will feel weightlessness at the highest point?

31. Show that for small oscillations the motion of a simple pendulum is simple harmonic. Derive an expression for its time period. What would be the time period of simple pendulum at the centre of the earth. Justify your answer.

32. The vertical motion of a huge piston in a machine is approximately SHM with a frequency of 0.5/s. A block of 10kg is placed on piston, what is the maximum amplitude for the block and piston to remain together?

(5 Marks Questions)

33. A body oscillates with SHM along the x-axis. Its displacement varies with time according to the equation $x = (4.00m) \cos(\pi t + \pi/4)$. Calculate (a) displacement (b) velocity (c) acceleration at t = 1.00s (d) the maximum speed and maximum acceleration and (e) phase at t = 2.00s.

34. Deduce an expression for the (a) displacement (b) velocity (c) acceleration of a particle executing SHM.

35. (a) Draw a graph showing the variation of kinetic energy and potential energy of a particle executing SHM with its displacement from mean position.
(b) Show that total mechanical energy of a particle executing simple harmonic motion remains conserved with time, when dissipative forces are neglected.

C. COMBINATION OF SHM

(2 Marks Questions)

1. Prove that the equation $x = a \sin \omega t + b \cos \omega t$ shows SHM.

2. Show that motion of a particle represented by y = sin ωt – cos ωt is a simple harmonic motion with time period $2\pi/\omega$.

D. MISCELLANEOUS SHM

(1 Marks Questions)

1. The length of the simple pendulum which ticks seconds is
   (a) 0.5m (b) 1m (c) 1.5m (d) 2m

2. What is the effect on the time period of a simple pendulum if the mass of the bob is doubled?
   (a) Halved (b) Doubled (c) becomes 8 times (d) no effect

3. There are two springs, one delicate and another hard or stout one. For which spring, the frequency of the oscillator will be more?

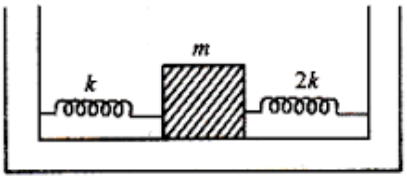
4. Write the expression for time period of a simple pendulum.

5. Define force constant of a spring.

6. Does the direction of acceleration at various points during the oscillation of a simple pendulum remain towards mean position?

(2 Marks Questions)

7. Two springs of force constants K and 2K are connected in a block of m as shown in the figure. What is the frequency of oscillation of this block?

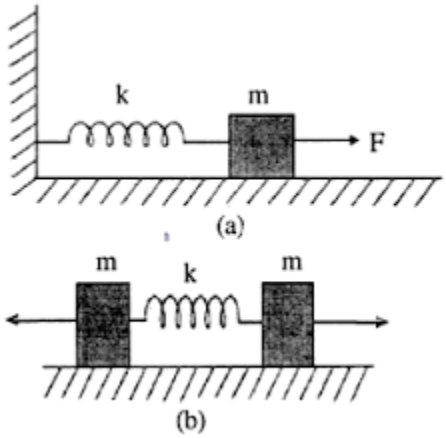


8. The formula for time period T for a loaded spring, $T = 2\pi\sqrt{\frac{\text{displacement}}{\text{acceleration}}}$. Foes the time period depend on the length of the spring?

9. A massless spring of spring constant k is attached with a mass ma and is made to oscillate vertically. Deduce the expression for its time period.

(3 Marks Questions)

10. Figures (a) shows a spring of force constant k clamped rigidly at one end and a mass m attached to its free end. A force F is applied to the free end stretches the spring. Figure (b) shows the same spring with both ends attached to mass m at either end. Each end of the spring in figure (b) is stretched by the same force F. What will be the maximum extension of the spring in both cases? Also, find out the time period for each case.



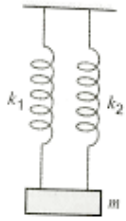
11. An infinite number of springs with spring constant k, 2k, 4k, 8k, 16k, …∞. Respectively are connected in series. What is the equivalent spring constant?

12. Determine the period of small oscillations of a pendulum that is bob suspended by a thread L = 20cm in length, if it is located in a liquid whose density is 3 times less than that of bob.

(5 Marks Questions)

13. (a) One end of a U tube containing mercury is conned to a suction pump and the other end to atmosphere. A small pressure difference is maintained between the two columns. Show that when the suction pump is removed, the liquid column of mercury in the U-tube executes SHM.

(b) An arrangement of springs for SHM is shown in the figure. If mass of block is m, then find frequency of oscillation.

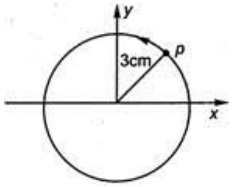


14. Show that the time period of a oscillation of a liquid column in a U tube is independent of the mass of the liquid column, the density of the liquid and the cross section area of U tube but depends only upon the length of the liquid column and on the value of the acceleration due to gravity.

E. CIRCULAR MOTION AND SHM

(1 Marks Questions)

1. The figure shows circular motion of a reference particle to represent simple harmonic motion. What is the amplitude of simple harmonic motion?



(3 Marks Questions)

2. Plot the reference circle for each of the following simple harmonic motion. Indicate the initial (t= 0) opposition of the particle, the radius of the circle, and the angular speed of the rotating particle. For simplicity, the sense of rotation may be fixed to be anticlockwise in every case: (x is in cm and t is in s)

(a) $x = -2\sin\left(3t + \frac{\pi}{3}\right)$ (b) $x = \cos\left(\frac{\pi}{6} - t\right)$

F. DAMPING OSCILLATION AND RESONANCE

(1 Marks Questions)

1. A particle oscillating under a force is a $\vec{F} = -k\vec{x} - b\vec{v}$ is a(k and b are constants).
   (a) simple harmonic motion (b) linear oscillator
   (c) damped oscillator (d) forced oscillator

2. At resonance, the amplitude of forced oscillations is

(a) minimum (b) maximum (c) zero (d) none of these

3. Marching troops are asked to break their steps while crossing the bridge. Why?

4. Why is loud sound heard at resonance?

5. At a certain speed of a bus, its whole body starts vibrating strongly. Explain.

(2 Marks Questions)

5. In a forced oscillation of a particle, the amplitude is maximum for a frequency ω_1 of the force, while the energy is maximum for a frequency ω_2 of the force. What is the relation between ω_1 and ω_2?

(3 Marks Questions)

6. A 21.2 kg object oscillates at the end of a vertical spring that has a spring constant 20500 N/m. The effect of air resistances is represented by the damping coefficient b = 2kg/s. Fine the time interval that elapses while the energy of the system drops to 10% of its initial value (given ln 10 = 2.302).

(5 Marks Questions)

7. Explain damped harmonic oscillation and the equation of such oscillations.

8. Discuss driven oscillations.

G. CHALLENGING PROBLEMS

1. Two pendulums of length 100cm and 121cm start oscillating. At some instant the two are at the mean position in the same phase. After how many oscillations of the longer pendulum will the two be in the same phase the mean position again?

2. Two particles are oscillating along two close parallel straight lines side by side, with the same frequency and amplitudes. They pass each other, moving in opposite direction when their displacement is half of the amplitude. The mean positions of the two particles lie on a straight line perpendicular to the paths of the two particles. Find the phase difference.