PART 1 : SHM

PERIODIC MOTION : It is that motion which is repeated identically after a fixed interval of time. Example : The revolution of earth around the sun.

OSCILLATORY MOTION : It is that motion in which the body moves to and fro or back and forth repeatedly about a fixed point (called mean position or equilibrium position). Example The motion of a pendulum.

- Here body is confined within well-defined limits called extreme positions.
- Oscillatory motion can be expressed in terms of sin and cosine functions as these trigonometric functions are periodic as well as bounded.

DIFFERENCE BETWEEN OSCILLATORY AND VIBRATORY MOTION : When frequency of vibration is small, it is called oscillatory motion. Eg. Oscillations of simple pendulum.

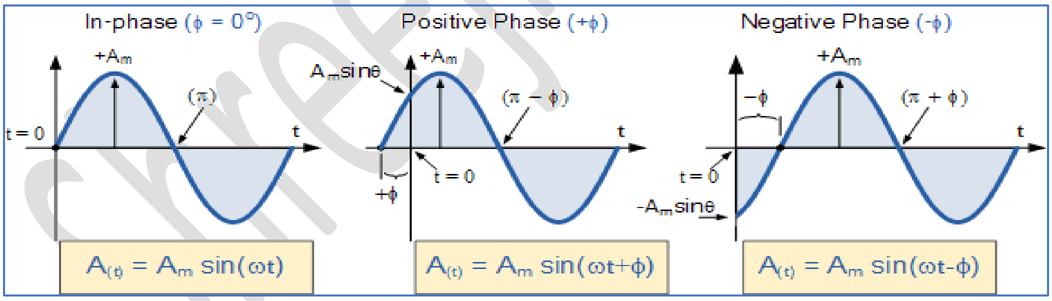
When frequency of vibration is high, it is called vibratory motion. Eg. Vibrations of a string of musical instruments.

HARMONIC OSCILLATIONS : It is that oscillations that can be expressed in terms of single harmonic function i.e. Sine or cosine function.

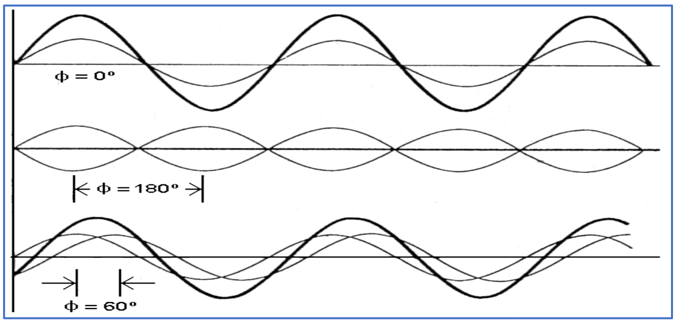
$$y = a\sin\omega t = asin2\pi ft \ ,\omega = angular\ frequency, f\ = frequency$$

PHASE : It is a physical quantity which completely expresses the position and direction of motion of particle at that instant with respect to its mean position. OR It is the argument of sin or cosine function (ωt) used to represent the generalised equation of motion of vibrating particle.

INITIAL PHASE : It is the phase at time t = 0 $y = a\sin{(wt + \emptyset)}$



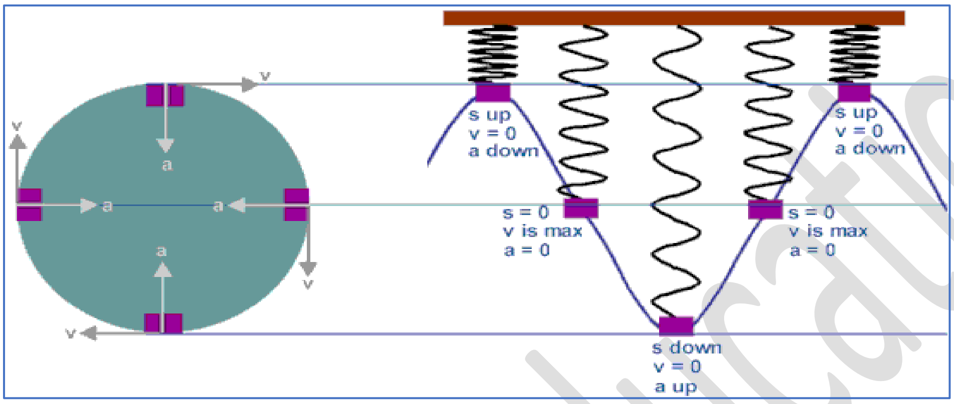
PHASE DIFFERENCE : It tells us about the lack of harmony in the vibrating states of two particles at a given instant.

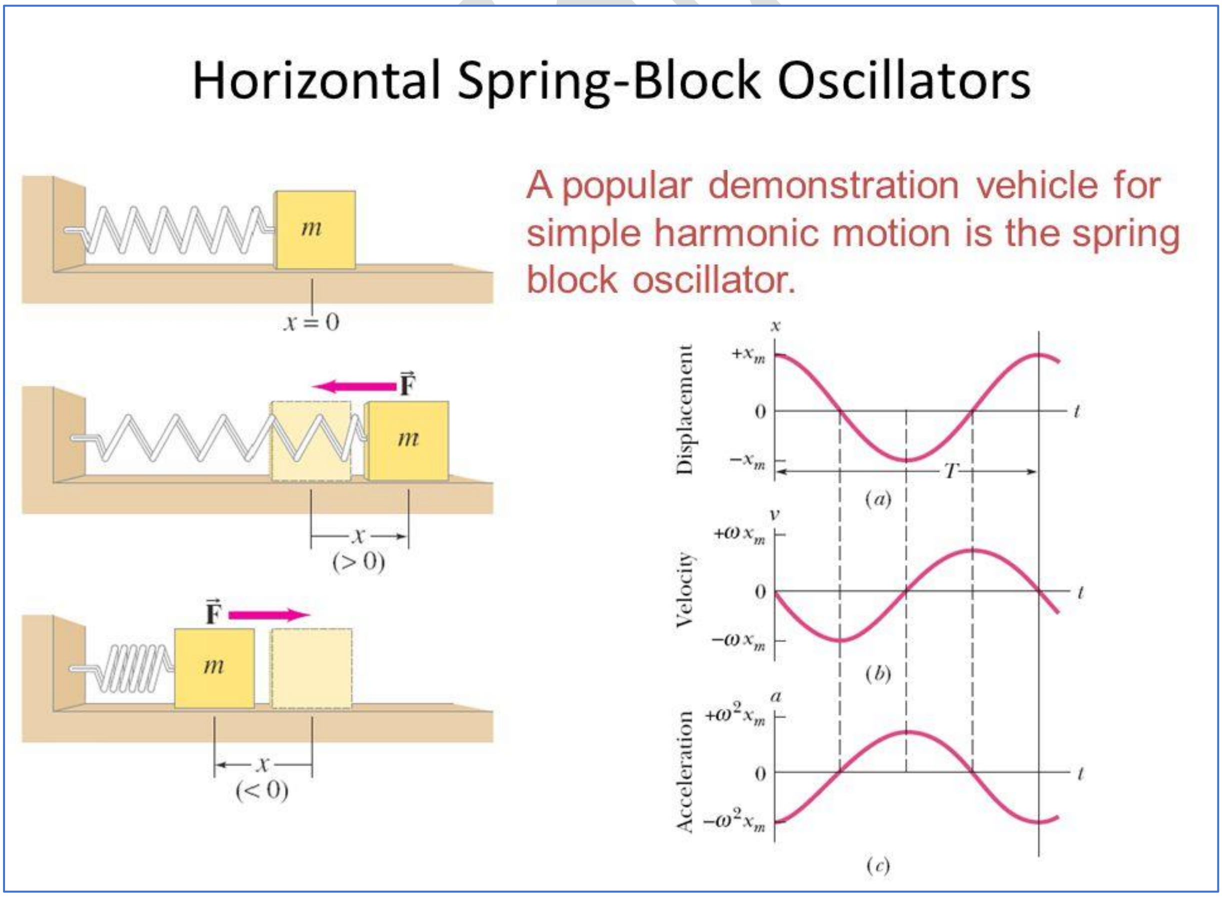


SIMPLE HARMONIC MOTION : It is a special type of periodic motion in which the particle moves to and fro repeatedly about its mean position under the influence of restoring force, which is always directed towards the mean position and whose magnitude at any instant is directly proportional to its displacement from the mean position at that instant.

$$F = -kx,\ \ x = displacement\ from\ mean\ position.$$
$$The - ve\ sign\ shows\ that\ F\ is\ always\ directed\ towards\ the\ centre$$

GRAPHICAL REPRESENTATION OF SIMPLE HARMONIC MOTION :

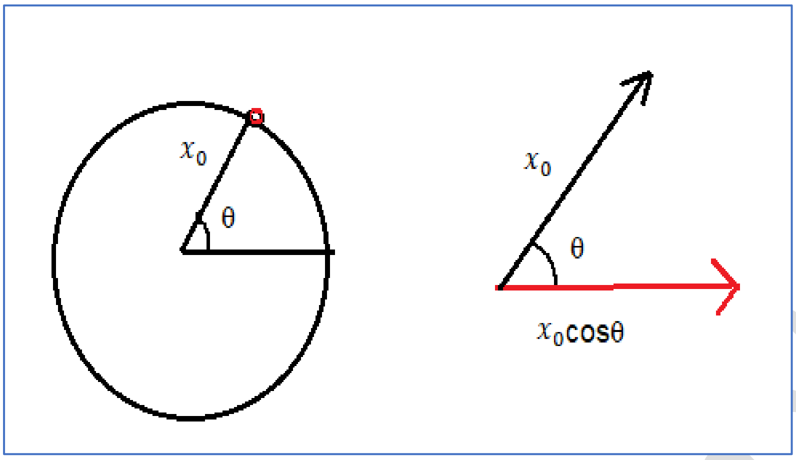




REPRESENTING SHM WITH CIRCULAR MOTION :

DISPLACEMENT,VELOCITY,ACCELERATION OF SHM :

let us consider a ball travelling a circle of radius x_0 as shown. Here SHM is represented with circular motion as shown in fig.



DISPLACEMENT :

As shown in figure, the horizontal component of displacement is given by :

$$x = x_0 cos\omega t$$

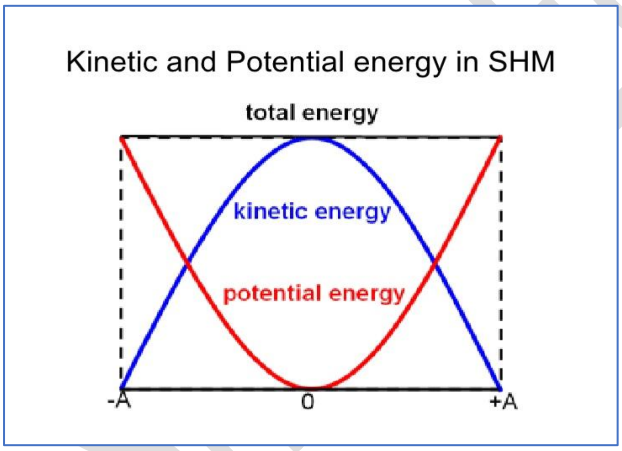
VELOCITY : $v_x = -\omega x_0 sin\omega t$

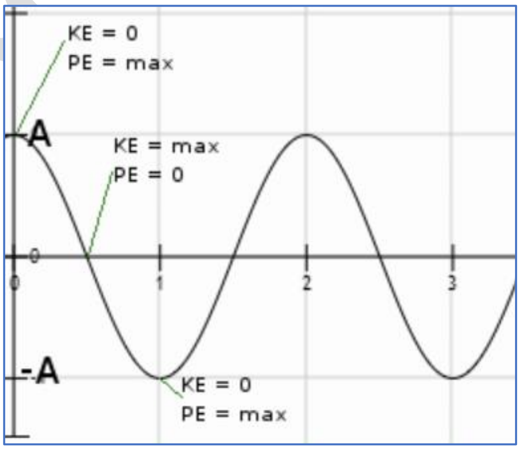
$$= -\omega\sqrt{{x_0}^2 - x^2}$$

which has maximum value when x = 0.

ACCELERATION : $a_x = -\omega^2 x_0 cos\omega t = -\omega^2 x$

ENERGY CHANGES DURING SIMPLE HARMONIC MOTION :





$$v = \omega\sqrt{(x_0^2 - x^2)}, \Rightarrow E_K = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2(x_0^2 - x^2)$$

$$E_P = \frac{1}{2}kx^2, k = m\omega^2 \Rightarrow E_P = \frac{1}{2}m\omega^2x^2$$

$$E_T = E_P + E_K \Rightarrow E_T = \frac{1}{2}m\omega^2x^2 + \frac{1}{2}m\omega^2(x_0^2 - x^2) = \frac{1}{2}m\omega^2x_0^2$$

PRACTISE QUESTIONS :

1. A pendulum bob of mass 200g is oscillating with amplitude 3 cm and frequency 0.5 Hz. How much KE will the bob have as it passes through the origin ?
2. A pendulum bob of mass 100g swings with amplitude 4 cm and frequency 1.5 Hz. Calculate :
    a. The angular frequency of the pendulum.
    b. The maximum KE of the bob.
    c. The maximum PE of the bob.
    d. The KE of the bob when the displacement is 2 cm.
    e. The PE of the bob when the displacement is 2 cm.
3. A pendulum bob is swinging with SHM at a frequency of 1 Hz and amplitude of 3 cm. at what position will the bob be moving with maximum velocity and what is the size of the velocity ?
4. A body oscillates with SHM of time period 2s. What is the amplitude of the oscillation if its velocity is 1m/s as it passes through the mean position.
5. A mass on a spring oscillates with amplitude 5 cm and frequency 2 Hz. The mass is released from the highest point. Calculate the velocity of the mass after it has travelled 1 cm.
6. As a mass on a spring travels upwards through the equilibrium position, its velocity is 0.5 m/s. If the frequency of the pendulum is 1 Hz, what will the velocity of the bob be after 0.5 s ?
7. A mass on a spring is oscillating with a frequency of 0.2 Hz and amplitude 3.0 cm. What is the displacement of the mass 10.66 s after it is released from the top ?
8. A pendulum completes 20 swings in 12 s. What is its frequency and angular frequency ?
9. A particle executing SHM along a straight line has a velocity of 4 m/s, when at a distance of 3 m from its mean position and 3 m/s, when at a distance of 4 m from it. Find the time it takes to travel 2.5 m from the positive extremity of its oscillation.
10. A 5 kg collar is attached to a spring of spring constant 500 N/m. It slides without friction over a horizontal rod. The collar is displaced from its equilibrium position by 10 cm and released. Calculate the (1) period of oscillations (2) the maximum speed and (3) maximum acceleration of the collar.