Topic 17.1: Simple Harmonic Oscillations

Free Oscillation

Backward and forward or to-and-fro motion of a body between 2 limits is known as an oscillation.

Free oscillation is when a body oscillates without any loss or gain of energy, i.e. the energy is constant. There are no resistive forces and no external forces applied if the body is in free oscillation. Amplitude of a free oscillator remains constant.

Some examples of free oscillations are motion of simple pendulum in vacuum, oscillations of object connected to a horizontal spring and sound produced in vacuum by tuning fork in short distance.

Motion of an Oscillator

One complete oscillation is when an oscillator moves from its equilibrium position or rest position to maximum displacement on one side to another maximum displacement on the other side and then back to its equilibrium position (refer to figure 17.1a and 17.1b)

Figure 17.1a:

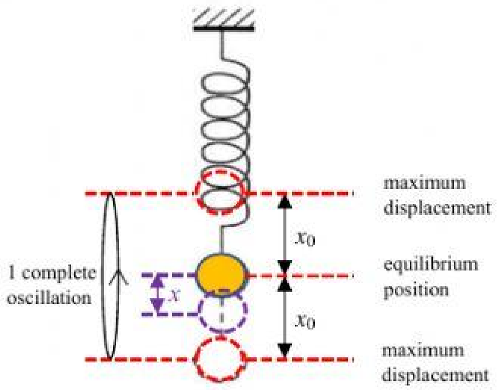
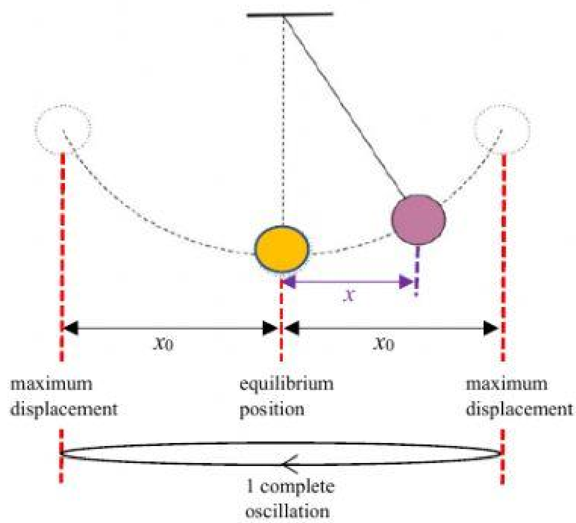


Figure 17.1b:



The displacement-time graphs for oscillator can be plotted. As an example, in Figure 17.2, a mass attached to a spring oscillates above a position sensor. The position sensor is connected to a computer through a data-logging interface which will cause a trace to appear on the monitor. The shape of the graph depends on the oscillating system but for many oscillations the graph is approximately a sine (or cosine) curve.

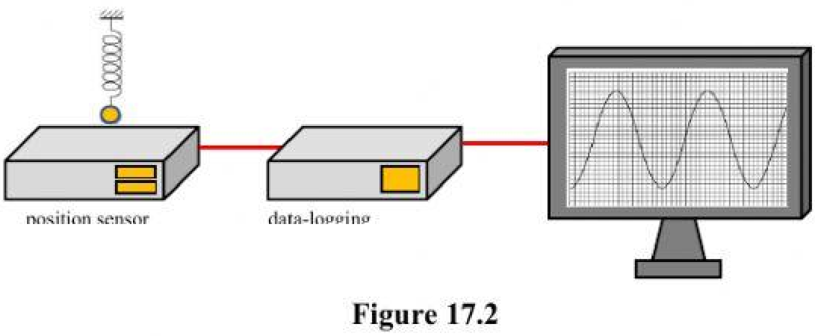


Figure 17.2

Terms

Figure 17.1a and 17.1b shows that x is the displacement moved by the oscillator. Displacement is the distance moved by the oscillator from the equilibrium position and it is a vector quantity.

Amplitude, x_0, is the maximum displacement of the oscillator from its equilibrium position. It is a scalar quantity. For small changes in amplitudes, period stays constant.
Period, T, is the time taken for one complete oscillation.

Frequency, f, is the number of complete oscillations per unit time taken. It is measured in Hertz (symbol: Hz), where 1 Hertz is 1 oscillation per second (1 Hz = 1 s^{-1}).

Period and frequency are related by the equation:

$$T = \frac{1}{f}$$

We had also seen before that angular speed or velocity is defined as angle swept out per unit time or rate of change of angle. This is also the definition of angular frequency.

Therefore, the equation for angular frequency is:

$$angular\ frequency\ \omega = \frac{angular\ displacement\ \theta}{time\ \ t}$$

Period, T, can then also be expressed in terms of angular frequency where:

$$\omega = \frac{2\pi}{T} \quad \text{or} \quad T = \frac{2\pi}{\omega}$$

And hence, angular frequency and frequency are related by this equation:

$$\omega = 2\pi f$$

When crests and troughs of 2 waves are aligned together, they were said to be in phase with one another. If they are not aligned, then there is a phase difference between them.