Oscillations-Part-1

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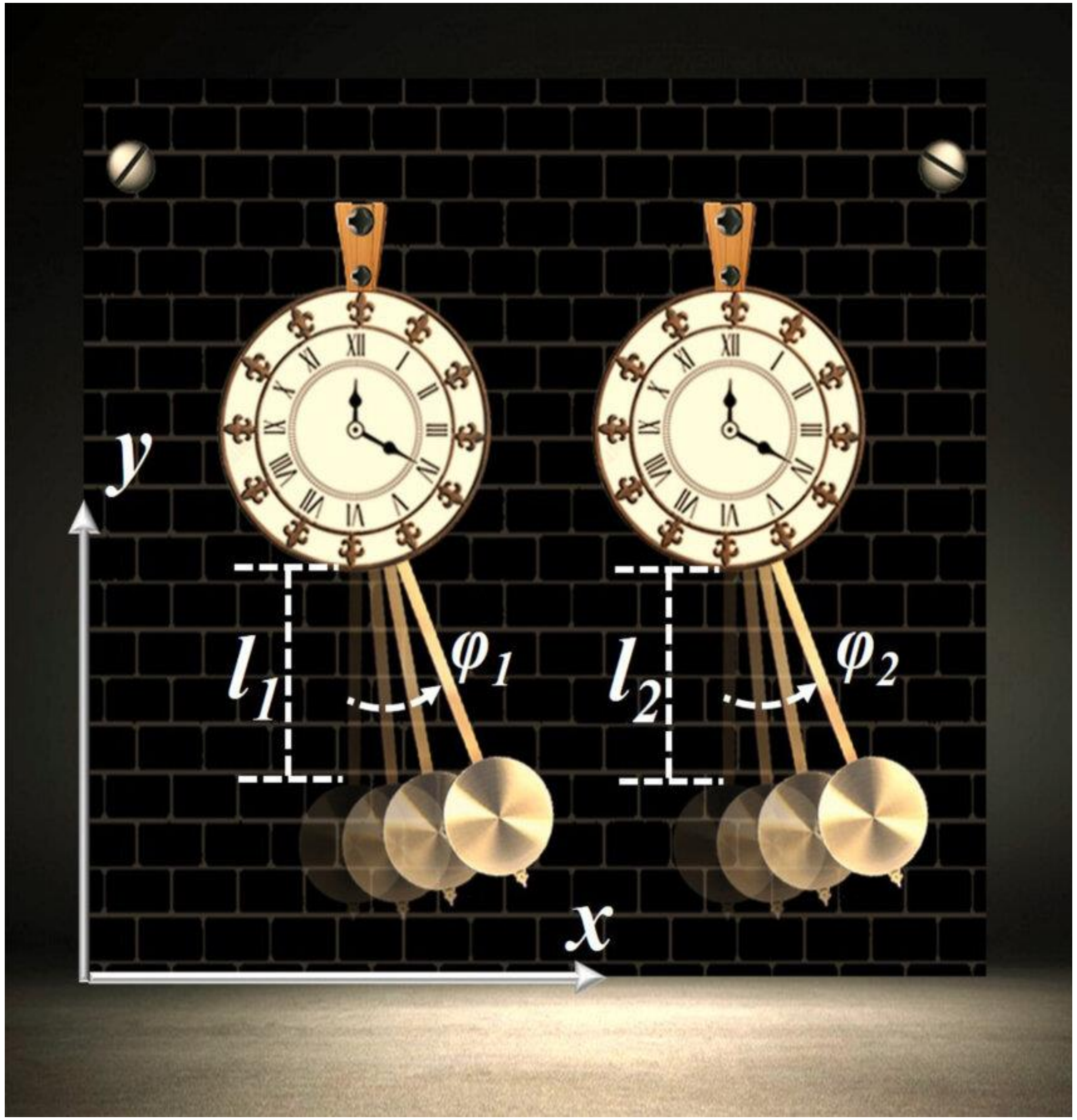
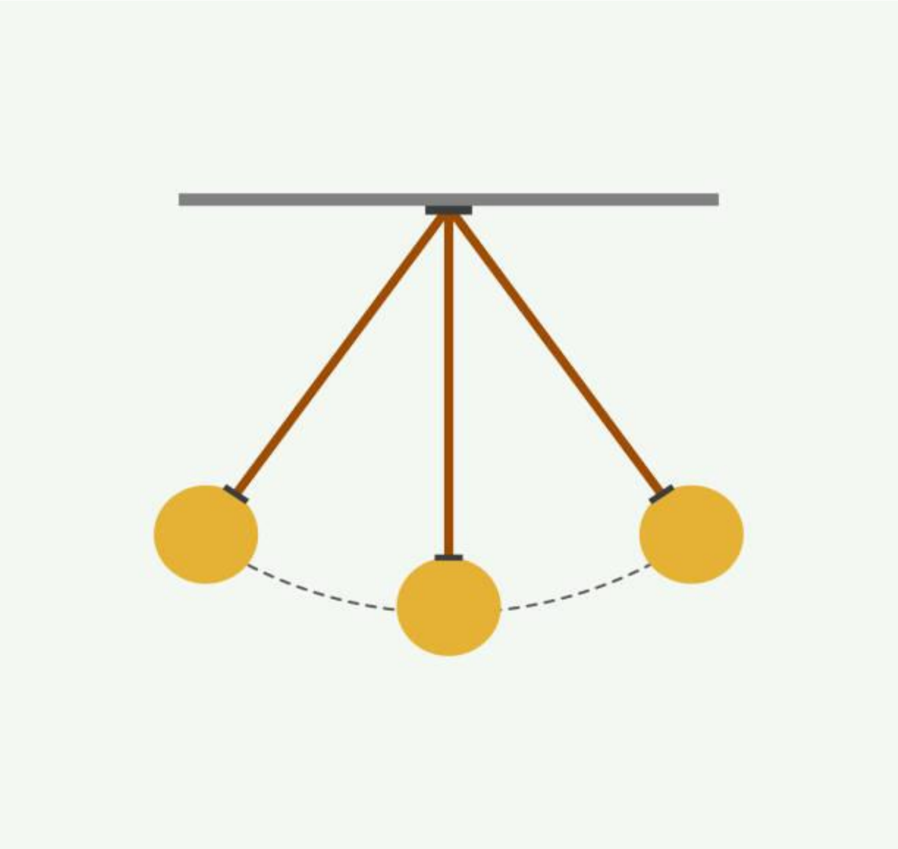


Oscillations

Cambridge-Advanced Level Physics

Part-1



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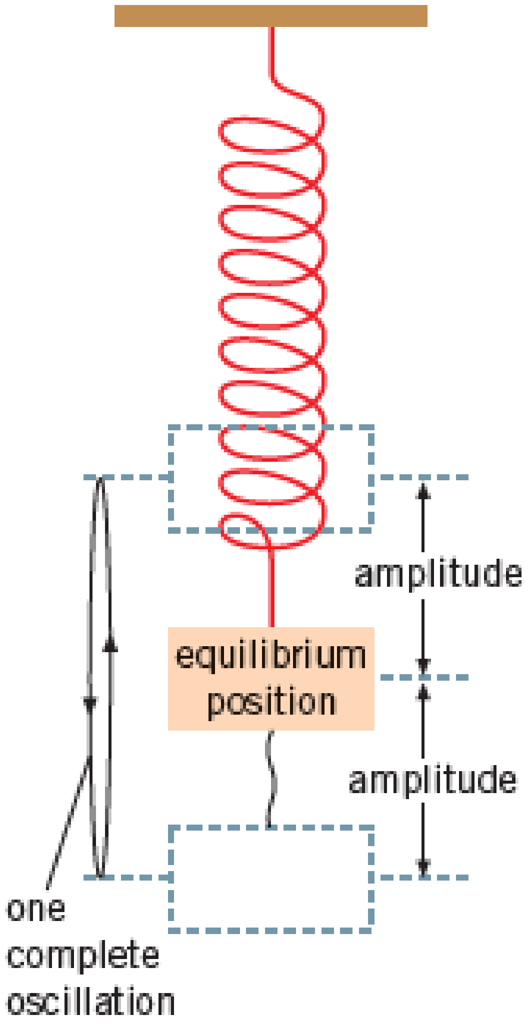


Oscillations

- One complete movement from the starting or rest position, up, then down and finally back up to the rest position, is known as an oscillation.

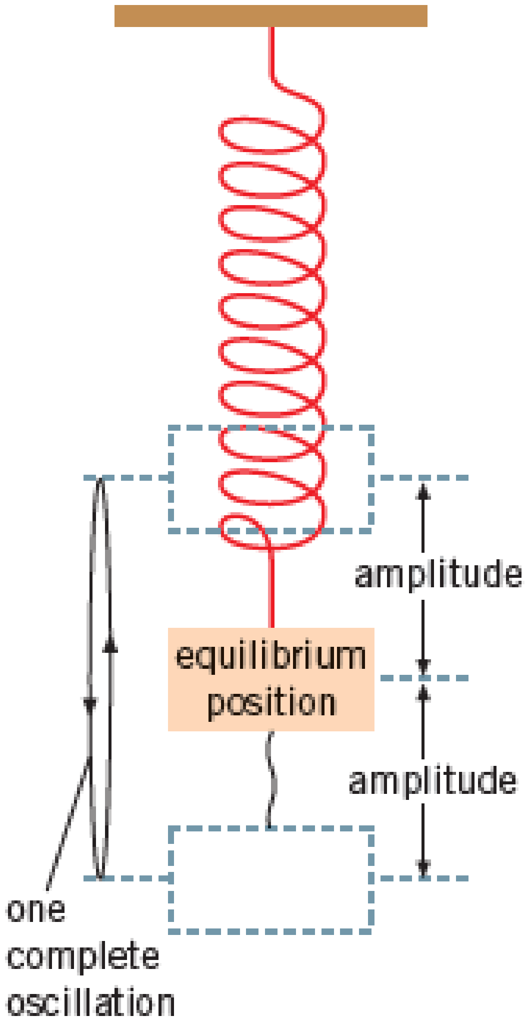
- The time taken for one complete oscillation or vibration is referred to as the period T of the oscillation.

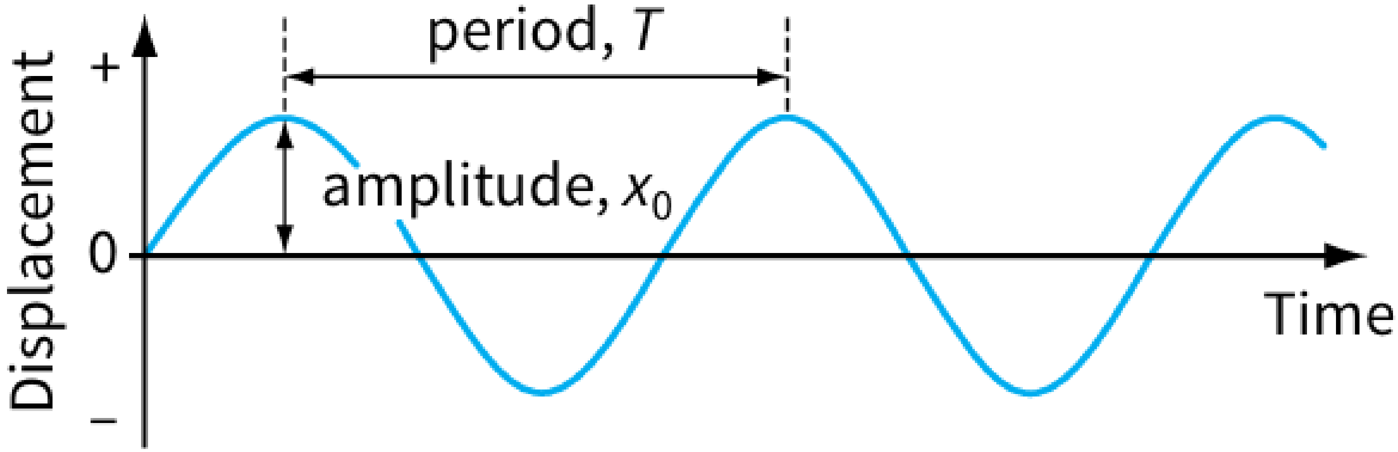
- The number of oscillations or vibrations per unit time is the frequency f.

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

- The distance from the equilibrium position is known as the displacement.

- The amplitude (a scalar quantity) is the maximum displacement(x_0).





Simple Harmonic Motion

- A body executes simple harmonic motion if its acceleration is directly proportional to its displacement from its equilibrium position, and in the opposite direction to its displacement.

Mathematically, we write this definition as

$$a = -\omega^2 x$$

The negative sign tells us that the acceleration a is always in the opposite direction to the displacement x.

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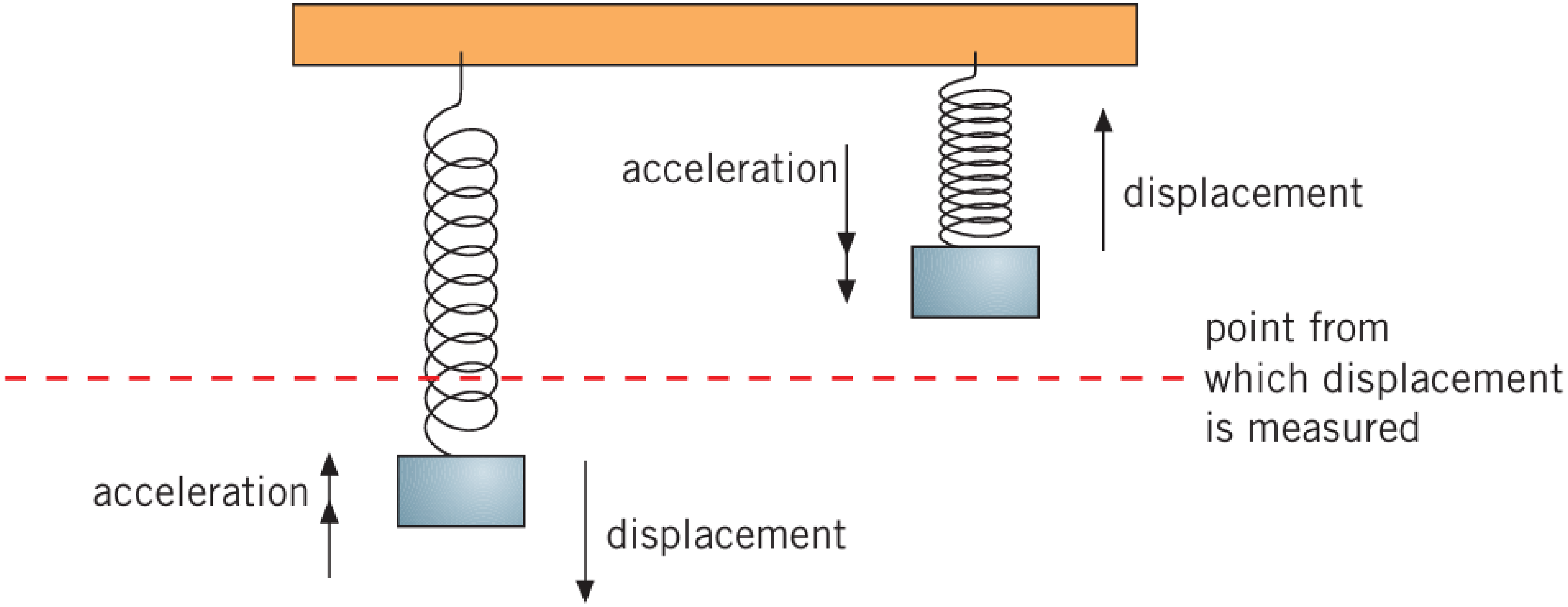

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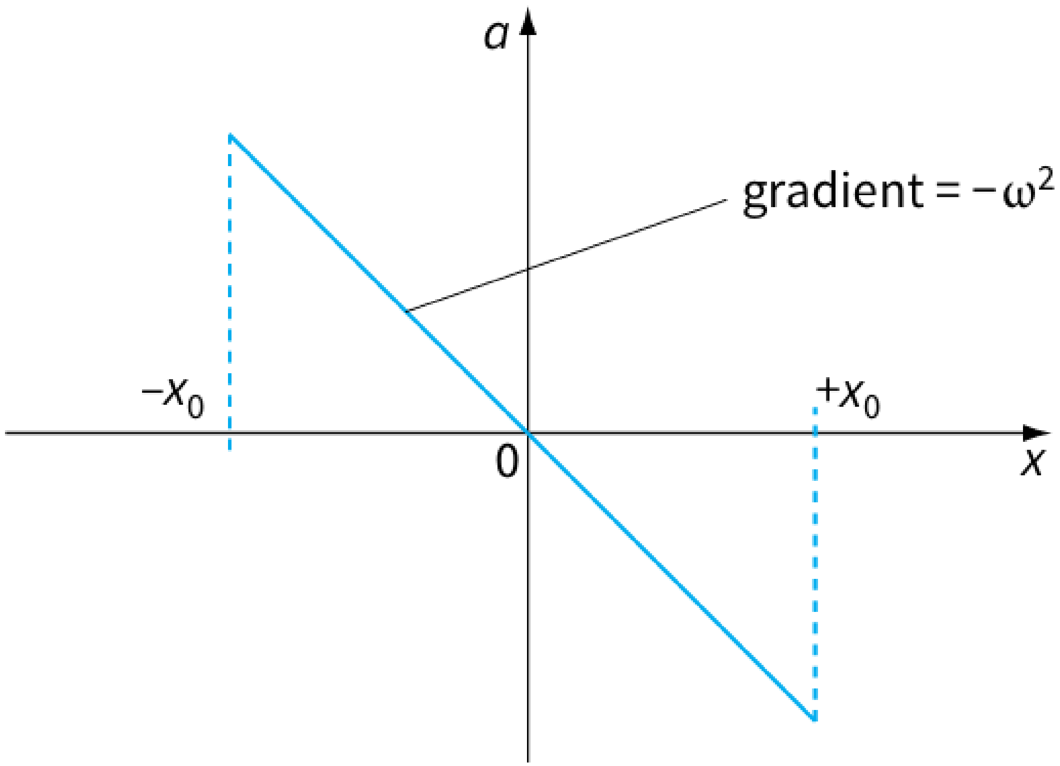


$$a = -\omega^2 x$$

$$y = -m\,x$$

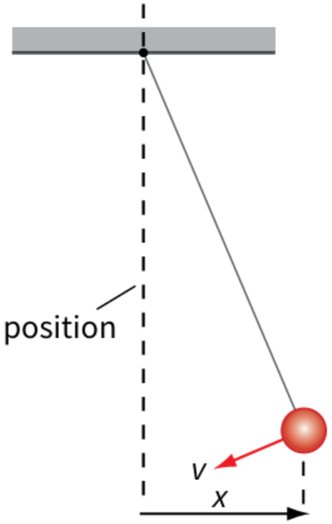
$$\omega^2 = m$$

$$\omega = \sqrt{m}$$

- The square root of the constant ω^2 (that is, ω) is known as the angular frequency of the oscillation.

$$\omega = 2\pi f$$

$$\boldsymbol{\omega = \frac{2\pi}{T}}$$

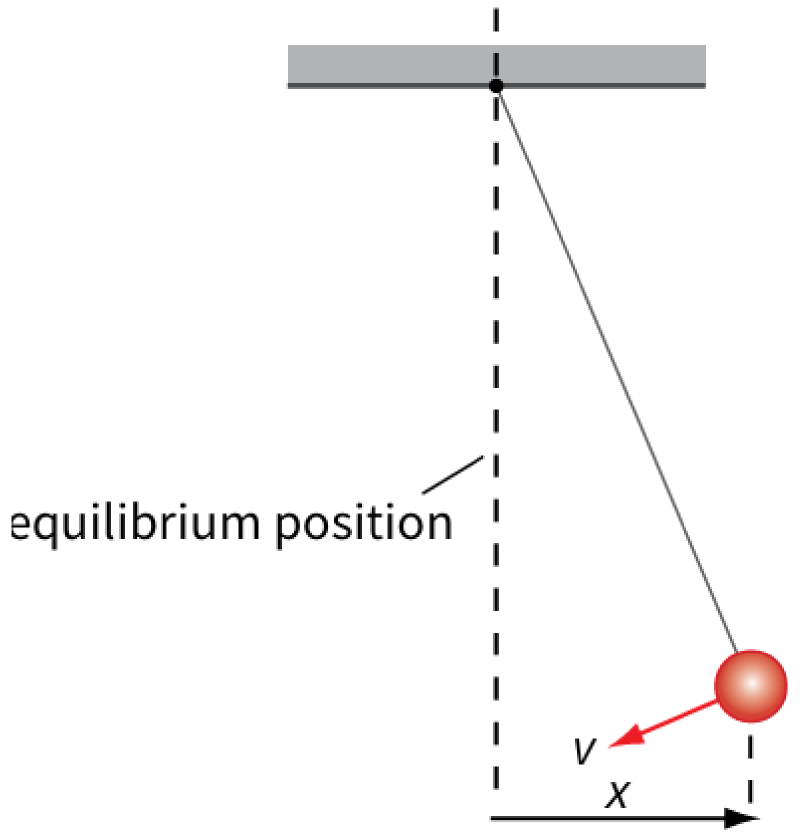


The three requirements for s.h.m. of a mechanical system are:

- a mass that oscillates

- a position where the mass is in equilibrium (conventionally, displacement x to the right of this position is taken as positive; to the left it is negative)

- a restoring force that acts to return the mass to its equilibrium position; the restoring force F is directly proportional to the displacement x of the mass from its equilibrium position and is directed towards that point.



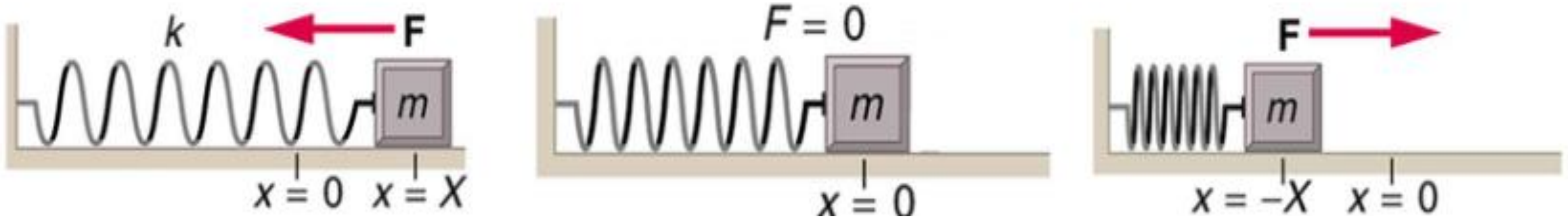
Concept Learning Questions

1) A mass secured at the end of a spring moves with s.h.m. The frequency of its motion is 1.4 Hz.

a) Write an equation of the form $a = -\omega^2 x$ to show how the acceleration of the mass depends on its displacement.

b) Calculate the acceleration of the mass when it is displaced 0.050 m from its equilibrium position.

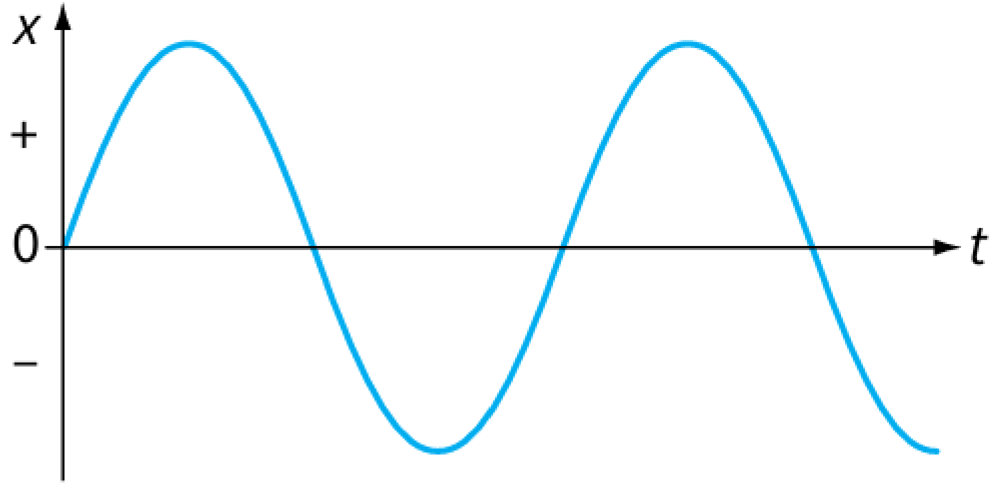
- The force is always acting towards the fixed point, or by calling it a restoring force.



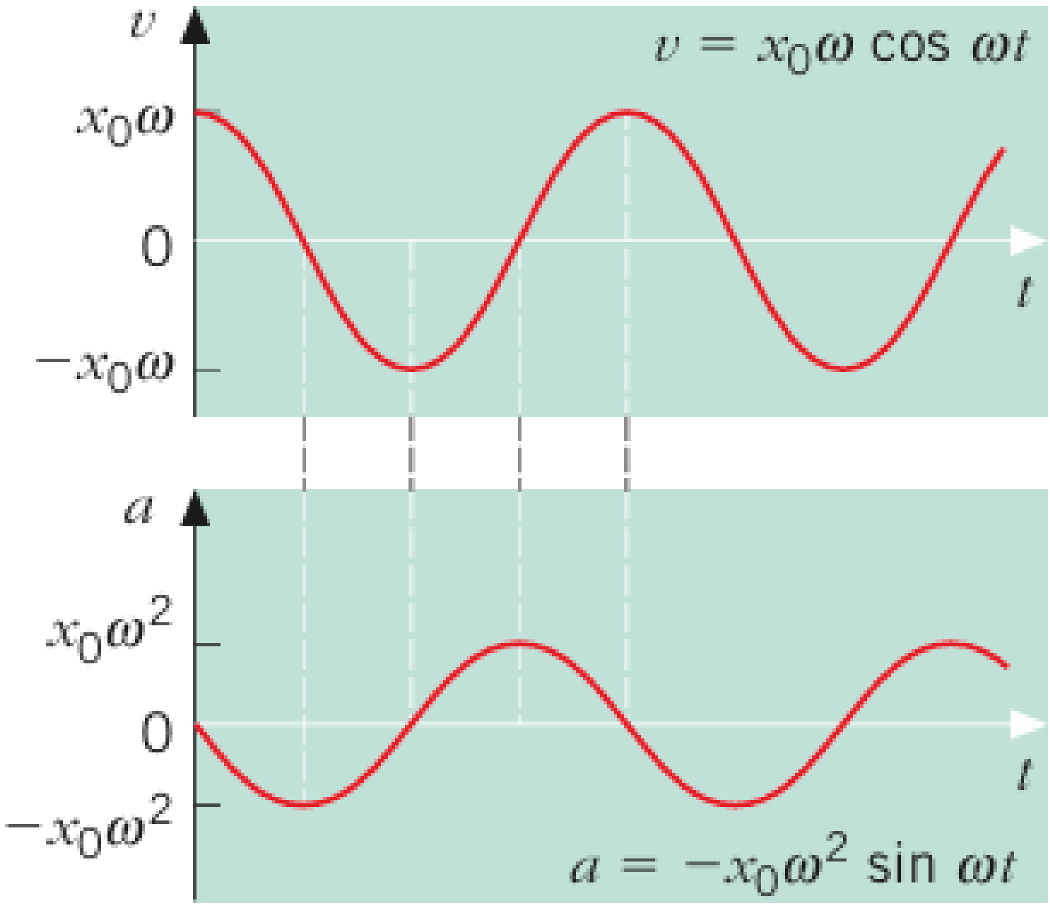
$$F = ma$$
$$a = -\omega^2 x$$
$$F = -m\omega^2 x$$

Solution of equation for simple harmonic motion

$When\ t = 0, x = 0;$

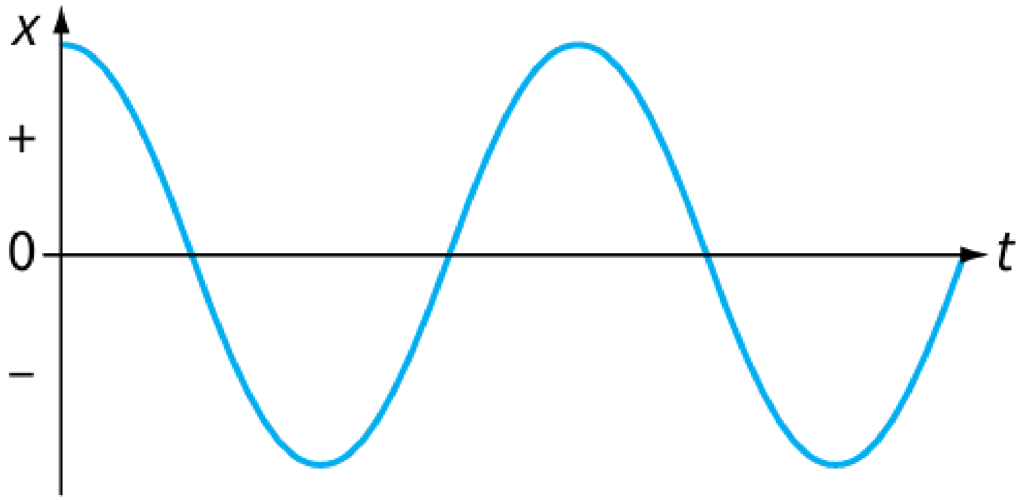


$x = x_0 \sin\omega t$

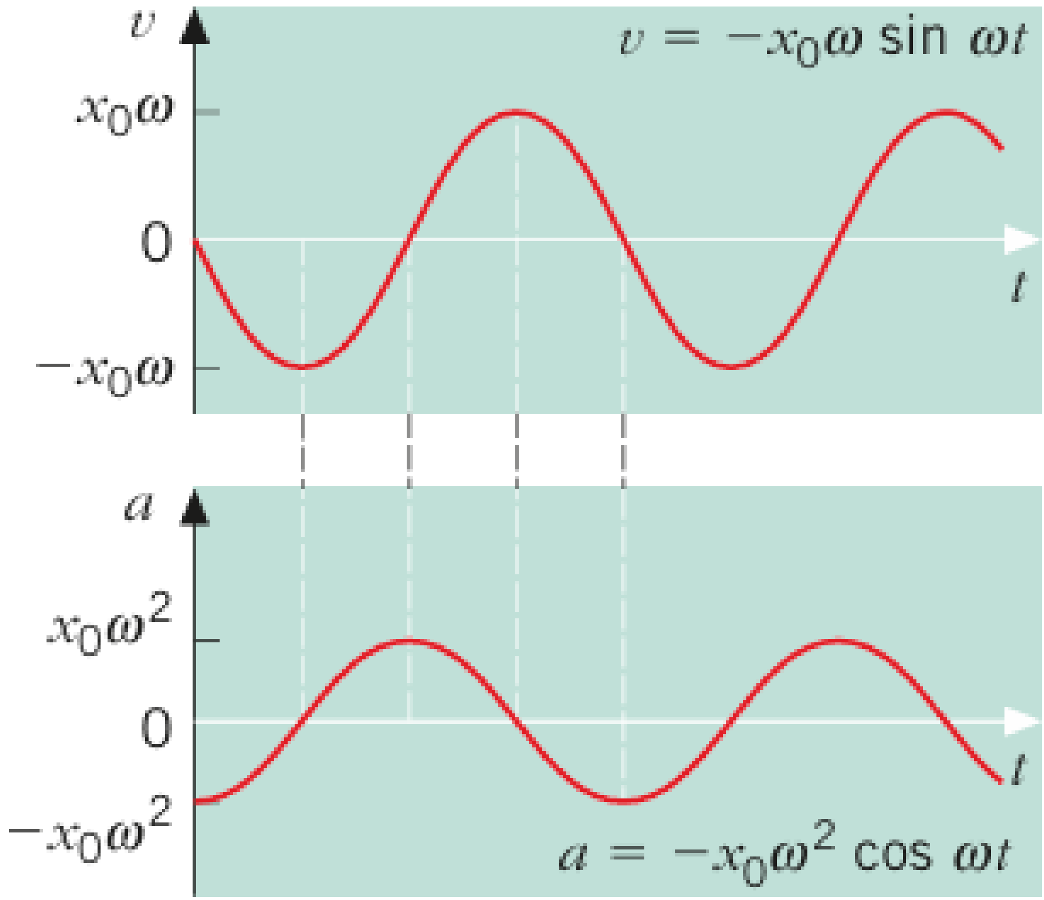


Solution of equation for simple harmonic motion

$When\ t = 0, x = X_0$



$x = x_0 \cos\omega t$



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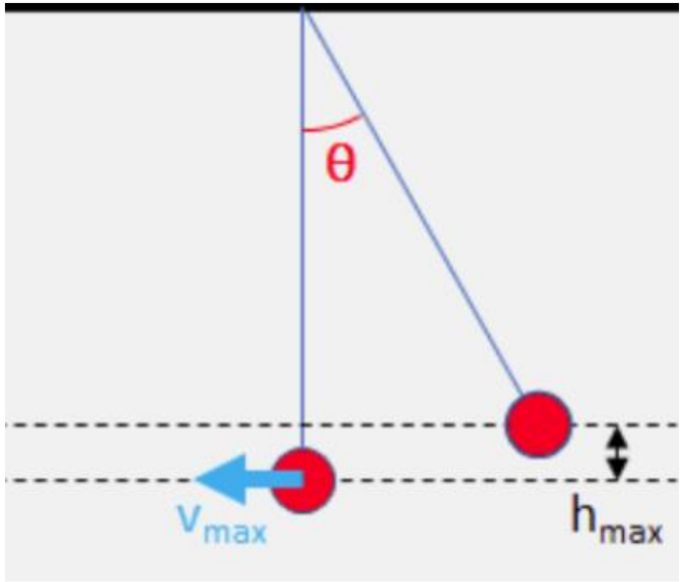
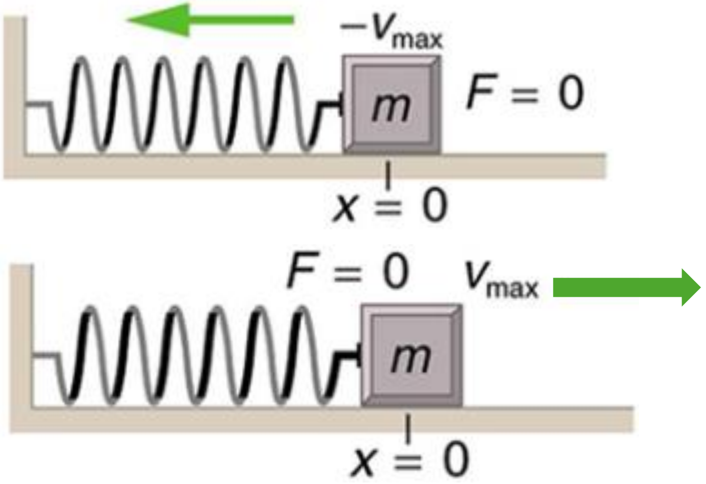
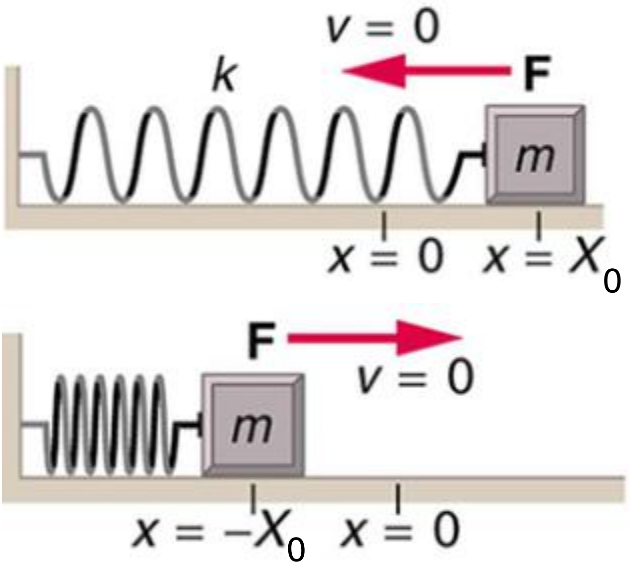


Maximum velocity (V_0)

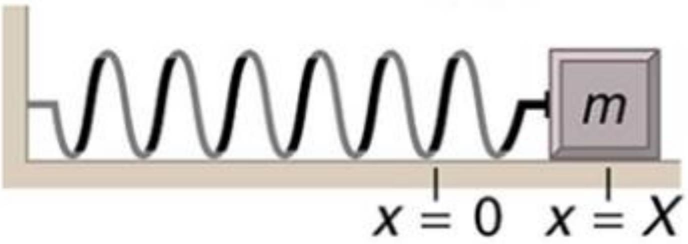
$$V_0 = x_0\,\omega$$



Zero velocity



Velocity at a displacement x = x



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

Concept Learning Questions.

1) An object undergoing SHM has an amplitude(x_0)of 0.1 m and a period of 2 s. Calculate the displacement of the object at t =1.5 s.(t=0, x=0)

x_0 = 0.1 m

T = 2 s

t= 1.5 s , x = ?

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{2} = \pi$$

$$x = x_0 \sin(\omega t)$$

$$x = 0.1 \sin(\pi \times 1.5)$$

(Remember to put your Calculator into radians mode)

$$x = -0.1\ m$$

2) The vibration of a component in a machine is represented by the equation: $x = 3.0 \times 10^{-4} \sin(240\pi t)$ where the displacement x is in metres.

a) Determine the amplitude x_0,

b) frequency f and period T of the vibration.

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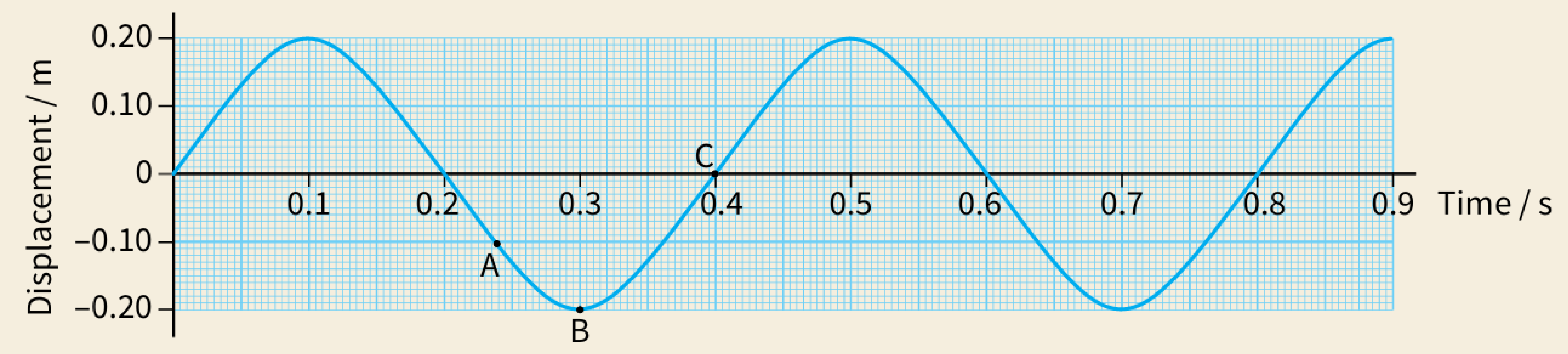
3) A pendulum oscillates with frequency 1.5 Hz and amplitude 0.10 m. If it is passing through its equilibrium position when t = 0, write an equation to represent its displacement x in terms of amplitude x_0, angular frequency ω and time t. Determine its displacement when t = 0.50 s. (Answer: -0.1 m)

4) The following figure shows the displacement–time graph for an oscillating mass. Use the graph to determine the following:

a) amplitude
b) period
c) frequency
d) angular frequency
e) displacement at A
f) velocity at B
g) velocity at C.



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