A Level H2 Physics Tutorial 10: Oscillations

Syllabus :
(a) describe simple examples of free oscillations .

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1. Describe 3 simple examples of free oscillations.

(b) investigate the motion of an oscillator using experimental and graphical methods

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2.

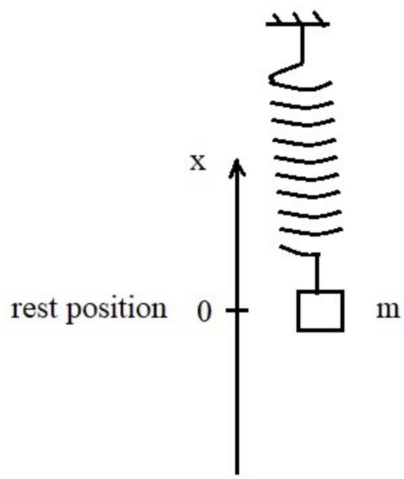

Figure 10-1

(a) A mass m is attached to a spring as shown. It is pulled downwards by 1m and let go. Sketch the graph of its displacement against time for 3 oscillations. The period is 1 s.

(b) (i) Label an amplitude and a period on the graph.
(ii) Find the frequency and angular frequency.

(c) An identical spring and mass next to it is let go a quarter of a period later, from the same displacement.

(i) On the same graph, sketch the graph for this.
(ii) What is the phase difference between the two?

(c) show an understanding of and use the terms amplitude, period, frequency, angular frequency and phase difference and express the period in terms of both frequency and angular frequency

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3. (a) State the meanings of the following terms :

(i) amplitude
(ii) period
(iii) frequency
(iv) angular frequency
(v) phase difference

(b) Express the period in terms of

(i) frequency
(ii) angular frequency

(d) recall and use the equation $a = -\omega^2 x$ as the defining equation of simple harmonic motion

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(e) recognise and use $x = x_0 \sin \omega t$ as a solution to the equation $a = -\omega^2 x$

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4. A spring with a mass displaced and let go would oscillate.

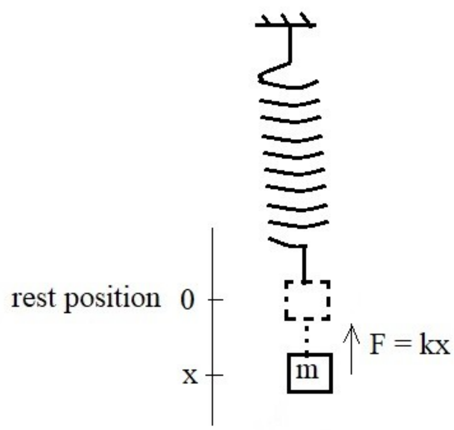

Figure 10-2

For a displacement x, the restoring force is

$$F = -kx,$$

where x is a constant. Using Newton's second law,

$$ma = -kx,$$

where a is acceleration of the spring.

Let ω^2 be k/m. Then the equation becomes $a = -\omega^2 x$

This can be solved to give $x = x_0 \sin \omega t$
as a possible solution, where x_0 is the amplitude..

(i) Sketch an x-t graph showing 2 periods of the motion.

(ii) From energy conservation, total kinetic energy $\frac{1}{2}mv^2$ and potential energy $\frac{1}{2}kx^2$ must be constant as it oscillates. Write down an expression relating this total energy to the maximum potential energy $\frac{1}{2}kx_0^2$.

(iii) Hence show that the maximum velocity is $v_0 = \omega x_0$.

(iv) Explain physically why $x = x_0 \cos \omega t$ can also be a solution.

(f) recognise and use the equations $v = v_0 \cos \omega t$ and $v = \pm\omega\sqrt{(x_0^2 - x^2)}$

5.

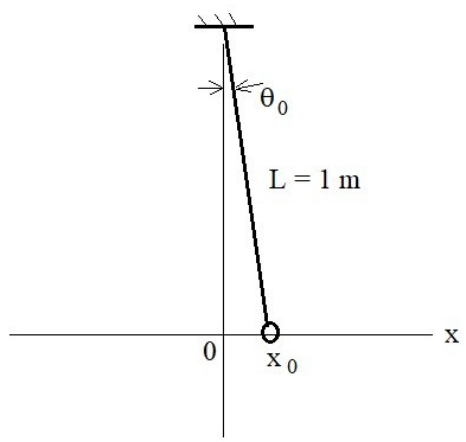

Figure 10-3

When released from a small angle, a pendulum swings roughly along the x axis between $-x_0$ amd $+x_0$.

It is approximately simple harmonic, with $\omega^2 = g/L$.

(a) Calculate the maximum velocity of the bob.

(b) The mass of the bob is 10 g. Find its maximum kinetic energy.

(c) At its rest position, the bob is slightly lower than at $x = x_0$. Using the maximum kinetic energy, find the difference in height.

(g) describe, with graphical illustrations, the changes in displacement, velocity and acceleration during simple harmonic motion

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6. A 0.1 kg mass is attached to one end of a spring. The mass oscillates with a period of 1 s, and an amplitude of 10 cm. Sketch the following graphs for 2 periods of its motion. Indicate the peak value in each case.

(a) displacement-time graph

(b) velocity-time graphical

(c) acceleration-time graphical

(d) velocity displacement graphical

(e) acceleration-displacement graph

(h) describe the interchange between kinetic and potential energy during simple harmonic motion

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7. A mass m of 0.1 kg on a spring oscillates with amplitude 2 cm and frequency 1 Hz.

(i) Find the maximum velocity and maximum kinetic energy.

(ii) Sketch the kinetic energy and potential energy against time on the same graph.

(iii) Describe how the kinetic and potential energies change from one to the other.

(iv) Sketch a graph of the kinetic and potential energies against time for 2 periods of the motion.

(i) describe practical examples of damped oscillations with particular reference to the effects of the degree of damping and to the importance of critical damping in applications such as a car suspension system

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(j) describe practical examples of forced oscillations and resonance

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(k) describe graphically how the amplitude of a forced oscillation changes with driving frequency near to the natural frequency of the system, and understand qualitatively the factors which determine the frequency response and sharpness of the resonance

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(l) show an appreciation that there are some circumstances in which resonance is useful, and other circumstances in which resonance should be avoided.

Updated on 26 February 2025