Simple Harmonic Motion

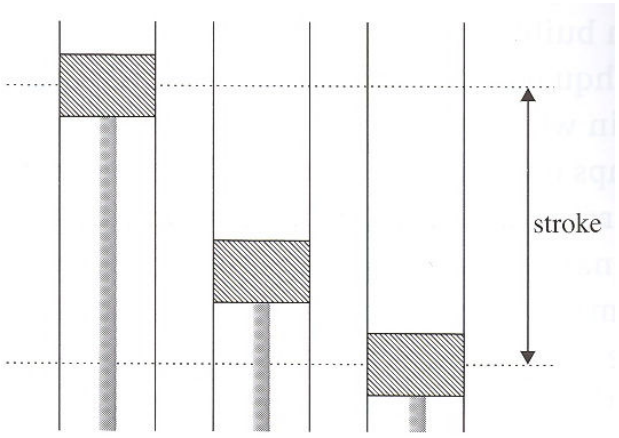
1. A ball goes back and forth along a horizontal floor bouncing off two vertical walls. Is the motion an example of an oscillation? If yes, is the oscillation simple harmonic?

2. The displacement of a particle executing SHM is given by $y = 5.0\cos(2t)$, where y is in millimeters and t is in seconds. Calculate:
   (a) The initial displacement of the particle
   (b) The displacement at t=1.2s
   (c) The time at which the displacement first becomes -2.0 mm
   (d) The displacement when the velocity of the particle is 6.0 mm s^{-1}

3. Write down an equation for the displacement of a particle undergoing SHM with an amplitude equal to 8.0 cm and frequency of 14 Hz, assuming that at t=0 the displacement is 8.0 cm and the particle is at rest.

4. A point on a guitar string oscillates in SHM with an amplitude of 5.0 mm and a frequency of 460 Hz. Determine the maximum velocity and acceleration of this point.

5. The piston (of mass 0.25 kg) of a car engine has a stroke (i.e. distance between extreme positions) of 9.0 cm and operates at 4500 rev min^{-1}, as shown.

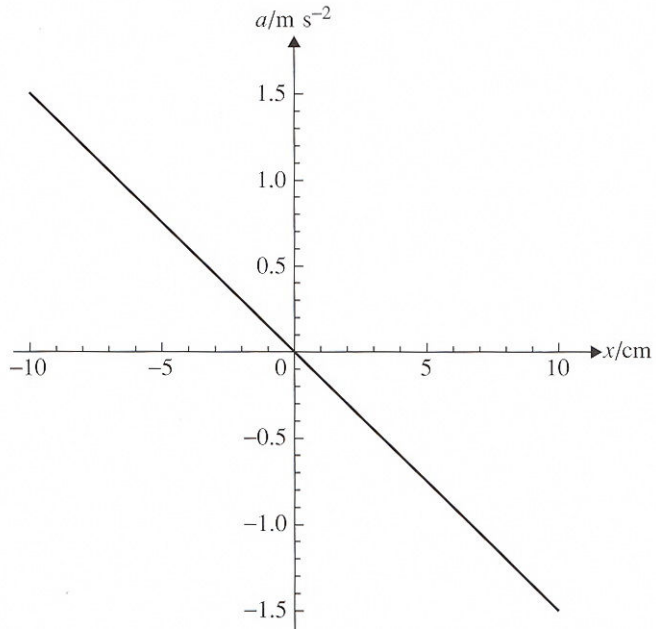


   (a) Calculate the acceleration of the piston at maximum displacement.
   (b) Calculate the velocity as the piston moves past is equilibrium point.
   (c) What is the net force exerted on the piston at maximum displacement?

6. A particle undergoes SHM with angular frequency ω. The initial displacement is x_0 and the initial velocity is v_0. Deduce that an expression for the amplitude of this motion is

$$A = \sqrt{x_0^2 + \frac{v_0^2}{\omega^2}}$$

7. The following graph shows the variation with displacement x of the acceleration a of a body of mass 0.150 kg.



(a) Use the graph to explain why the motion of the body is SHM.
Determine the following:
(b) The period of the motion
(c) The maximum velocity of the body during an oscillation
(d) The maximum net force exerted on the body
(e) The total energy of the body

8. A body of mass 1.80 kg executes SHM such that its displacement from equilibrium is given by $x = 0.360\cos(6.80t)$, where x is in meters and t is in seconds. Determine:
(a) The amplitude, frequency and period of the oscillations
(b) The total energy of the body
(c) The kinetic energy and the elastic potential energy of the body when the displacement is 0.125 m.

9. The shock absorbers of a car protect the passengers by absorbing the impact felt by the car when going over bumps on the road. Should the shock absorbers be under-damped, critically damped, or over damped? Discuss your answer.

10. It is said that soldiers marching over a bridge will break their step. What might be a reason for this?

Numerical Answers
2. (a) 5.0 mm; (b) -3.7 mm; (c) 0.99 s; (d) ±4.0 mm
3. 8.0cos(28πt)
4. v=14 ms^{-1}; a=4.2x10^4 ms^{-2}
5. (a)1.0x10^4 ms^{-2}; (b) 21 ms^{-1}; (c) 2.5x10^3 N
7. (b) 1.6 s; (c) 0.40 ms^{-1}; (d) 0.24 N; (e) 0.012 J
8. (a) A=0.360 m, f=1.08 Hz, T=0.924 s: (b) 5.39 J; (c) 4.74 J, 0.650 J