Simple Harmonic Motion

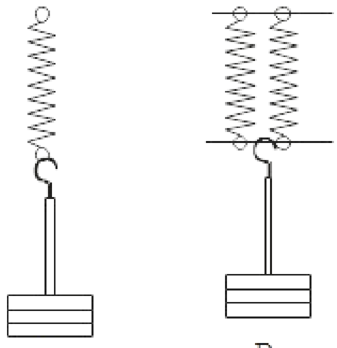
1. (a) Draw a free body diagram for the forces acting on a pendulum when it is at a slight angle.

   (b) Show on the diagram the direction of the resultant force.

2. A mass *m*, oscillating on one spring, as shown in A, has a period of *T*.

   (a) What is the period when the same mass oscillates on two springs, shown in B?

   (b) How much mass must be used with the two springs to make the period *T* again?



3. A 500 g mass oscillates hanging from a spring with spring constant 40 Nm^{-1}.

   (a) What is the period of the oscillation? *(0.70 s)*

   (b) What is the frequency of the oscillation? *(1.42 Hz)*

4. A car of mass 600kg goes over a bump in the road and oscillates with a period of 0.60s. What is the effective spring constant of the total suspension? *(6.6×10^4 Nm^{-1})*

5. What is the period of a pendulum 0.80 m long? *(1.80 s)*

6. What length of pendulum has a period of 2.0 s? *(0.99 m)*

7. A diver, mass 70 kg, stands on the end of a diving board and it is deflected vertically a distance of 0.25 m.

   (a) What is the spring constant of the diving board under these circumstances? (2.7 *x* $10^3 Nm^{-1}$)

   (b) When the diver starts the board oscillating while still standing on the end, what will be the period of the oscillation? *(1.0s)*

8. The wing of a car is pushed down with a force of 200 N and the spring on the front wheel is compressed by 12 mm. (Assume that only this one spring is affected.)

   (a) Calculate the spring constant of the suspension spring at this wheel. *(1.67×10^4 Nm^{-1})*

   (b) Assuming each wheel is fitted with an identical spring and the mass of the car and driver is 600kg, calculate its natural frequency of oscillation. *(1.67 Hz)*

9. A spring of natural length 300 mm hanging vertically extends to a length of 355 mm when a mass of 0.150 kg hangs from it. It is then pulled down by a further 30mm and allowed to oscillate. Calculate

   (a) The spring constant of the spring, *(27 Nm^{-1})*

   (b) the period of the oscillations, *(0.47 s)*

   (c) the maximum speed of the mass, *(0.40 ms^{-1})*

   (d) the maximum k.e. of the mass, *(0.012 J)*

   (e) the maximum and minimum tensions in the spring. *(2.33 N, 0.68 N)*

10. In a sodium chloride crystal, each sodium ion has a mass of 3.8×10^{-26} kg and the bonds in the lattice act as a spring with effective spring constant 200Nm^{-1}.

    speed of light, $c = 3.0 \times 10^8$ ms^{-1}

    (a) What is the natural frequency of oscillation of a sodium ion? *($1.15 \text{ x } 10^{13}$ Hz)*

    (b) The ions can be made to vibrate by exposing the to electromagnetic radiation of this frequency. What wavelength of radiation is this? *($2.6 \text{ x } 10^{-5}$ m)*

    (c) If the energy of vibration of each ion is 6.0×10^{-21} J, what is the amplitude of the oscillation? *($7.7 \text{ x } 10^{-12}$ m)*

11. A diatomic molecule, such as HF or HCl can vibrate because of extension and compression of the bond between the atoms. Because the H atom is much less massive than the Cl or F atom, you can imagine the H atom to be vibrating on the bond, while the other atom is stationary. The mass of a H atom is 1.7×10^{-27} kg

    Calculate the bond stiffness:

    (a) for the HF bond, given that the HF molecule oscillates with a frequency of 1.25×10^{14} Hz,

    (b) for the HCl bond, given that the HCl molecule oscillates with a frequency of 9.1×10^{13} Hz.