4   A light spring hangs vertically from a fixed point. An object of mass m is attached to the free end of an unstretched spring as shown in Fig. 4.1.
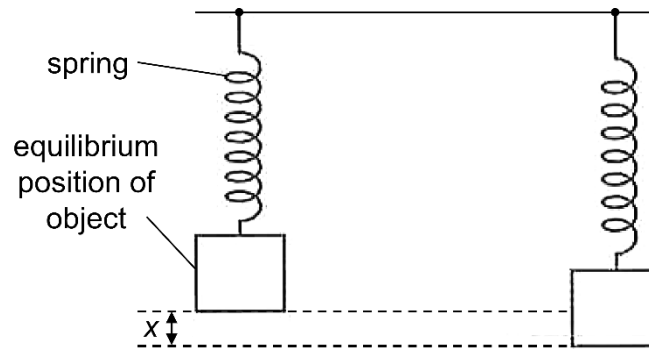

Fig. 4.1

The extension of the spring at equilibrium is x_o and its spring constant is k.

(a)   State an expression relating the forces acting on the object when it is in the equilibrium position.

.... [1]

(b)   The object is displaced vertically downwards and then released.

Using the expression in **(a)**, show that the object's acceleration a is related to its displacement x from the equilibrium position by the equation:

$$a = -\frac{k}{m}x$$

Explain your working.

[2]

(c) Fig. 4.2 shows the variation of the kinetic energy of the object with time.

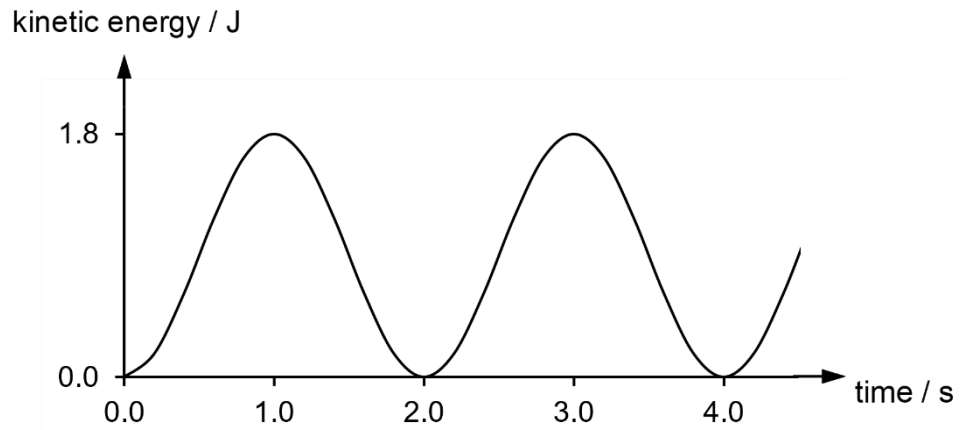kinetic energy / J

Fig. 4.2

(i) Determine the frequency of the oscillation.

frequency =…………………… Hz [2]

(ii) Determine the mass of the object given that the spring constant is 28 N m^{-1}.

mass = …………………… kg [2]

(iii) Calculate the maximum velocity of the object.

velocity = …………………… m s^{-1} [1]

(iv)   Calculate the amplitude of the oscillation.

amplitude = …………………... m [1]

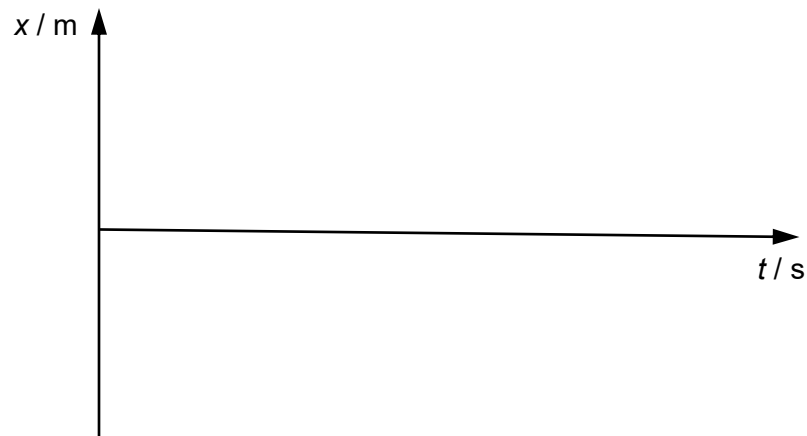**(d)**   On Fig. 4.3, sketch the variation with time t of the displacement x of the object.

x / m

t / s

Fig. 4.3

[2]

[Total: 11]