4 A pendulum consists of a bob (small metal sphere) attached to the end of a piece of string. The other end of the string is attached to a fixed point. The bob oscillates with small oscillations about its equilibrium position, as shown in Fig. 4.1.

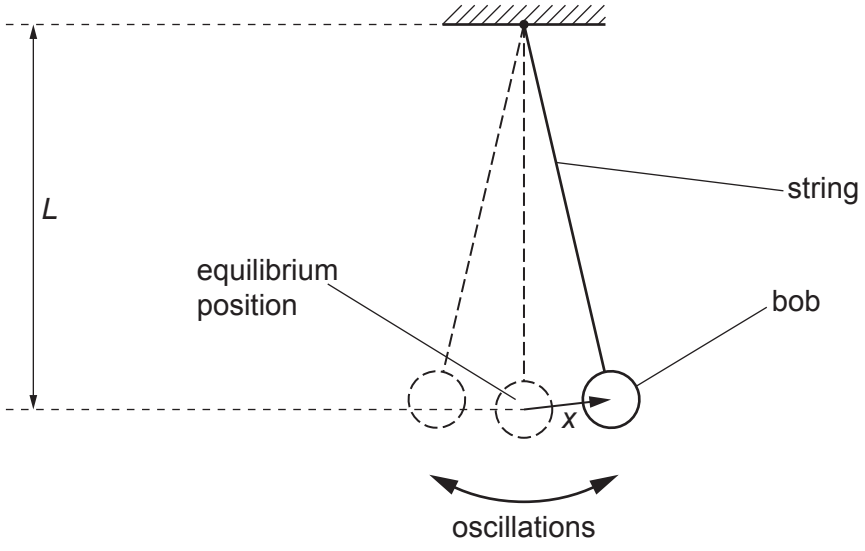

Fig. 4.1 (not to scale)

The length L of the pendulum, measured from the fixed point to the centre of the bob, is 1.24 m.

The acceleration a of the bob varies with its displacement x from the equilibrium position as shown in Fig. 4.2.

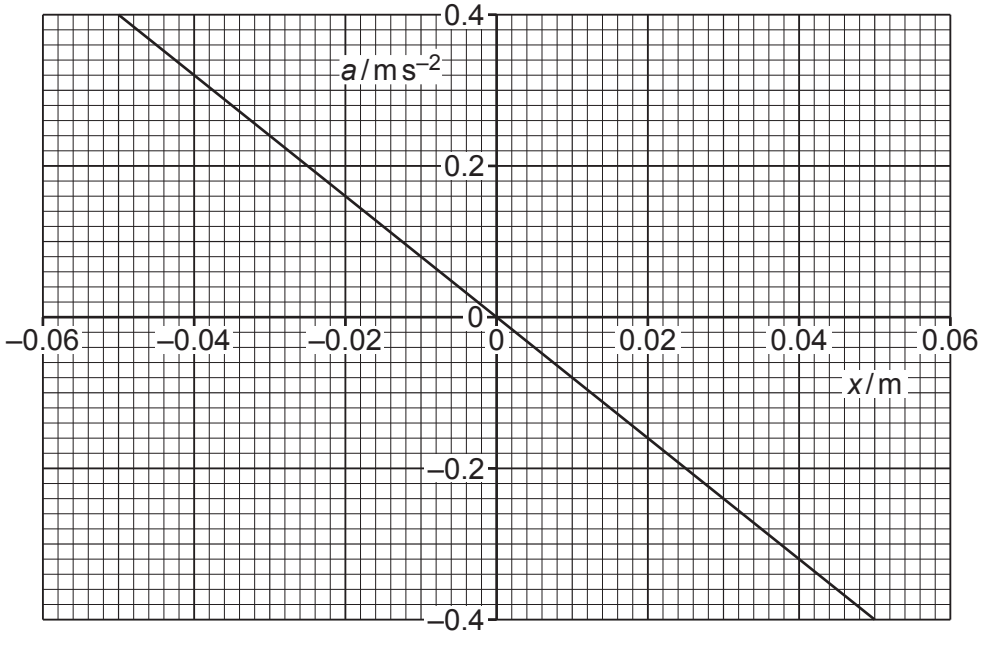

Fig. 4.2

(a) State how Fig. 4.2 shows that the motion of the pendulum is simple harmonic.

.....

.....

..... [2]

(b) **(i)** Use Fig. 4.2 to determine the angular frequency ω of the oscillations.

ω = ... rad s^{-1} [2]

(ii) The angular frequency ω is related to the length L of the pendulum by

$$\omega = \sqrt{\frac{k}{L}}$$

where k is a constant.

Use your answer in **(b)(i)** to determine k. Give a unit with your answer.

k = ... unit ..... [2]

(c) While the pendulum is oscillating, the length of the string is increased in such a way that the total energy of the oscillations remains constant.

Suggest and explain the qualitative effect of this change on the amplitude of the oscillations.

.....

.....

..... [2]

[Total: 8]