4 A mass m is suspended from a vertical spring of spring constant k attached to a fixed support. The mass is pulled down and held at a vertical displacement of 0.16 m from its equilibrium position, as shown in Fig. 4.1.

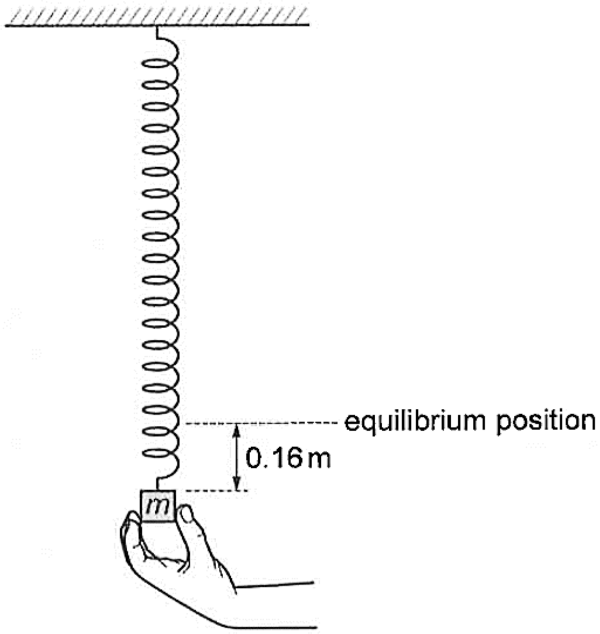

Fig. 4.1

The mass is released.

(a) Show that the mass's acceleration a is related to its displacement x from the equilibrium position by the equation:

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

Explain your working.

[3]

(b) The mass undergoes simple harmonic oscillations described by the equation in **(a)**.

Show that the period T of the oscillations of the mass is given by:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

[2]

(c) Ten oscillations are timed using a stopwatch. The data for the mass and the time, together with their uncertainties, are shown in Table 4.1.

Table 4.1

time for 10 oscillations / s	7.2 ± 0.2
m / g	$120 \pm 1\%$

Determine the value of k together with its actual uncertainty. Give your answer to an appropriate number of significant figures.

k = ……………. $\pm$ ……………. N m^{-1} [3]

(d) Calculate the total energy of oscillations of the spring-mass system.

total energy = ………………………………….. J [2]

(e) On Fig. 4.2, sketch a graph to show the variation with time of the kinetic energy of the mass for one complete oscillation, starting from the time of release. Label the axes with values obtained from **(c)** and **(d)**.

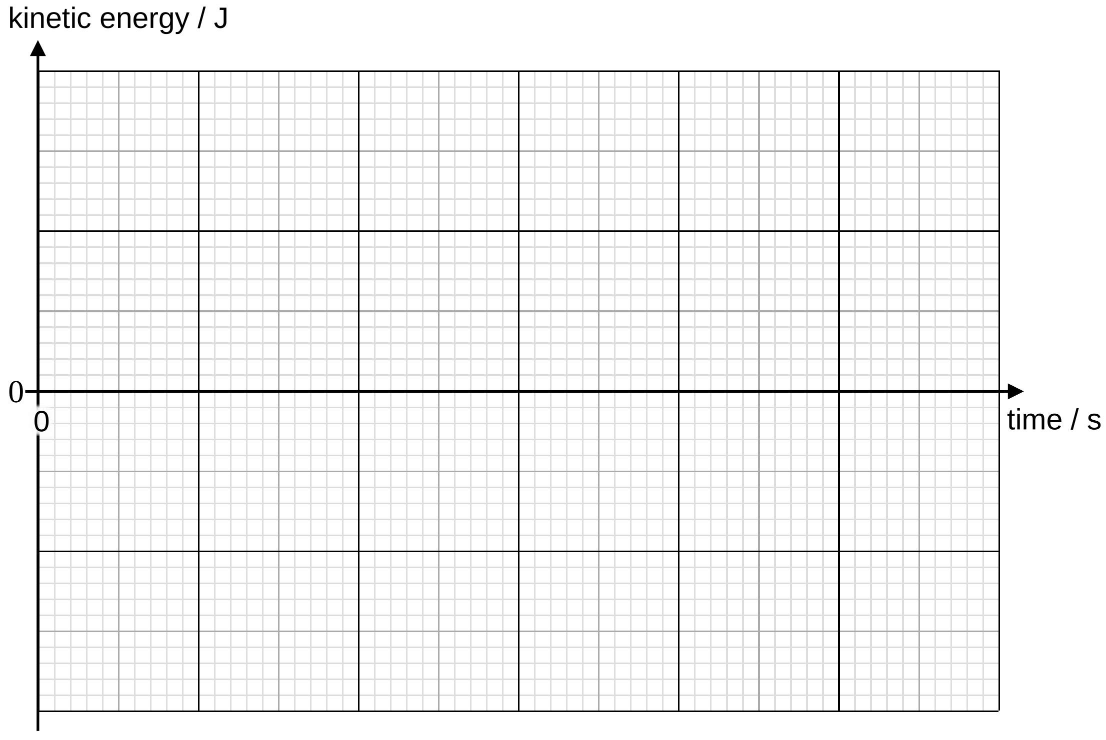

Fig. 4.2 [2]

[Total: 12]