4 Two vertical springs, each having spring constant $k = 3.0\ \mathrm{N\ cm^{-1}}$, support a mass. The lower spring is attached to an oscillator anchored on a bench, as shown in Fig. 4.1.

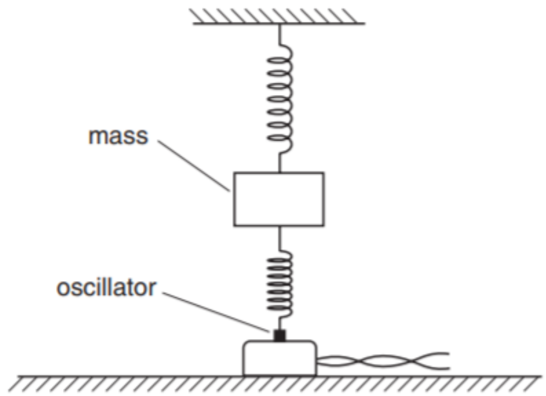

Fig. 4.1

The oscillator is switched off. The mass is displaced vertically and then released so that it vibrates. During these vibrations, the springs are always extended. The vertical acceleration *a* of the mass *m* is given by the expression

$$ma = -2kx,$$

where *x* is the vertical displacement of the mass from its equilibrium position.

(a) For a mass of 250 g, an amplitude of 1.50 cm,

(i) Determine the frequency of vibration of the mass.

frequency = ……………………..……. Hz [2]

(ii) Determine the maximum speed of vibration of the mass

maximum speed = ……………………..……. m s^{-1} [2]

(b) The oscillator is switched on and the frequency f of vibration is gradually increased. The amplitude of vibration of the oscillator is constant.

(i) Draw a graph in Fig. 4.2 showing the variation of the amplitude of vibration with the frequency of the oscillator for an object of mass *m*.

Label the graph appropriately and name it as (i). [2]

(ii) The mass is now replaced with another of the same dimension but of half the density. Draw another graph on Fig. 4.2, showing the variation of the amplitude of vibration with the frequency of the oscillator. Label this (ii). [1]

(iii) The mass in part **(ii)** is now replaced with another object of mass *m* but is spherical in shape. Draw another graph on Fig. 4.2, showing the variation of the amplitude of vibration with the frequency of the oscillator. Label this (iii). [1]

Fig. 4.2

(c) The oscillating mass is now doubled.

Explain how the frequency of oscillation in part (a) can be maintained.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

.... [2]