4 **(a)** Distinguish between free oscillations and forced oscillations.

free oscillations: .....

.....

forced oscillations: .....

.....

[2]

(b) A trolley is held on a horizontal surface by means of two stretched springs, as shown in Fig. 4.1.

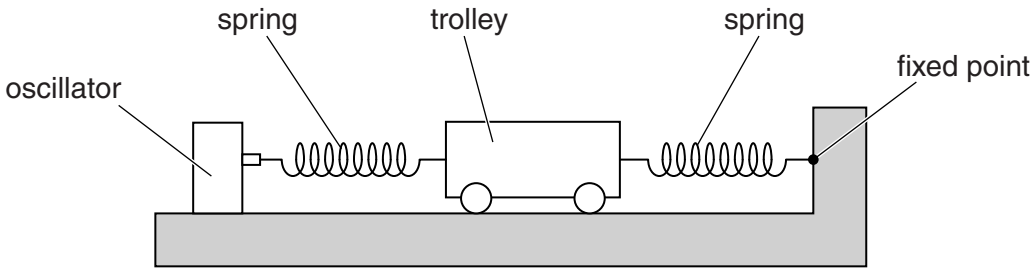

Fig. 4.1

One spring is attached to a fixed point. The other spring is attached to an oscillator that causes horizontal oscillations of the trolley.

The oscillator vibrates with a constant amplitude of vibration. The frequency of vibration of the oscillator is gradually increased from a very low value.

The variation with frequency f of the amplitude x_0 of vibration of the trolley is shown in Fig. 4.2.

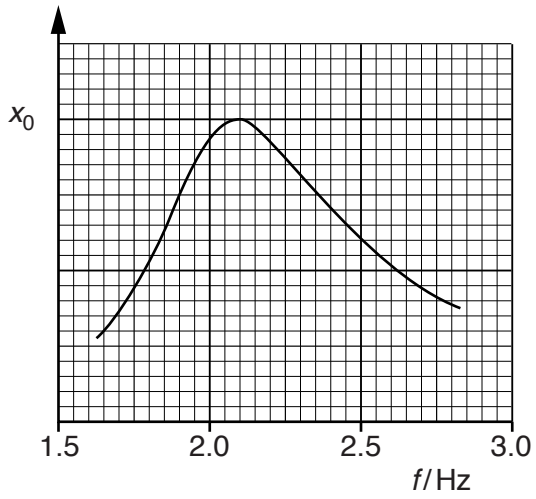

Fig. 4.2

Use Fig. 4.2 to state and explain

(i) the value of the natural frequency of vibration of the trolley,

.....

.....

.....

.....[3]

(ii) whether there are any frictional forces acting on the trolley.

.....

.....

.....[1]

(c) The oscillator in **(b)** is now stopped.

The trolley is given a horizontal displacement of 4.7 cm along the line of the springs. The trolley is then released.

Use information from Fig. 4.2 to estimate the maximum speed of the trolley.

speed = ... $m\,s^{-1}$ [2]