3 **(a)** State what is meant by *simple harmonic motion*.

……

……

…… [2]

(b) A small frictionless trolley is attached to a fixed point **P** by means of a spring. A second spring is used to attach the trolley to a variable frequency oscillator, as shown in Fig. 3.1.

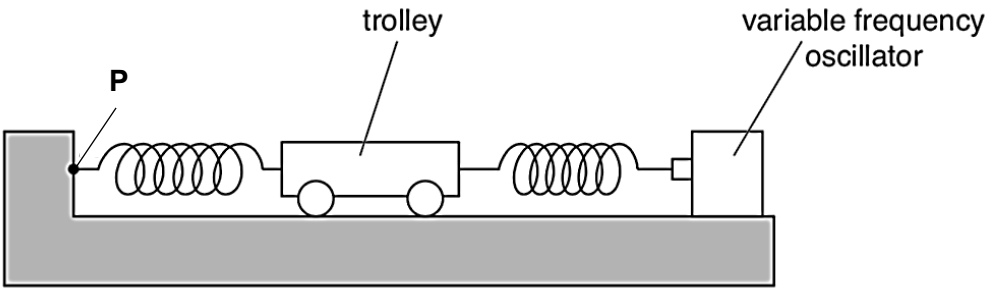

Fig. 3.1

Both springs remain extended within their limits of proportionality. Initially, the oscillator is switched off. The trolley is displaced horizontally along the line joining the two springs and is then released. The variation with time t of the velocity v of the trolley is shown in Fig. 3.2.

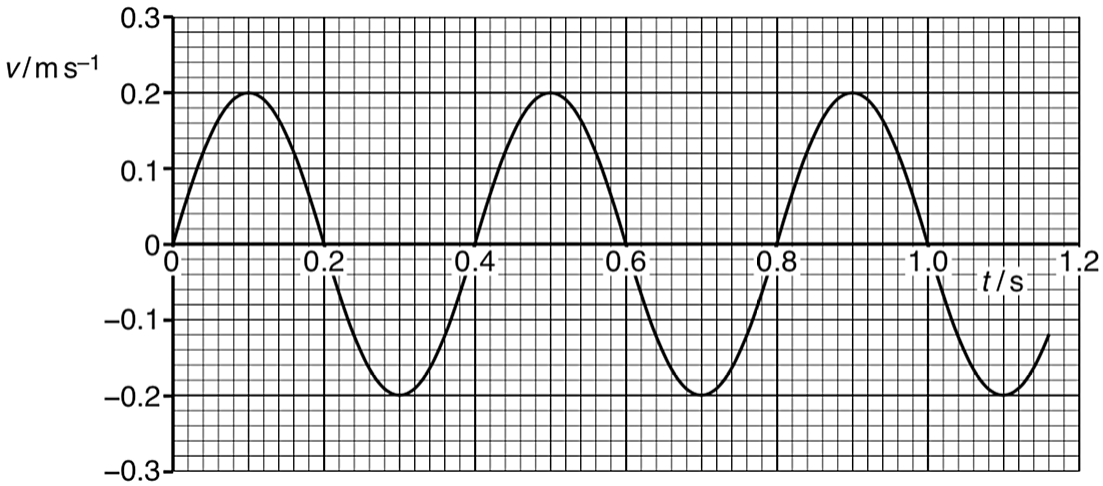

Fig. 3.2.

(i) Using Fig. 3.2, state two different times at which

1. the displacement of the trolley is zero,

time = …… s and …… s [1]

2. the acceleration in one direction is maximum.

time = …… s and …… s [1]

(ii) Determine the frequency of oscillation of the trolley.

frequency = …….. Hz [1]

(iii) The variation with time of the displacement of the trolley is also sinusoidal.

State the phase difference between the displacement and the velocity.

phase difference = ……. ° [1]

(c) The oscillator is now switched on. The amplitude of the oscillator is constant. The frequency *f* of vibration of the oscillator is varied. The trolley is forced to oscillate by means of vibrations of the oscillator.

(i) Distinguish between *free oscillations* and *forced oscillations*

…….....

…….....

…….....

……..... [2]

(ii) It was observed that the trolley vibrates with different amplitudes as the frequencies of the oscillator changes.

On the axes provided on Fig. 3.3, sketch a possible amplitude-frequency graph for this trolley. [1]

Fig. 3.3

(iii) State the approximate frequency at which the amplitude is maximum

frequency = …… Hz [1]