3 Fig. 3.1 shows a 0.45 kg mass held on a horizontal air track by two identical springs that are initially unstretched. The mass is pulled 5.0 cm to the left and released. The mass oscillates horizontally on a cushion of air.

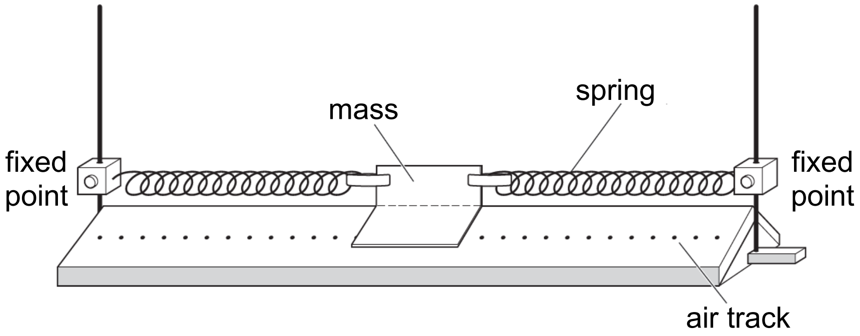

Fig. 3.1

(a) Explain why the mass oscillates with simple harmonic motion when displaced horizontally.

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[2]

The variation of kinetic energy with displacement *x* of the mass is shown in Fig. 3.2.

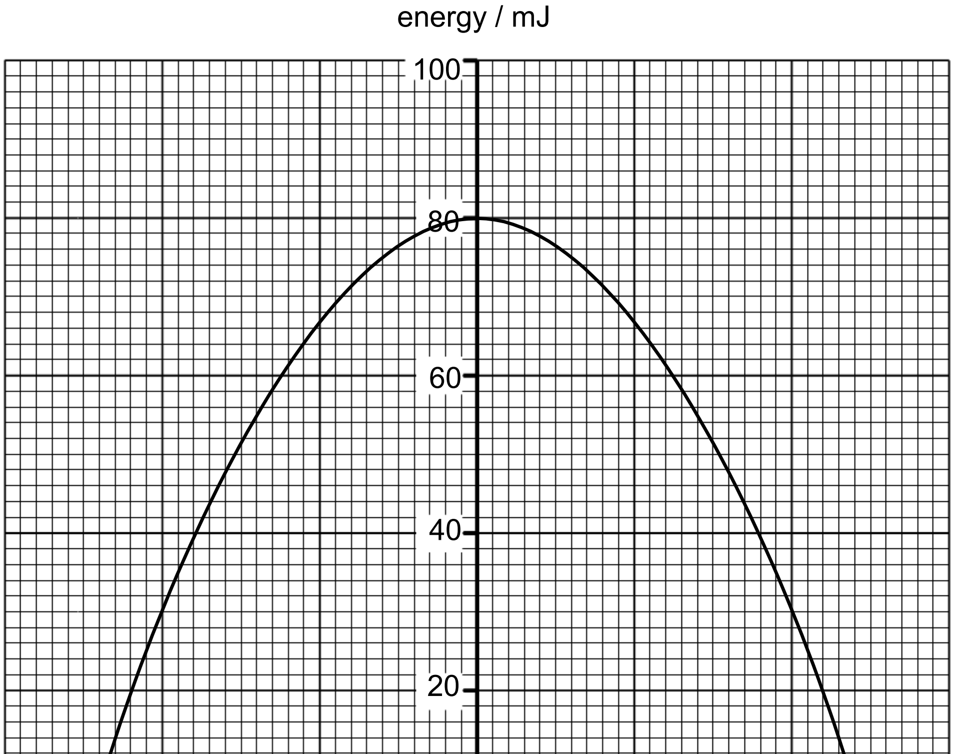

Fig. 3.2

(b) **(i)** Use Fig. 3.2 to determine the frequency of the oscillations.

frequency = ... Hz [2]

(ii) Draw, on Fig. 3.2, a graph to show the variation of potential energy stored in the springs with displacement *x* of the mass. [1]

(c) The blower of the air track is switched off so that the mass is in direct contact with the track. One end of the spring is attached to a driver (oscillator) shown in Fig. 3.3. The amplitude of oscillation of the driver is kept constant.

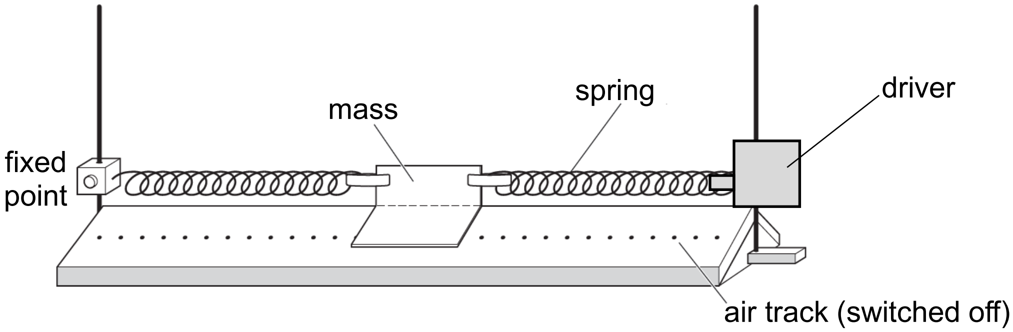

Fig. 3.3

The frequency of oscillations is gradually increased from zero. The variation of the amplitude of oscillation of the mass with driving frequency is shown in Fig. 3.4.

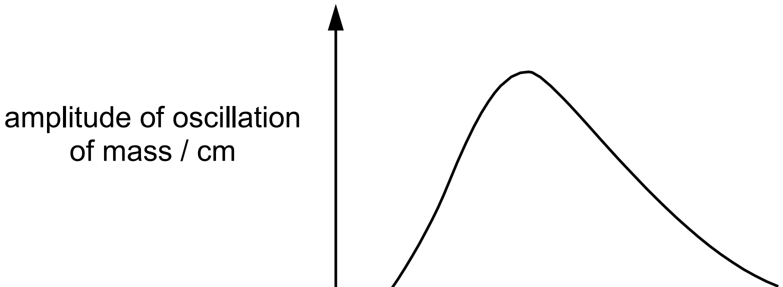

Fig. 3.4

(i) State how Fig. 3.4 shows that the mass is undergoing damped oscillations.

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[1]

(ii) The model in Fig. 3.3 and result in Fig. 3.4 can be applied to a practical situation.

Tall buildings, such as the Taipei 101 tower as shown in Fig. 3.5, are equipped with a damping system to reduce movement of the tower in strong winds. A mass in the form of a huge sphere on support cables oscillates with the tower to reduce the effect of the wind. The oscillations of the sphere are damped with oil-filled hydraulic pistons connected to the sphere.

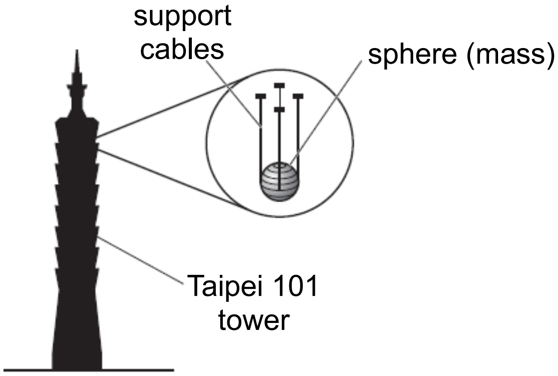

Fig. 3.5

Strong winds set the tower in oscillation. The natural frequency of oscillations of the tower is 0.15 Hz.

Suggest, by reference to energy transfer, why the frequency of the sphere-damping system must be close to 0.15 Hz to help reduce the motion of the tower.

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