Oxford Cambridge and RSA

A level Physics A

H556/03 Unified physics

Question Set 8

1 The 500m tall Taipei 101 tower is shown in Fig. 2.1. The tower has a massive sphere suspended across five floors near the top of the building to dampen down movement of the tower in high winds and earthquakes. The sphere is connected to pistons (not shown) which drive oil through small holes providing damping. The vibration energy of the sphere is converted to thermal energy.

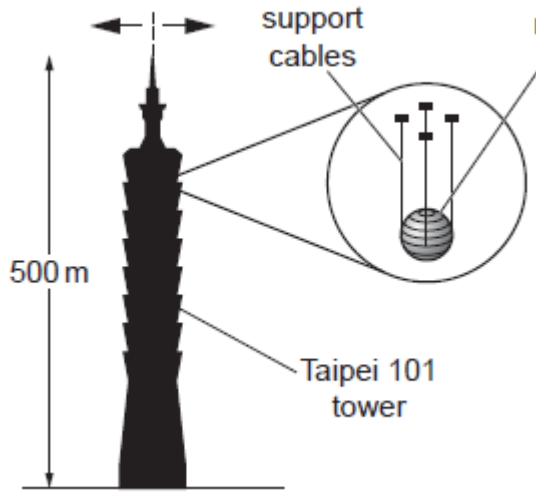

Fig. 2.1

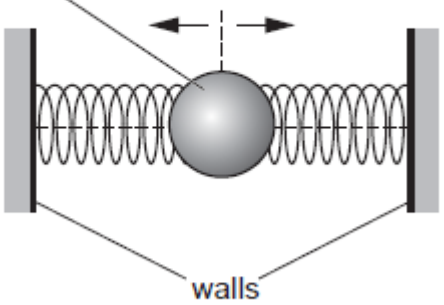

Fig. 2.2

Fig. 2.2 models the damper system as the sphere held between two springs. The movement of the walls of the tower forces the sphere to oscillate in **simple harmonic motion**.

In the strongest wind, the natural frequency of the oscillations of the tower is 0.15 Hz and the maximum acceleration of the sphere is 0.050 m s^{-2}.

(a) Calculate the maximum displacement of the sphere in the strongest wind.

maximum displacement = ... m **[3]**

(b) Explain why the natural frequency of the damper system must be about 0.15 Hz.

[2]

(c) The acceleration a of the sphere is given by the equation

$$a = -\left(\frac{k}{m}\right)x$$

where k is the force constant of the spring combination, x is the displacement of the sphere and m is the mass of the sphere.

The mass of the sphere is 6.6×10^5 kg. The natural frequency of the oscillations of the sphere is 0.15 Hz.

(i) Show that the force constant k of the spring combination is about 6×10^5 N m^{-1}.

[3]

(ii) The S-wave of an earthquake causes a sudden movement of the building displacing the sphere 0.71 m from its equilibrium position relative to the building.

Use your answer in **(i)** to calculate the energy transferred to the springs of the damper system.

energy transferred = ... J **[2]**

Total Marks for Question Set 8: 10