5 A pendulum consists of a sphere suspended from a fixed point by an inelastic light string. When the sphere is set in motion, it oscillates with simple harmonic motion. At its lowest position, it has kinetic energy of 0.86 J and momentum of 0.72 N s.

(a) Define *simple harmonic motion*.

……

…… [1]

(b) Show that the mass of the sphere is 0.30 kg.

[2]

(c) The simple pendulum is now placed in front of a screen. A vertical rod is fixed near the rim of a horizontal turntable which is rotating at a frequency of 0.55 Hz. A horizontal beam of light casts a shadow of the rod onto the screen in front of which the simple pendulum is suspended, as shown in Fig. 5.1. The shadow of the rod also oscillates with simple harmonic motion.

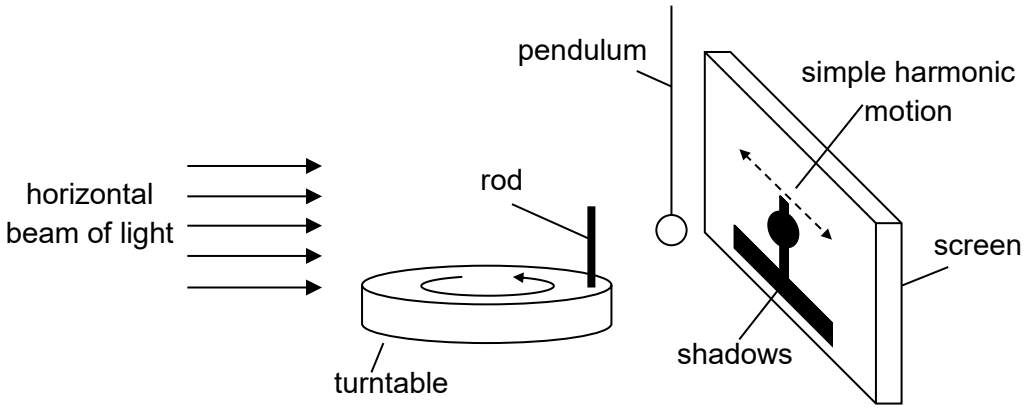

Fig. 5.1

(i) The period T of a pendulum is related to its length L by the expression $T = 2\pi\sqrt{\frac{L}{g}}$, where g is the acceleration of free fall.

The pendulum is now set in motion, and it is observed that the shadows of the rod and the pendulum sphere move in phase on the screen.

Calculate the length of the pendulum, L.

L = …… m [2]

(ii) The pendulum is then held stationary and set in motion again. Now it is observed that shadow of the sphere passes the equilibrium position 0.50 s later than the shadow of the rod.

Calculate the phase difference between their motions.

phase difference = …… rad [1]

(d) The pendulum is next placed in water and set into motion. Fig. 5.2 shows the variation of displacement from its equilibrium position, x of the pendulum with time, t, for the first half oscillation.

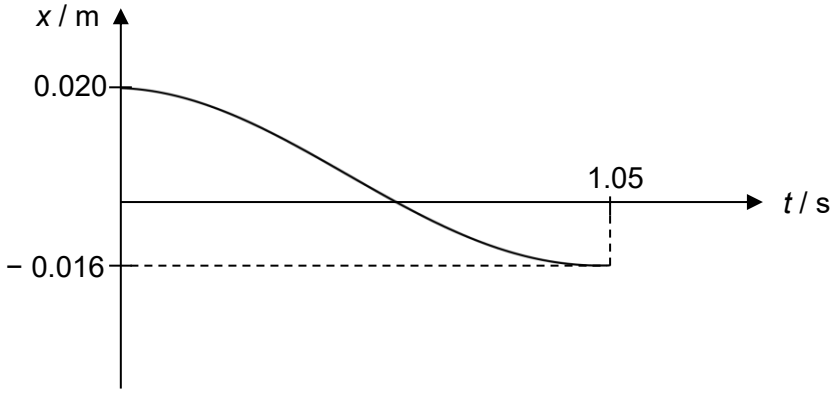

Fig. 5.2

(i) Explain why the maximum negative displacement of the pendulum is not equal to its maximum positive displacement.

……...

……. [1]

(ii) Determine the decrease in energy of the oscillation for the first half of the oscillation.

decrease in energy = …….. J [2]