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

.....

.....

.....

..... [2]

(b) An electric toothbrush has a circular brush head of diameter 12 mm as shown in Fig. 8.1.

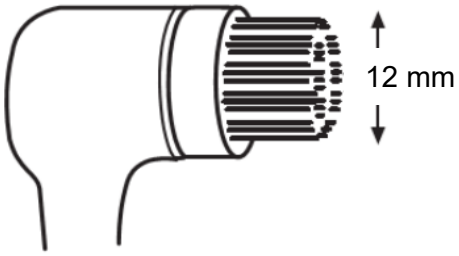


Fig. 8.1

The toothbrush has two settings.

On setting 1, the brush head vibrates with simple harmonic motion with a frequency of 33 Hz. From its leftmost position, it moves a maximum horizontal distance of 4.2 mm as shown in Fig. 8.2.

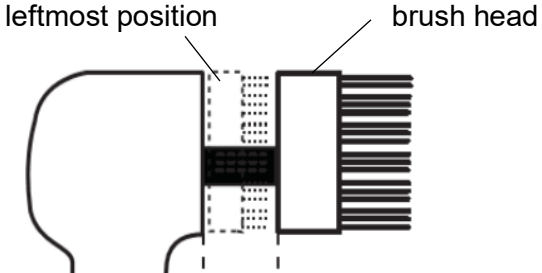


Fig. 8.2

(i) Using the information provided, write an expression for the variation with time t of displacement x, in metres, of the brush head from its equilibrium position.

x = ... [2]

(ii) Determine the speed of the brush head when it has moved a horizontal distance of 0.8 mm to the right from its leftmost position.

Explain your working.

speed = ... m s^{-1} [3]

(c) On setting 2, the brush head can be considered to oscillate with simple harmonic motion with amplitude *A* as shown in Fig. 8.3.

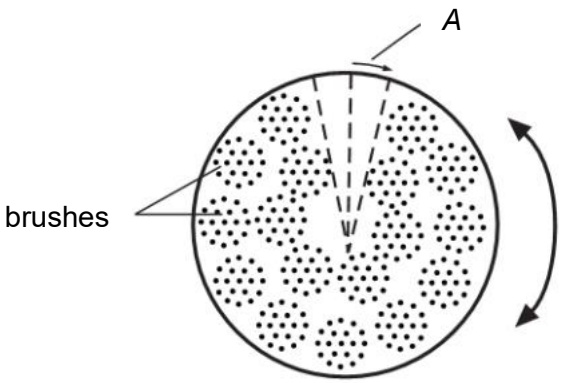


Fig. 8.3

The velocity, in m s^{-1}, of a point on the circumference of the head can be given by the expression

$$v = 9.2 \times 10^{-2} \cos 77t$$

Determine A.

A = ... m [2]

(d) Fig. 8.4 shows a particle of toothpaste of mass 2.5×10^{-6} kg on the edge of the brush head.

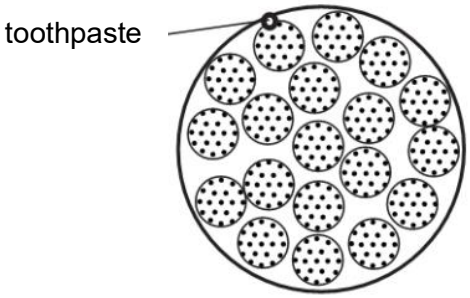


Fig. 8.4

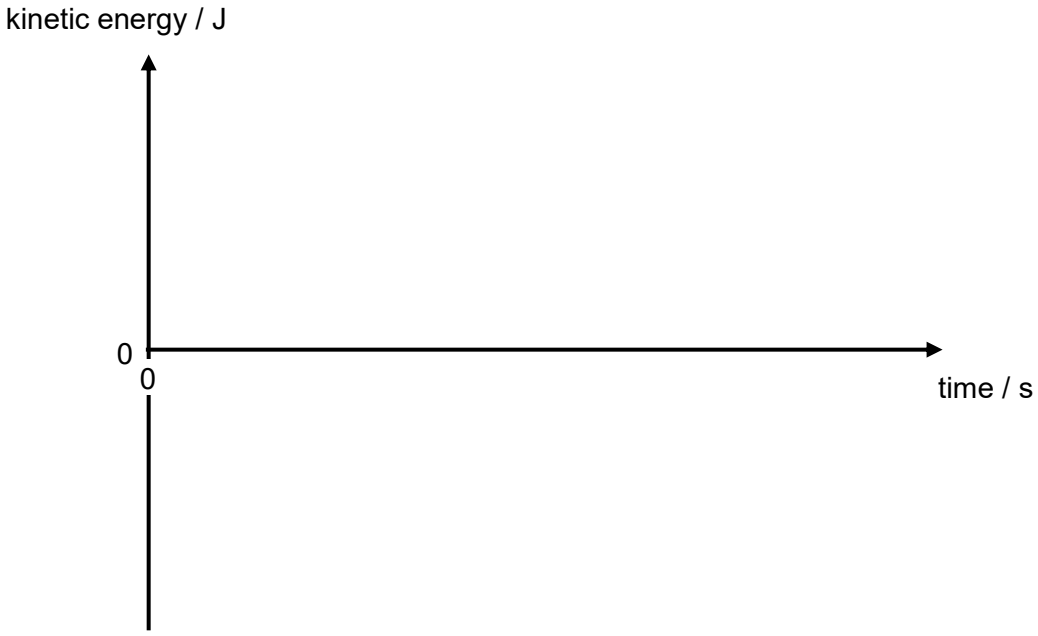
The switch is on setting 2.

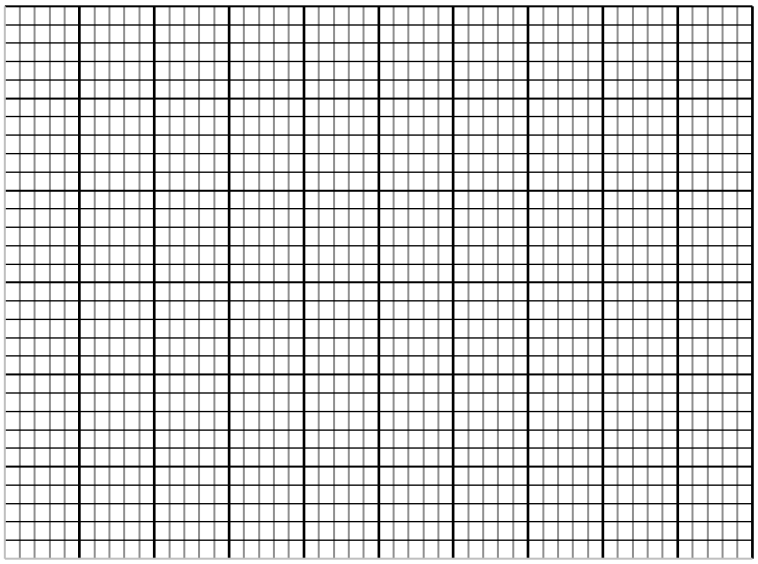
(i) Calculate the maximum kinetic energy of the particle of toothpaste.

maximum kinetic energy = ... J [2]

(ii) On the axes of Fig. 8.5, sketch a graph of the variation of the kinetic energy of the particle with time over two periods. Appropriate numerical values are required on both axes.

Add suitable scales to both axes.





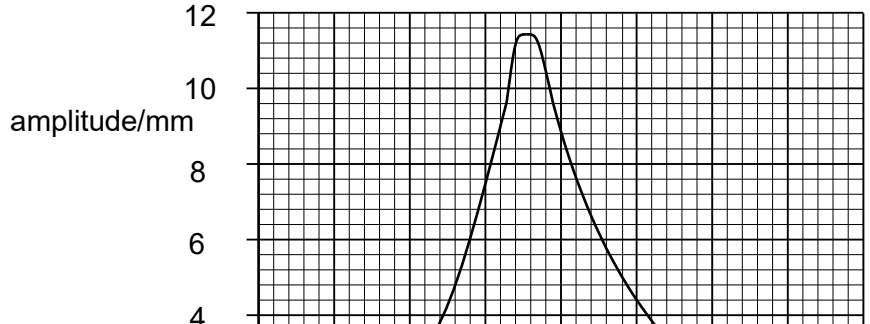
[3]

Fig. 8.5

(iii) Determine the time interval between the maximum linear velocity of the toothpaste and its subsequent maximum linear acceleration when both are in the same direction.

time = ... s [2]

(e) The brush head is rotated by a machine whose oscillations are simple harmonic. A component of mass 0.0460 kg in the toothbrush was forced into oscillations when the machine is in use. Fig. 8.6 shows how the amplitude of the oscillation varies with frequency.



(i) State

1. what is meant by a *forced* oscillation,

.....

..... [1]

2. the name of the effect observed at a frequency of 35 Hz in Fig. 8.6.

.....

..... [1]

(ii) Draw on Fig. 8.6 to show how the amplitude of the oscillation varies with frequency if the component is supported on a rubber mounting.

[2]