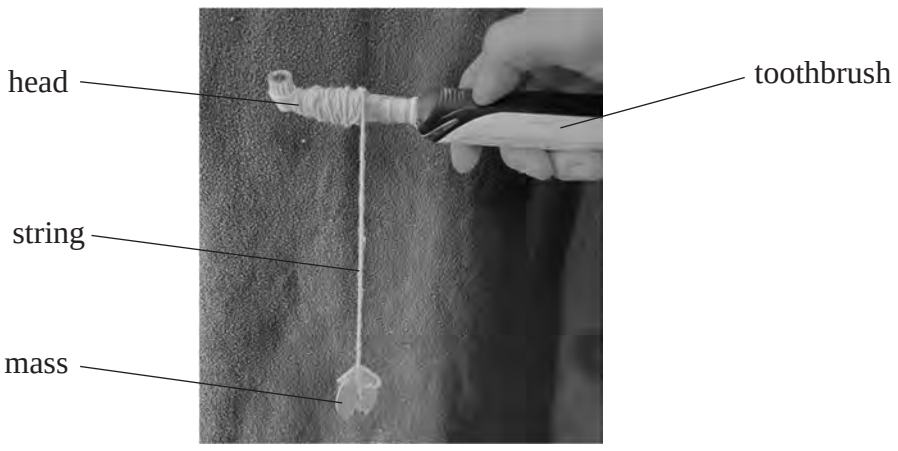
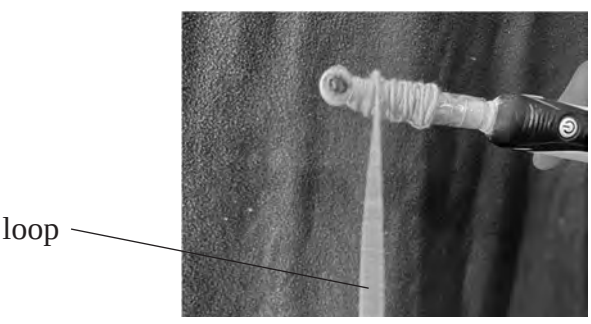
15 A student wound a piece of string around the head of an electric toothbrush. The student attached a small mass to the other end of the string, as shown in Photograph 1.



Photograph 1

The toothbrush was switched on and the head started to vibrate. The student rotated the toothbrush slowly to unwind the string. At a particular length, large vibrations were observed on the string. The string formed a loop, as shown in Photograph 2.



Photograph 2

(a) Explain how the vibrations of the toothbrush head caused the loop to form.

(5)

(b) The student continued to unwind the string and the loop disappeared. When the length of the unwound string was twice that shown in Photograph 2 two loops were seen. Three loops were seen when the unwound length was three times that shown in Photograph 2 and so on.

Determine the frequency of vibration of the toothbrush head.

unwound length of string with 4 loops = 0.69 m
mass on string = 0.010 kg
mass per unit length of string = 9.1×10^{-4} kg m^{-1}

(5)

Frequency = ...

(Total for Question 15 = 10 marks)