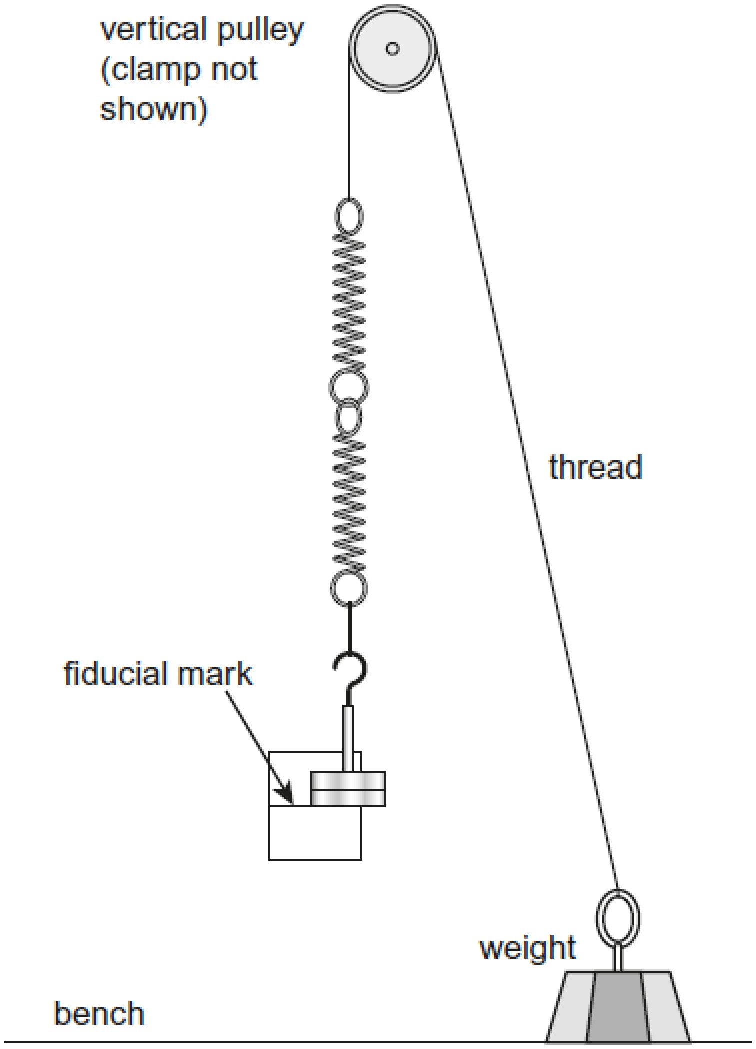
14 A student investigates the vertical oscillations of the mass–spring system shown in **Figure 1**.

Figure 1



The system is suspended from one end of a thread passing over a pulley.

The other end of the thread is tied to a weight.

The system is shown in **Figure 1** with the mass at the equilibrium position.

The spring constant (stiffness) is the same for each spring.

(a) Explain why the position of the fiducial mark shown in **Figure 1** is suitable for this experiment.

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(1)

The table below shows the measurements recorded by the student.

Time for 20 oscillations of the mass-spring system/s				
22.9	22.3	22.8	22.9	22.6

(b) (i) Determine the percentage uncertainty in these data.

percentage uncertainty = ____

(3)

(ii) Determine the natural frequency of the mass-spring system.

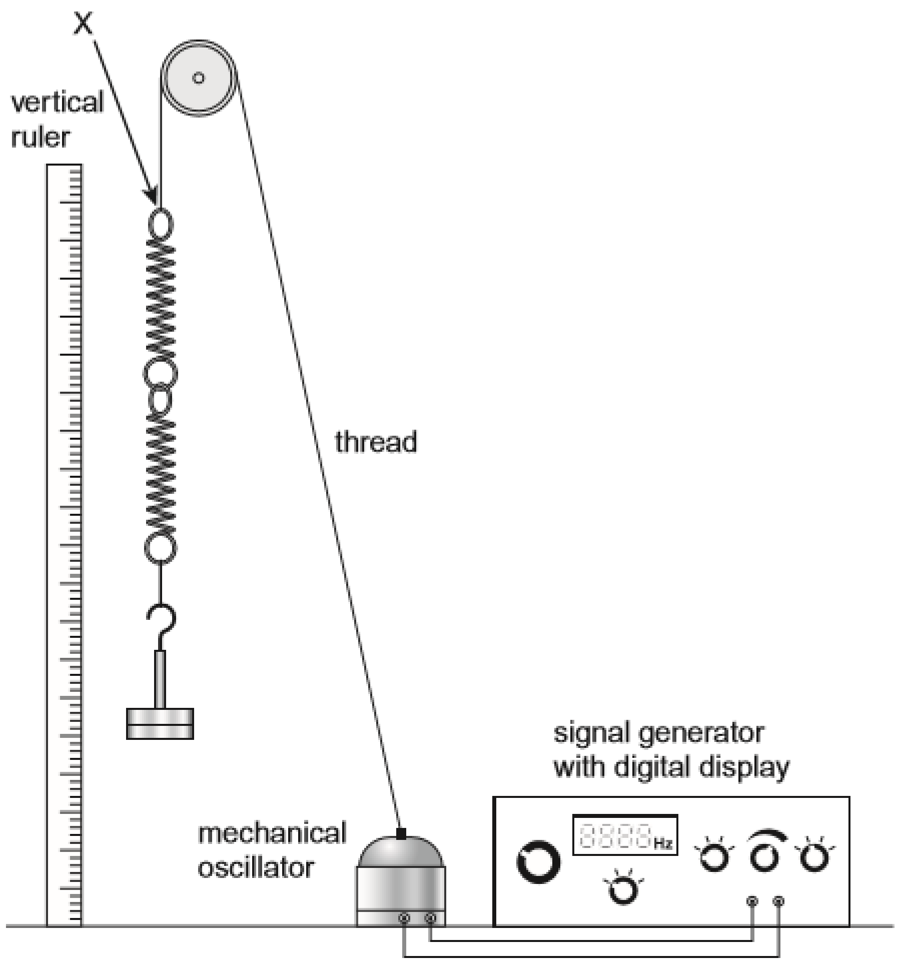
natural frequency = ____

(1)

(c) The student connects the thread to a mechanical oscillator. The oscillator is set in motion using a signal generator and this causes the mass–spring system to undergo forced oscillations.

A vertical ruler is set up alongside the mass–spring system as shown in **Figure 2**. The student measures values of *A*, the amplitude of the oscillations of the mass as *f*, the frequency of the forcing oscillations, is varied.

Figure 2



A graph for the student's experiment is shown in **Figure 3**.

(i) Add a suitable scale to the frequency axis.
You should refer to your answer in part **(b)(ii)** and note that the scale starts at 0 Hz.

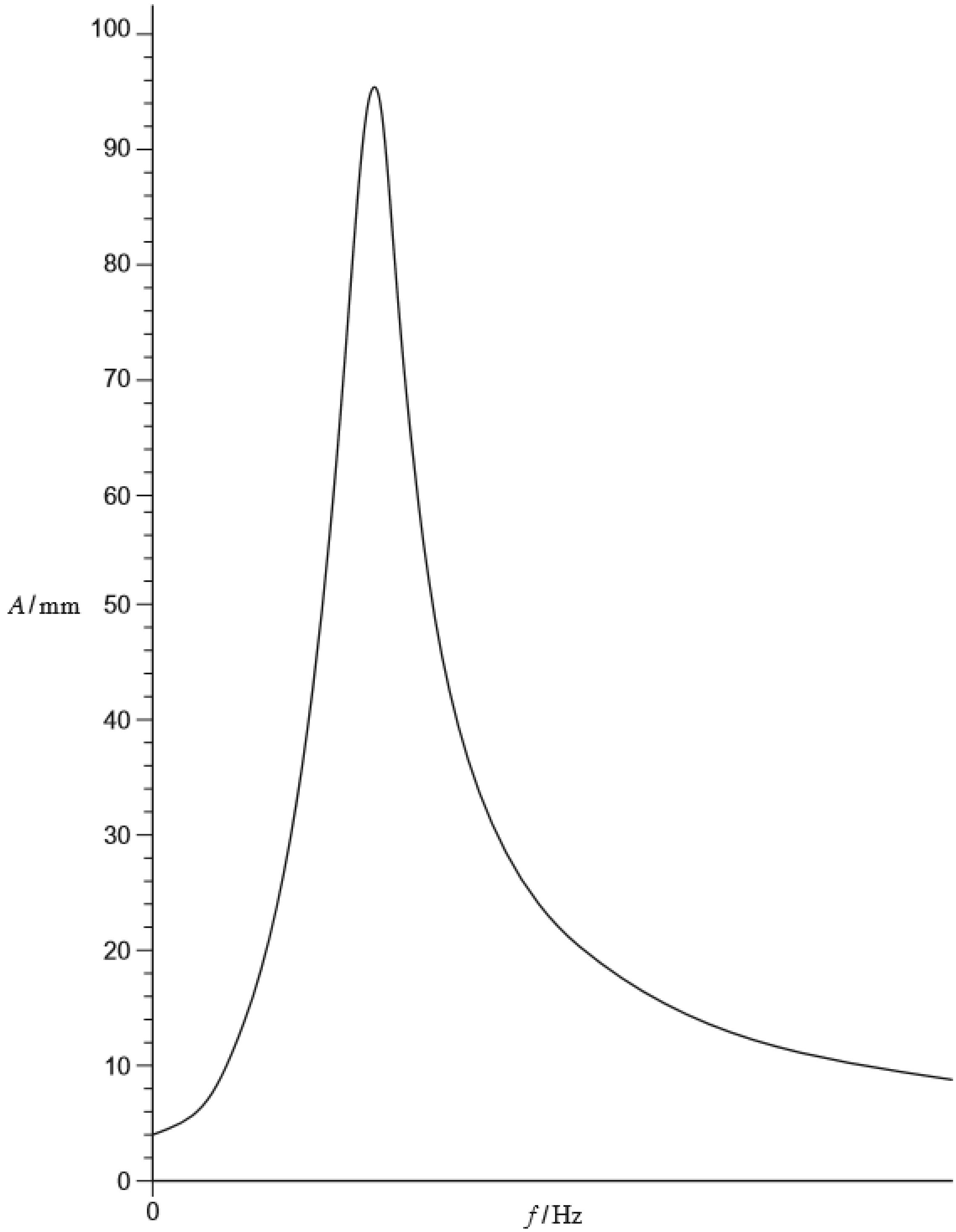
(1)

(ii) Deduce from **Figure 3** the amplitude of the oscillations of X, the point where the mass–spring system is joined to the thread.
You should assume that the length of the thread is constant.

amplitude of X = ______________________________

(1)

Figure 3



(d) (i) State and explain how the student was able to determine the accurate shape of the graph in the region where *A* is a maximum.

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(2)

(ii) The student removes one of the springs and then repeats the experiment.

Add a new line to **Figure 3** to show the graph the student obtains.

You may wish to use the equation $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$.

(2)

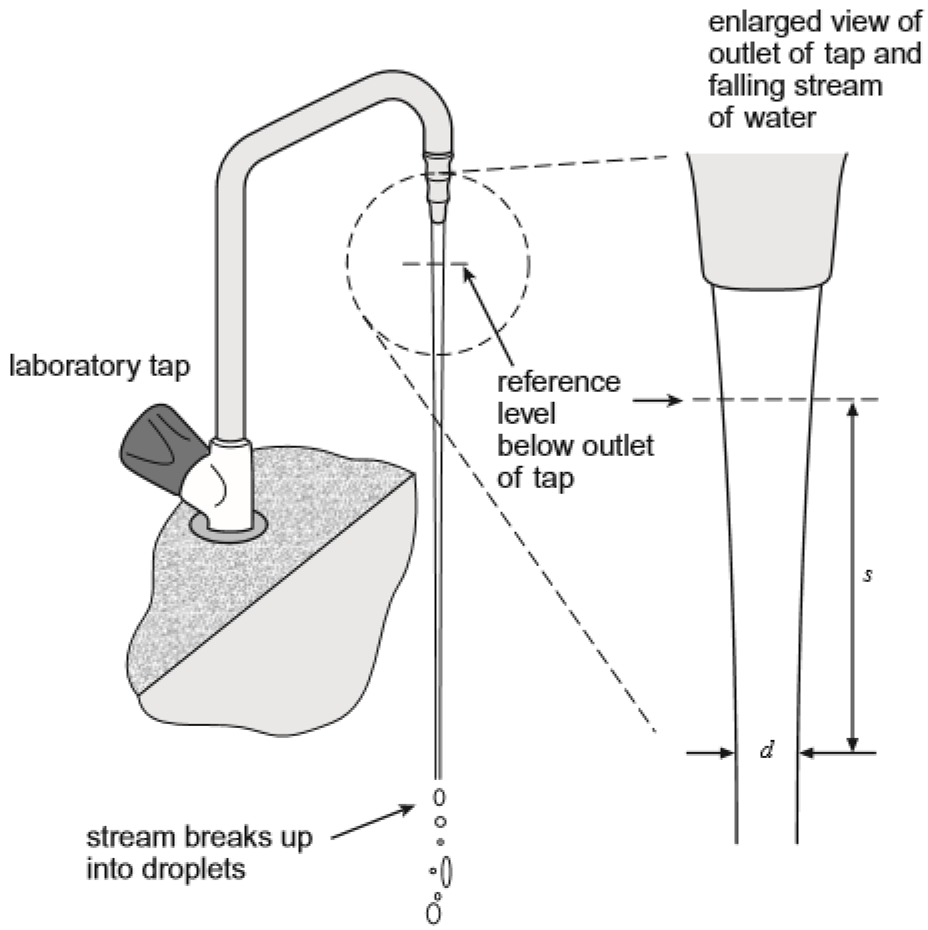
(Total 11 marks)

15 A stream of water flowing from a tap at a constant rate accelerates due to gravity. The stream becomes narrower the further it falls, before eventually breaking up into droplets.

An experiment is carried out to find out how *d*, the diameter of the stream of water, depends on *s*, the vertical distance the water has fallen. To avoid problems due to the effects of the tap outlet, *s* is measured from a reference level below the outlet.

The arrangement used for the experiment is shown in **Figure 1**

Figure 1



(a) The distance *s* is measured to the nearest mm using a vertical ruler.
The diameter *d* is measured to the nearest 0.1 mm using a travelling microscope.
Suggest why a travelling microscope was chosen to measure *d* rather than vernier callipers.

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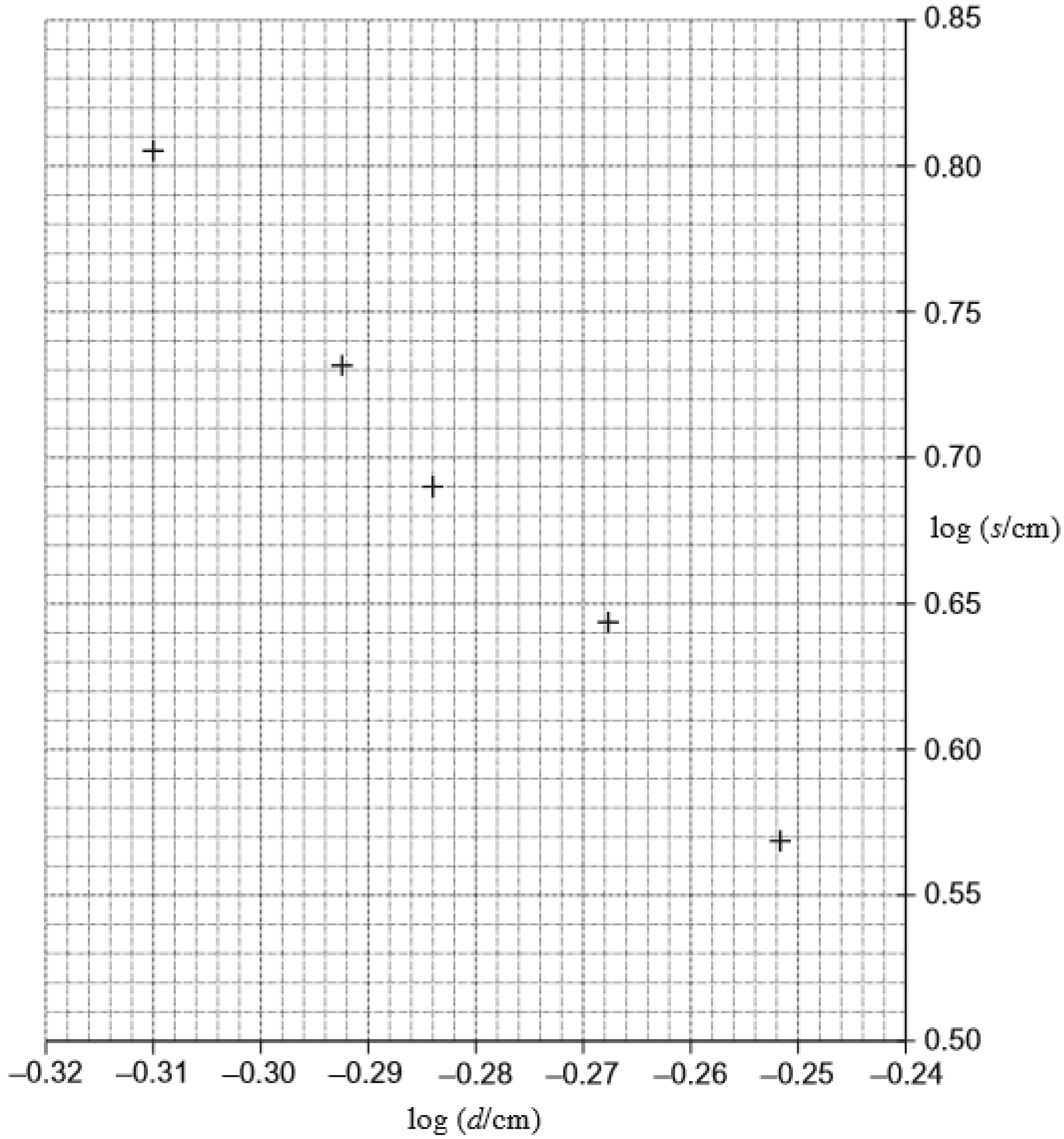
(1)

(b) The data from the experiment suggest that $s = kd^n$ where k is a constant and n is an integer.

These data are used to plot the graph in **Figure 2**.

Figure 2



(i) Determine n using **Figure 2**.

n ______________________________________

(2)

(ii) Explain how the numerical value of *k* can be obtained from **Figure 2**.

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(1)

(iii) Deduce the unit of *k*.

unit of *k* = ____

(1)

(Total 5 marks)