Name of the Student:_____
Max. Marks : 22 Marks **Time : 22 Minutes**

Q1.

(a) State the conditions for simple harmonic motion.

_____

_____

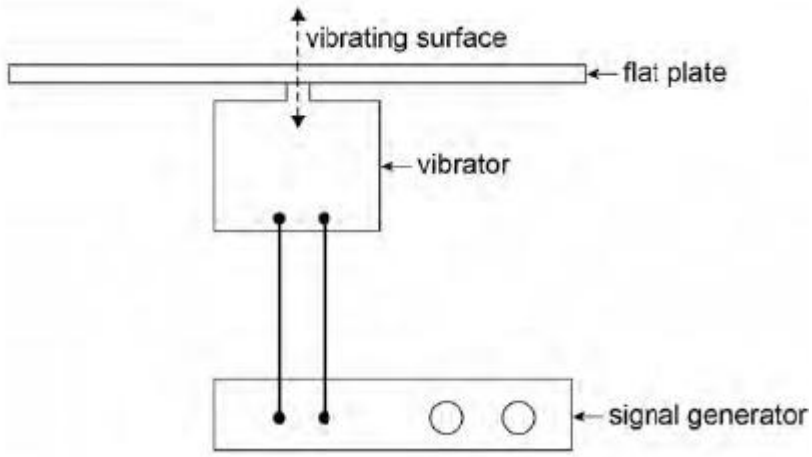
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(2)

(b) A rigid flat plate is made to vibrate vertically with simple harmonic motion. The frequency of the vibration is controlled by a signal generator as shown in **Figure 1**.

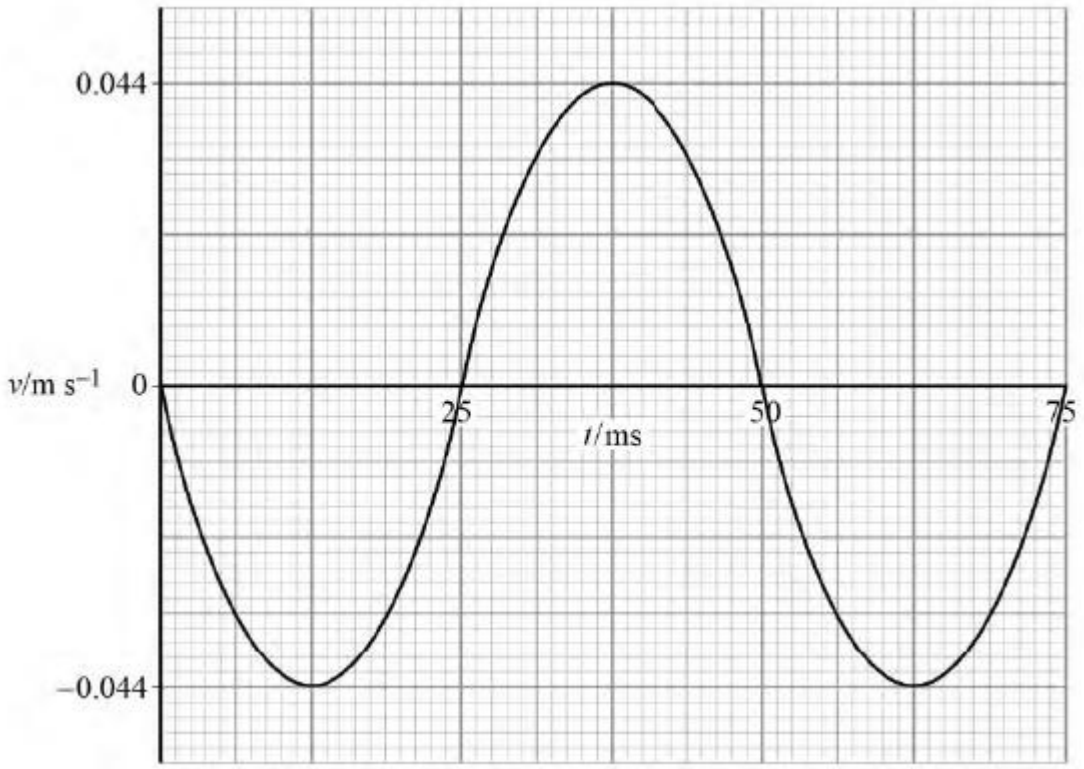
Figure 1



The velocity−time (v−t) graph for the vibrating plate at one frequency is shown in **Figure 2**.

Figure 2

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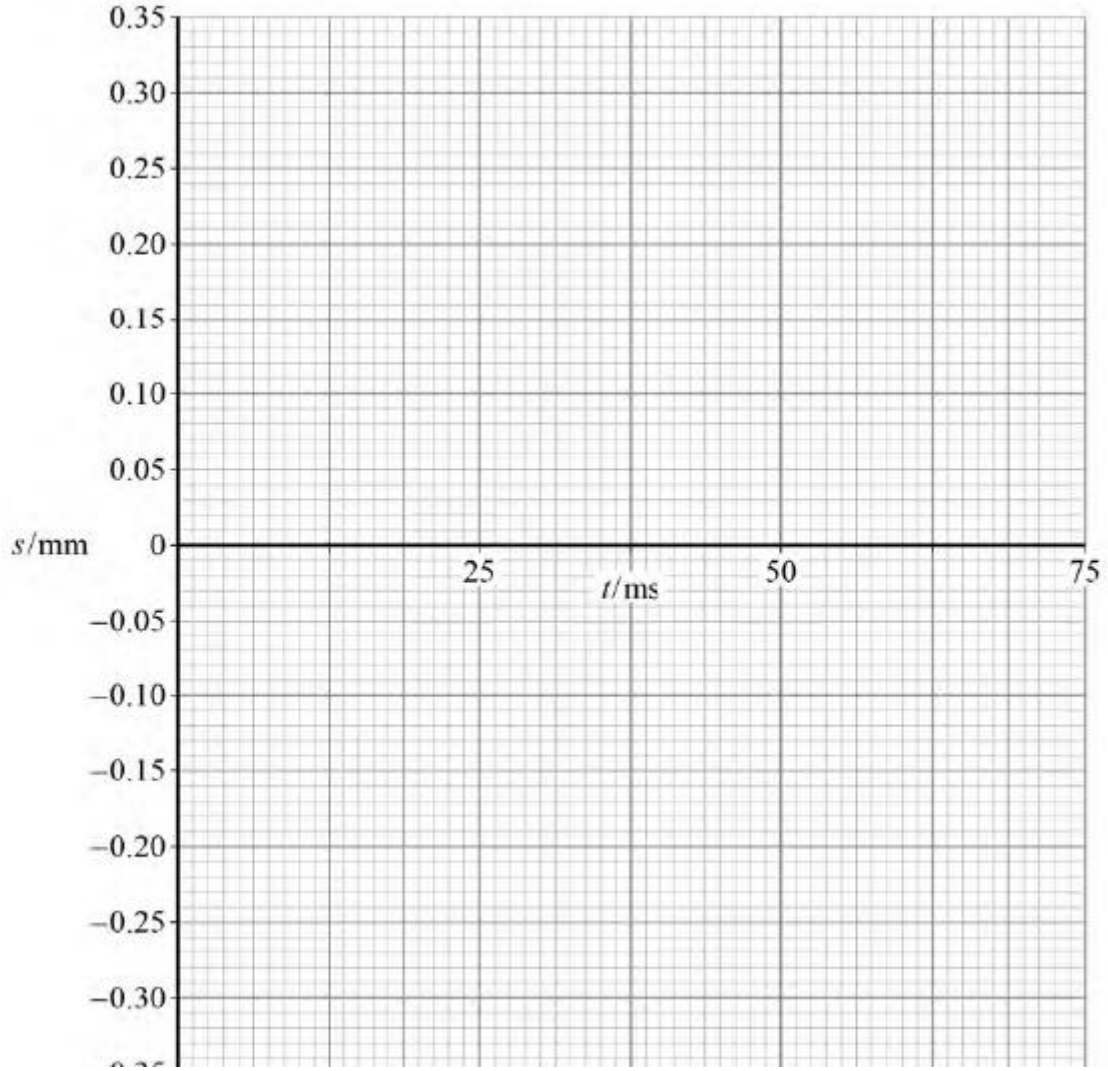
Show that the maximum displacement of the plate is 3.5×10^{-4} m.

(2)

(c) Draw on **Figure 3** the displacement−time (*s*−*t*) graph between 0 and 75 ms.

Figure 3

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(1)

(d) State **one** time at which the plate has maximum potential energy.

time = _____ s

(1)

(e) A small quantity of fine sand is placed onto the surface of the plate. Initially the sand grains stay in contact with the plate as it vibrates. The amplitude of the vibrating surface remains constant at 3.5×10^{-4} m over the full frequency range of the signal generator. Above a particular frequency the sand grains lose contact with the surface.

Explain how and why this happens.

_____

_____

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_____

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_____

(3)

(f) Calculate the lowest frequency at which the sand grains lose contact with the surface of the plate.

frequency = _____ Hz

(2)

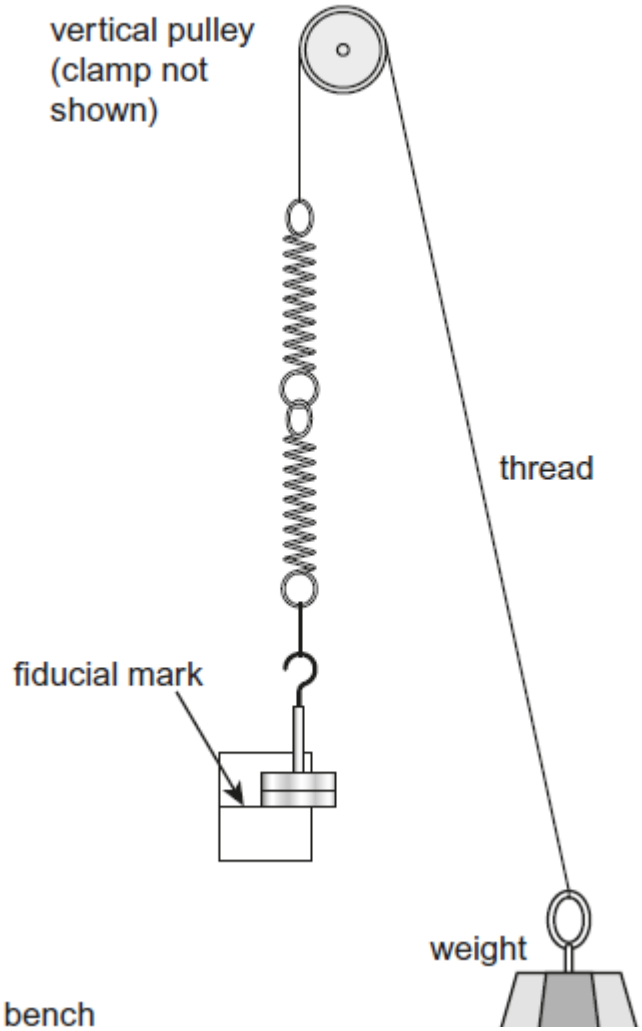
(Total 11 marks)

Q2.

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

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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.

_____

_____

_____

_____

(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

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

percentage uncertainty = _____

(3)

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

natural frequency = _____

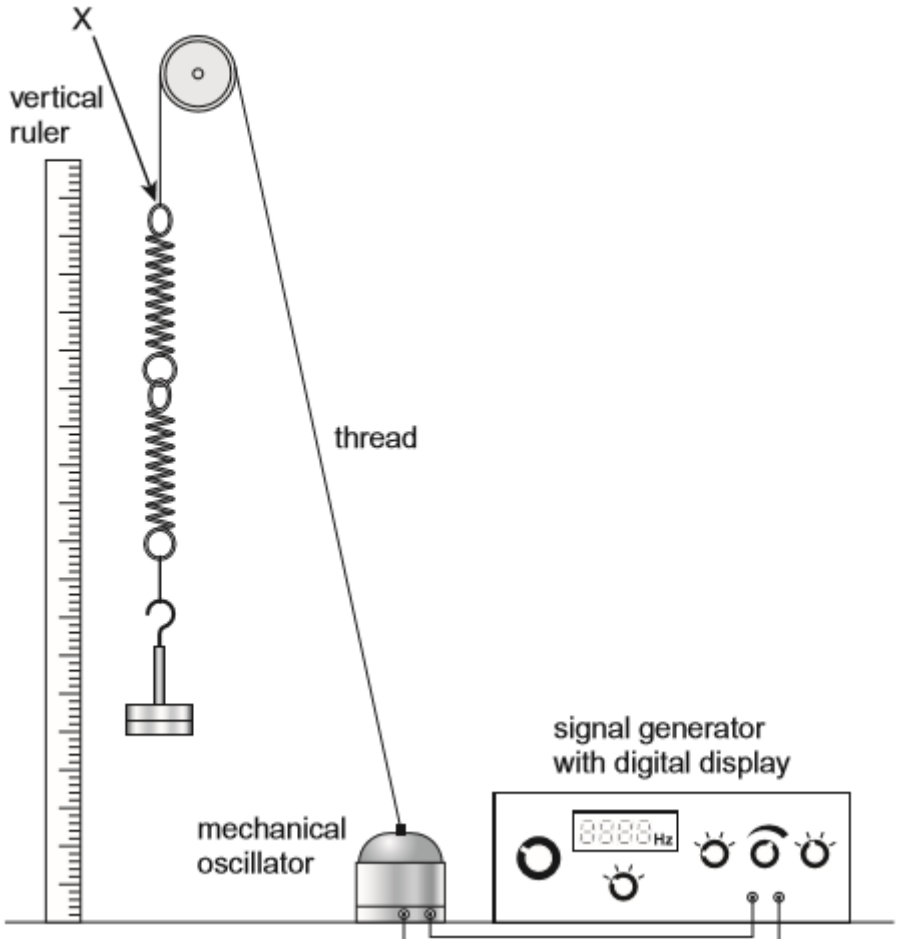
(1)

(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.

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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)

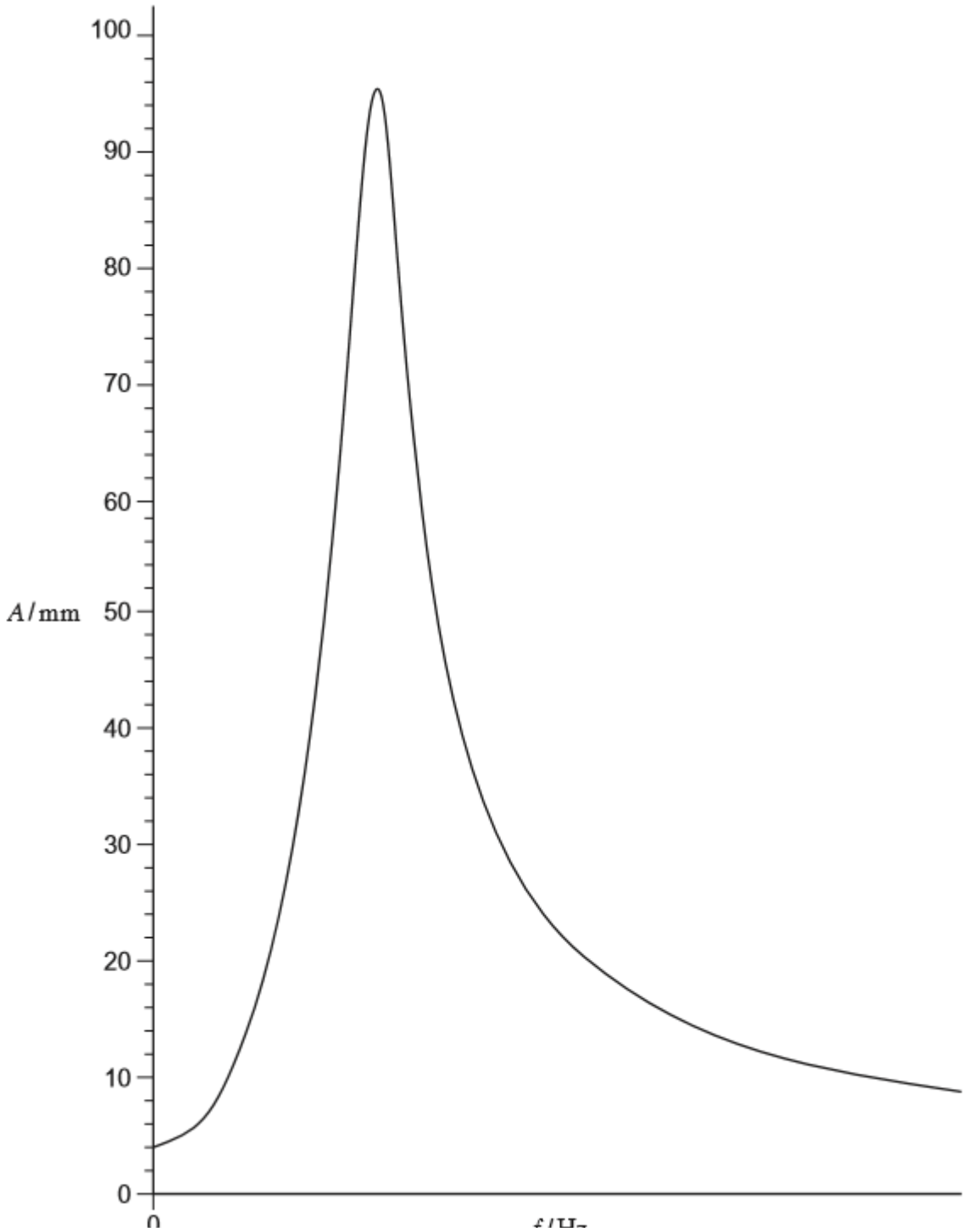
(ii) Deduce from **Figure 3** the amplitude of the oscillations of X, the point where the mass–spring system is joined to the thread.
You should assume that the length of the thread is constant.

amplitude of X = _____

(1)

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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.

_____

_____

_____

_____

(2)

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(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)

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