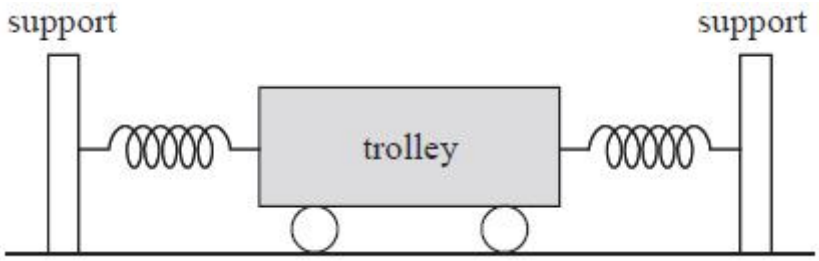
Name of the Student:_____
Max. Marks : 23 Marks **Time : 23 Minutes**

Q1.

The diagram shows a mass-spring system that consists of a trolley held in equilibrium by springs attached to two fixed supports.



The trolley has a mass *m* and the spring arrangement has a force constant *k*.

(a) (i) The trolley is displaced towards one of the supports through a distance *x* and then released. Show that the initial acceleration of the trolley when it is released is given by $a = -\frac{kx}{m}$ and explain the significance of the minus sign.

(2)

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(ii) Use the expression in (i) to show that the trolley will oscillate with a time period *T* given by

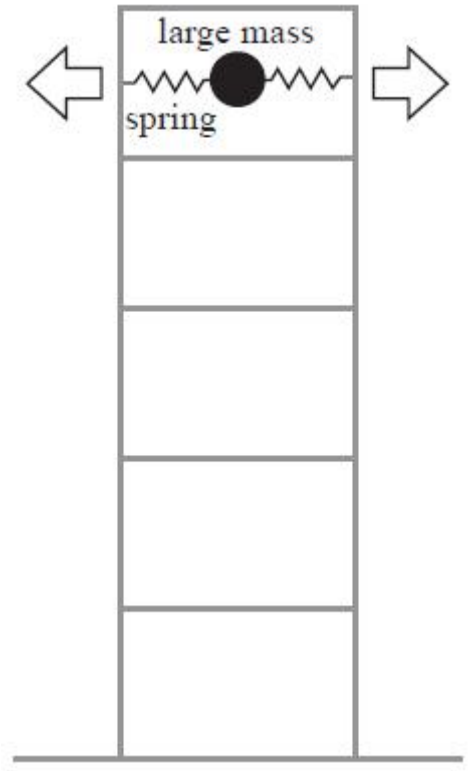
$$T = 2\pi\sqrt{\frac{m}{k}}$$

(3)

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(b) Mass-spring systems are sometimes used in tall buildings to reduce the oscillation of the building due to strong winds.



As the top of the building moves the mass is set into oscillation. The mass-spring system is designed to have a natural frequency equal to that of the building.

(i) In one building a mass-spring system has a mass of 3.5×10^5 kg and the spring arrangement has a force constant of 4.8×10^6 N m^{-1}.

Show that the natural frequency of the mass-spring system is about 0.6 Hz.

(3)

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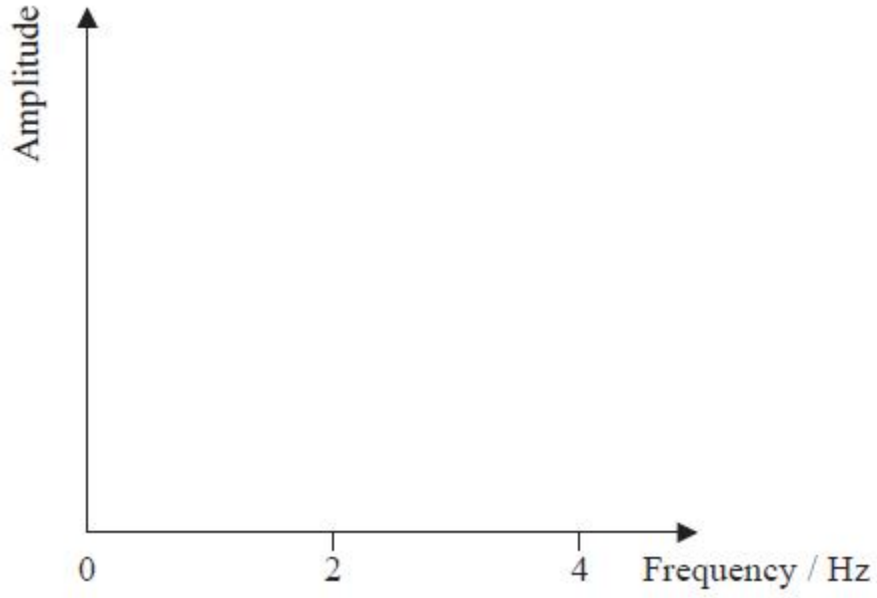
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(ii) Sketch a graph to show how the amplitude of oscillation of the mass would vary with the frequency of movement of the building. Ignore the effects of damping.

(3)

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(iii) In order to be effective the mass-spring system needs to be damped.
Explain what is meant by damping in this context and suggest why damping is a desirable feature of the mass-spring system in a tall building.

(3)

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(Total for question = 14 marks)

Q2.

A garden ornament consists of a plastic dragonfly mounted on a stick. The dragonfly's wings are attached to the body with springs, and they flutter up and down in a gentle breeze.



(a) When the air is not moving and the wings are displaced through a small vertical distance, they oscillate. The time for 10 oscillations is recorded. This is repeated twice more.

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Time / s		
t_1	t_2	t_3
6.2	6.6	6.9

(i) Calculate the frequency of oscillation of the wings

(3)

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Frequency = ...

(ii) The oscillation of the wings is thought to be simple harmonic motion.

State the conditions required for the oscillations to be simple harmonic.

(2)

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(b) The amplitude of the wings' oscillation dies down after only a small number of oscillations.

Explain why this happens

(2)

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(c) In certain breezy conditions the wings are seen to oscillate with a very large amplitude.

Name this effect and state the condition for it to occur.

(2)

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(Total for question = 9 marks)

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