Simple harmonic motion

Name & Set

1   A mass of 200 g is hung from a spring. As a consequence the length of the spring increases from 3.5 cm to 10.0 cm.

(i) Calculate the period of vibration of this system if the mass is pulled down 1.5 cm below its equilibrium position and then released?

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Calculate also

(ii) the maximum force acting on the mass as it oscillates

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2   What effect would the following changes have on the period of a mass spring system if each one were made independently while keeping everything else the same? Answers must be accompanied by explanations.

(i) the mass is quadrupled.

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(ii) if the length of the spring was doubled by adding a second identical spring in series with the first.

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(iii) if the system was transferred from the earth to the moon?

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3   When four people with a total mass of 350 kg sit in a car, it drops 2.5 cm closer to the ground. They get out and set the car oscillating in a vertical plane by pushing down on it in time with its oscillations. If it oscillates with a frequency of 2 Hz calculate a value for the mass of the car.

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4   Show that for a mass/spring system for which the stiffness of the spring is such that it extends a distance h when the mass is hung from it has the same period of oscillation as a simple pendulum which has a length that is equal to the static extension of the spring (i.e. =h)

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5   Two identical masses joined by a short length of string are hung from a spring as shown in the diagram. This causes the spring to extend by 5 cm. The system is set into vertical oscillations by cutting the string between the masses so that the lower one falls away. Calculate the frequency of the resulting oscillations.

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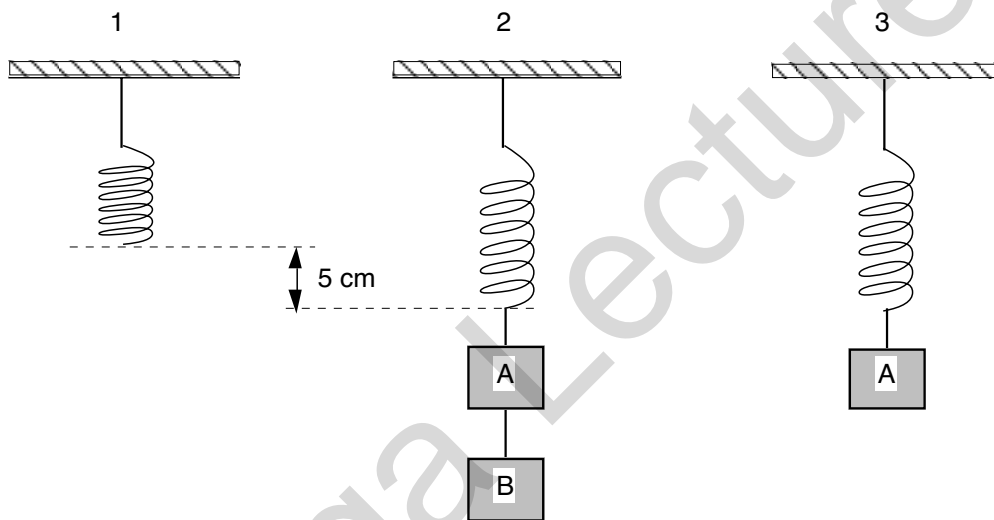
6   When a mass of 150 g is suspended from a particular spring it oscillates with a frequency of 3 Hz. When this mass is replaced by an object of unknown mass, it oscillates with a frequency of 1.2 Hz. What is the mass of this object?

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7   A simple pendulum of length 1 m swing with s.h.m. through a semi vertical angle of 5°. If the mass of the pendulum bob is 15 g

Calculate

(i) its period of oscillation

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(ii) the amplitude of the oscillation.

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(iii) the maximum acceleration of the bob

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8   What fraction of the total energy of an oscillator vibrating with s.h.m. is kinetic energy when its displacement is equal to half its amplitude?

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9   A mass of 300 g is attached to a spring of stiffness 25 Nm^{-1}. The mass is pulled down 15 cm and released.

Calculate

(i) its period of oscillation.

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(ii) the velocity of the mass at equilibrium

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(iii) the velocity of the mass when its displacement is 5 cm

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(iv) the total energy of the vibrating mass.

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10 A ball and chain is used in demolition work. The mass of the ball is 1500 kg and the chain is 10 m long. When in use, the maximum semi vertical angle of the chain is 10°.

Calculate

(i) the amplitude of the resulting swing.

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(ii) the period with which the ball and chain swings (assuming that it acts as a simple pendulum and that it oscillates with s.h.m.)

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(iii) the maximum velocity and kinetic energy of the ball.

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(iv) At what point of the swing should the ball strike the structure it is intended to demolish?

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11 What is the length of the simple pendulum that has a period of 1 second here on earth? What would the period of this pendulum be on the moon where the gravitational field strength is 1.6 Nkg^{-1}.

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12 By what factor should the length of a simple pendulum be changed to double its frequency?

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13   Which of the following are examples of s.h.m. and why

(i) Someone hopping along a road on a "pogo stick"

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(ii) The movement of a piston in a motor car engine.

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(iii) the vibrations of the cone of a loudspeaker.

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(iv) the oscillations of a bungy jumper when he has reached to bottom of the jump.

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(v) The movement of the tines of a tuning fork emitting a constant note.

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(vi) The blade of a jig saw in use.

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(vii) the motion of a badminton shuttlecock being struck back and forth over the net.

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(viii) the motion of a basketball being dribbled.

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(ix) the freely bouncing superball

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(x) a wave of the hand

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(xi) the motion of your leg when walking.

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14   A stiff metal plate is attached to a vibrator and oscillates with an amplitude of 15 mm.

Calculate

(i) the maximum acceleration and velocity of the plate when the vibrator oscillates with a frequency of 50 Hz.

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(ii) the frequency at which a small object resting freely on the plate is likely to detach itself from the plate. What will be the position and direction of motion of the plate when this occurs?

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15   Tarzan, mass 80 kg, swings through the jungle and across chasms on vines. If he steps off from point A how long does it take him to reach the other side (point B.)
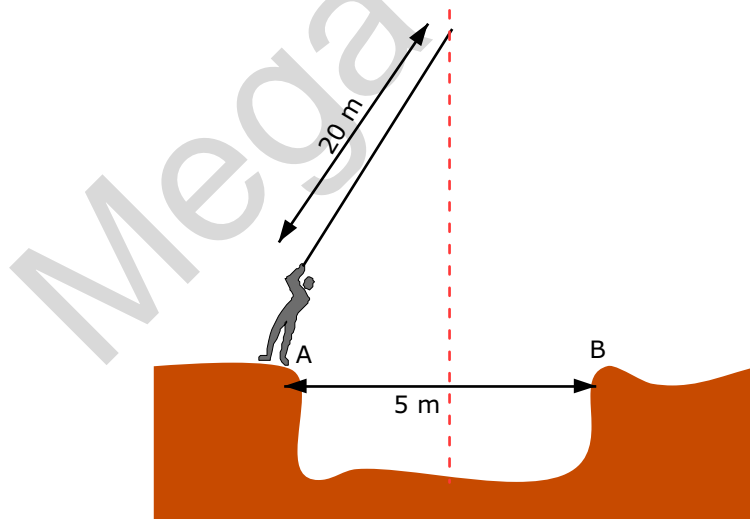
(i)   How long does it take Cheetah (his chimpanzee, mass 40 kg) to swing across the same chasm?

Assume that the vine is 20m long, that the chasm is 5 m. wide and that they both start from rest.

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16 Show that the formulas for the period of a simple pendulum and that for a mass-spring system are each homogeneous.

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