Essential Pre-Uni Physics F7.1

A Level

P P P

Part A Angular frequency

A mass on a spring oscillates 5 times in $4.2\,\mathrm{s}$. Calculate the angular frequency to 2 significant figures.

Part B Spring constant

Calculate the spring constant if the mass is $300\,\mathrm{g}$. Give your answer to 2 significant figures.

Physics. You work it out.

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Essential Pre-Uni Physics F7.2

A Level

P P P

You must give the correct units.

Calculate the maximum speed of an oscillator if its amplitude is $3.0\,\mathrm{cm}$ and its time period is $0.65\,\mathrm{s}$.

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STEM SMART Physics 34 - Oscillations

Physics. You work it out.

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Essential Pre-Uni Physics F7.4

A Level

P P P

A mass of $2.0\,\mathrm{kg}$ is suspended from a spring with constant $24\,\mathrm{N\,m^{-1}}$. Calculate the time period of the oscillation.

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Essential Pre-Uni Physics F7.6

A Level

You must give the correct unit for each answer.

Part A Maximum speed

A man jumps off a bridge attached to a bungee. The time period of the oscillation is $4.7\,\mathrm{s}$, and its amplitude is $6.2\,\mathrm{m}$. Calculate the maximum speed of the man as he goes up and down.

Part B Maximum resultant force

The man has a mass of $85\,\mathrm{kg}$. Calculate the maximum resultant force acting on him during the motion.

Part C Spring constant

Calculate the 'spring constant' of the bungee rope using the information given.

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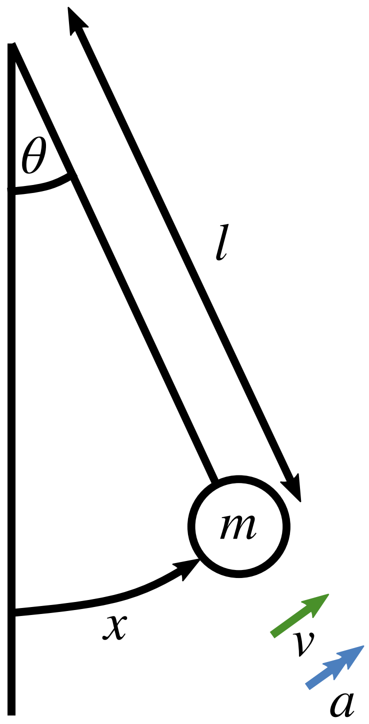
Simple Pendulum 20.1

A Level



A simple pendulum.

Quantities:

θ angular displacement (rad)
ω angular frequency $(\mathrm{rad\,s^{-1}})$
f frequency $(\mathrm{s^{-1}})$
x displacement (m)
v velocity $(\mathrm{m\,s^{-1}})$

T period (s)
a linear acceleration $(\mathrm{m\,s^{-2}})$
m mass (kg)
l length (m)
g acceleration due to gravity $(\mathrm{m\,s^{-2}})$

Equations:

$$T = \frac{2\pi}{\omega} \qquad \omega = \sqrt{\frac{g}{l}} \qquad a = -\omega^2 x \qquad f = \frac{1}{T} \qquad \omega = 2\pi f$$

$\sin\theta \approx \theta$ for small θ if θ is in radians.

Use the pendulum diagram provided to

Part A x in terms of l and θ

Write down an expression for the arc length (distance) x of the mass m from the vertical in terms of l and θ in radians.

The following symbols may be useful: `cos(), l, sin(), tan(), theta, x`

Part B Distance travelled

Calculate the distance the bob travels if it moves through an angle of 60° and the pendulum string has a length of $30\,\mathrm{cm}$.

Part C Resultant force

Write down the **magnitude** of the resultant force that acts perpendicular to the string on mass m.

The following symbols may be useful: `cos(), g, l, m, sin(), tan(), theta, x`

Part D Linear acceleration

Use your result from part C with Newton's Second Law derive an expression for the linear acceleration, a of the bob in terms of g and θ, taking care with the direction of the resultant force perpendicular to the string and the direction of positive acceleration shown on the diagram.

The following symbols may be useful: `a, cos(), g, sin(), tan(), theta`

Part E Simplify!

Use the small angle approximation for $\sin\theta$ to simplify your expression for a found in part D.

The following symbols may be useful: `a, g, theta`

Part F Linear acceleration in terms of g, l, x

By combining your result from part E with your answer for question A rewrite the linear acceleration a in terms of g, l and x.

The following symbols may be useful: `a, g, l, x`

Part G $\omega^2 = g/l$

Finally compare your answer from part F with the Simple Harmonic Motion equation for acceleration in terms of displacement, $a = -\omega^2 x$ to show that $\omega^2 = g/l$.

Gameboard:

STEM SMART Physics 34 - Oscillations

Simple Pendulum 20.3

A Level

P P P

A simple pendulum is made of a light string of length $l = 25\,\mathrm{cm}$ with a bob of mass $m = 30\,\mathrm{g}$ and is stationed on the Moon (Acceleration due to gravity $g_\mathrm{m} = 1.63\,\mathrm{m\,s^{-2}}$).

Part A Time period

What is the time period t_p for this pendulum?

Part B Oscillations in $1\,\mathrm{min}$

How many whole oscillations does the pendulum make in $1\,\mathrm{min}$?

Part C Angular frequency

Calculate the angular frequency ω of this pendulum using l and g and show that it is numerically equal to $2\pi f$, where f is the frequency.

Part D Doubling mass

What would the value of t_p and ω be if we doubled the mass of the bob to $2m$?

What is the value of t_p?

What is the value of ω?

Gameboard:

STEM SMART Physics 34 - Oscillations

Physics. You work it out.

Simple Pendulum 20.4

A Level

In a lecture demonstration three pendulums are set in motion. The first has a length l, the second has a length $4l$ and the third has a length $9l$.

If they all begin at the same amplitude and at the same time, how many whole swings will the first pendulum have completed after the initial drop when all three pendulums are instantaneously back in sync?

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Essential Pre-Uni Physics F7.5

A Level

The height of the water on a beach can be approximated as simple harmonic motion with a period of $12\,\mathrm{hours}$. If the mean water height is $3.5\,\mathrm{m}$, the amplitude of the tide is $1.6\,\mathrm{m}$, and 'high water' occurs at 7am one day, what would you predict the height of the water to be at 11am?

Gameboard:

STEM SMART Physics 34 - Oscillations

Gravtube

A Level

Imagine a tube had been drilled straight through the centre of a uniform spherical planet. The planet has a radius R, and the acceleration due to gravity at its surface is g. An object of mass m is released from rest at one end of the tube. From Gauss's Law, the gravitational force on an object of mass m inside a uniform massive spherical body (in this case, a planet), is given by $F = -\frac{GMm}{r^2}$ where r is the distance of the small mass from the centre of the planet and M is the mass of the planet that exists inside a sphere of radius r (i.e. all the mass of the planet that is closer to the planet's centre than the mass m). The force is negative as it acts inwards, towards the point $r = 0$.

Show that the acceleration of an object inside this tube is of the form $a = -\omega^2 r$ and so the object moves with simple harmonic motion.

Part A Time period of oscillations

What is the time period of the resulting oscillation if $g = 6.00\,\mathrm{m\,s^{-2}}$, and $R = 1200\,\mathrm{km}$?

Part B Comparing time periods

A satellite is placed in a circular orbit around the same planet, so that it is orbiting just above the ground (i.e. at a radius R). The centripetal acceleration of an object of mass m, in a circular orbit at a radius r, is given by $a_c = \omega^2 r$, where ω is the angular velocity of the mass in orbit.

Find an expression for ω and calculate the time period of the orbit at this radius?

Gameboard:
STEM SMART Physics 34 - Oscillations

SHM Perpendicular to a Spring

A Level

A small mass m is supported by a smooth table and connected by two light horizontal springs to two fixed walls. Each spring is of natural length L and has a spring constant k. The walls are a distance $4L$ apart and face each other. At equilibrium the two springs and the mass form a straight line.

Part A Angular frequency

What is the angular frequency of oscillations of the mass in the direction along the axis of the springs if $k = 40\,\mathrm{N\,m^{-1}}$ and $m = 0.50\,\mathrm{kg}$.

Part B Size of restoring force

The mass is given a small displacement y (such that y << L) at right angles to the line of the the springs at equilibrium. It has no displacement in the direction that the springs lie along at equilibrium.

What is the size of the restoring force at a displacement of $y = 2.0\,\mathrm{cm}$ using the values from the previous question.

Part C Comparison of time periods

By what factor is the time period for a small oscillation in the direction at right angles larger than that along the line of the springs. Please give your answer to 3.s.f.