# CAIE Physics A-level

## 17 - Oscillations

### Flashcards

What is simple harmonic motion?

# What is simple harmonic motion?

The periodic, oscillatory motion of a body, where the restoring force, acting on the moving body, is proportional to its displacement from the equilibrium position. This force opposes the direction of displacement.

$$F = -kx$$

What conditions are required for SHM to take place?

# What conditions are required for SHM to take place?

- Acceleration (and force) must be proportional to displacement from the equilibrium position.
- The acceleration must act towards the equilibrium point.
- $a \propto -x$

Considering an oscillating spring, give the definitions of the following:

Displacement

Amplitude

Period

Frequency

Considering an oscillating spring, give the definitions of the following:

- Displacement - (directional) distance from the equilibrium position (vector).
- Amplitude - maximum displacement of an oscillating system from the equilibrium position.
- Period - time taken for a complete oscillation.
- Frequency - number of oscillations per second.

State the equation relating angular frequency and time period.

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$$f = 1/T$$

Where f = frequency, T = time period

What is angular frequency?

What is angular frequency?

Angular frequency is a metric that describes the speed of oscillation, by comparing the distance travelled in a single oscillation to the circumference of a circle.

State the equation relating angular frequency and time period.

State the equation relating angular frequency and time period.

$$\omega = 2\pi/T$$

Where $\omega$ = angular frequency, T = time period

What are the two classic examples of systems that undergo SHM?

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1. A mass spring system.
2. A pendulum.

What does it mean to say that two springs, oscillating adjacent to one another, have a constant phase difference.

What does it mean to say that two springs, oscillating adjacent to one another, have a constant phase difference.

This means that the springs have the same period but are at different stages in their oscillatory cycle, at any one point in time. This angular ‘phase difference’ can be calculated. It is usually expressed in radians.

What is the constant of proportionality linking acceleration and displacement?

What is the constant of proportionality linking acceleration and displacement?

$-\omega^2$

True or false? Velocity is a maximum when displacement is maximum.

True or false? Velocity is maximum when displacement is maximum.

False.

The velocity is a minimum at the maximum displacement (amplitude) of oscillation.

Velocity is at a maximum when the oscillating body passes through the equilibrium position.

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How can you calculate the maximum speed using $\omega$ and A?

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$$V_{max} = \omega A$$

State equations for x, v, a in terms of trig functions and A, $\omega$ and t.

# State equations for x, v, a in terms of trig functions and A, $\omega$ and t.

Note that displacement can be described by both sin and cos functions, depending on where oscillation is considered to start from. Therefore both of the following systems of equations are valid.

1. $x = x_0\cos\omega t$, $v = -v_0\omega\sin\omega t$, $a = -a_0\omega^2\cos\omega t$
2. $x = x_0\sin\omega t$, $v = v_0\omega\cos\omega t$, $a = -a_0\omega^2\sin\omega t$

State the equation for ‘v’ in terms of displacement and angular velocity only.

State the equation for 'v' in terms of displacement and angular velocity only.

$$v = \mp\omega\sqrt{(x_0^2 - x^2)}$$

State the equations for T for an oscillating spring and for a simple pendulum.

State the equations for T for an oscillating spring and for a simple pendulum.

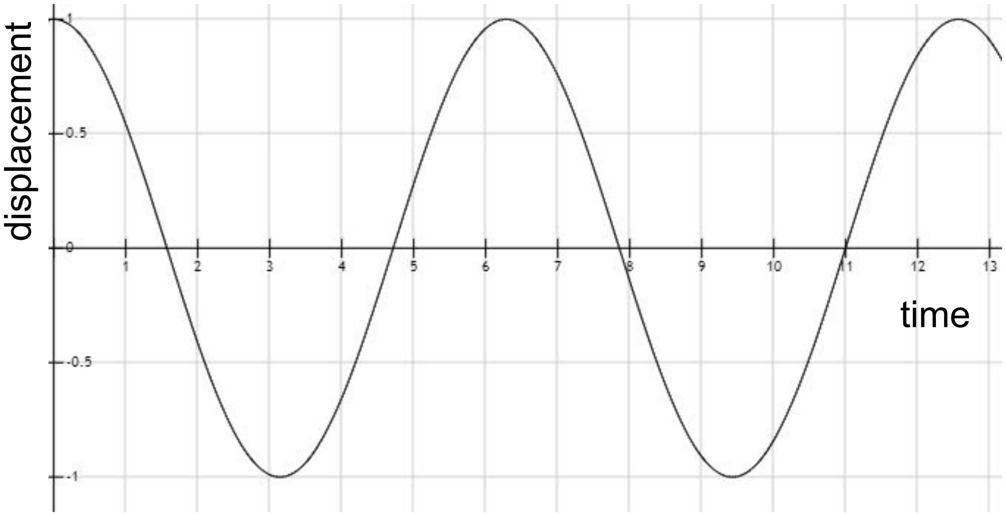
Spring

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

Pendulum

$$T = 2\pi\sqrt{\frac{l}{g}}$$

# If the following graph shows displacement against time, what would the velocity-time graph look like?



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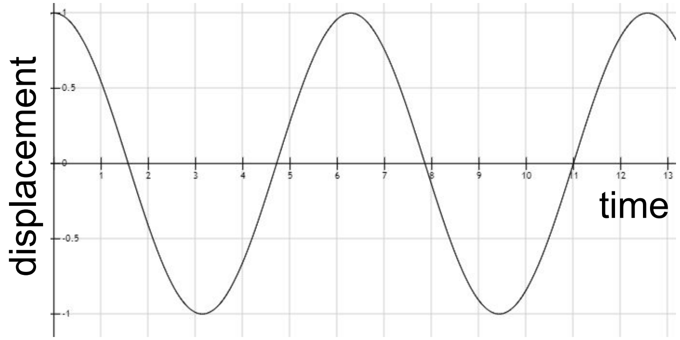
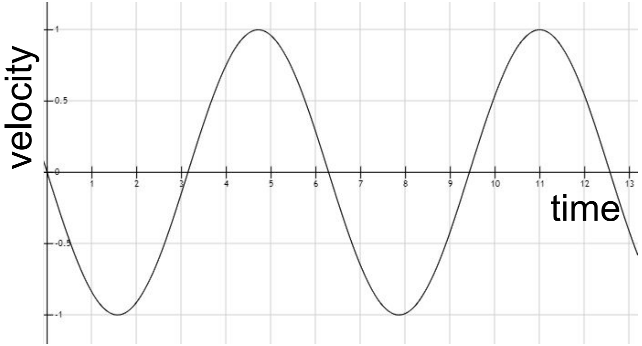
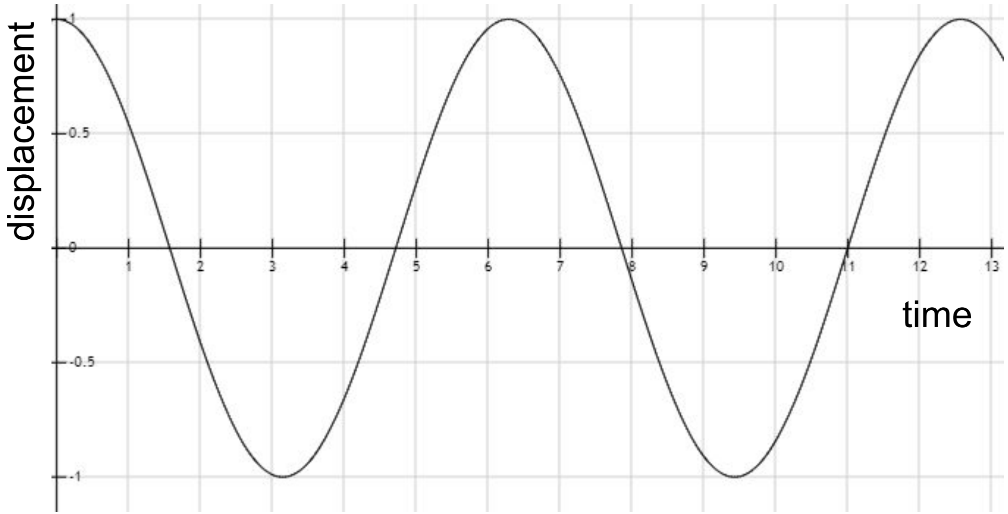


# If the following graph shows displacement against time, what would the acceleration-time graph look like?



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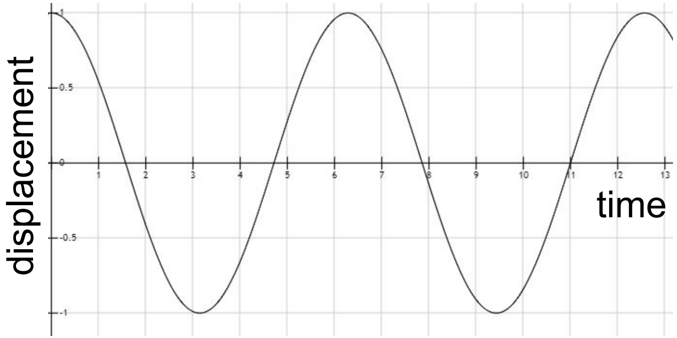


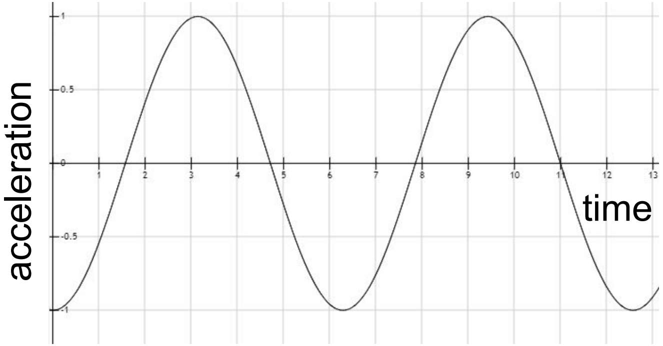

At what points in the oscillation does the system possess maximum kinetic energy, and at which points does it possess its maximum potential energy.

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The system stores its energy entirely as kinetic energy, at the point of maximum velocity i.e. at the equilibrium position.

It stores its energy entirely as potential energy at the points of zero velocity, maximum displacement and maximum acceleration.

Draw the graph for potential energy and kinetic energy against displacement for a SHM system.

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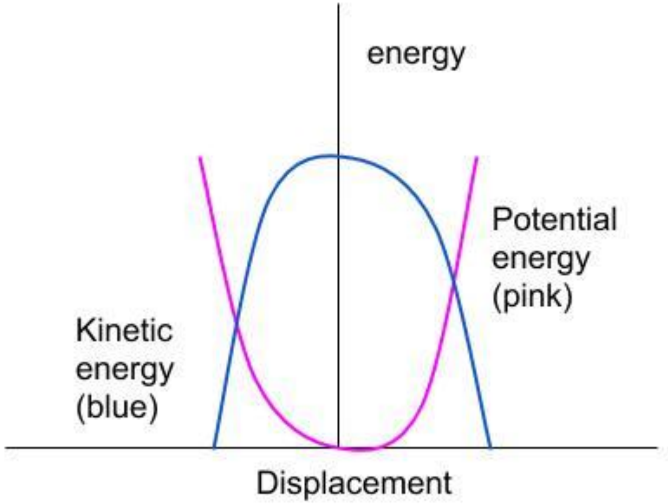

Give an equation that describes the total energy in a system undergoing SHM.

Give an equation that describes the total energy in a system undergoing SHM.

$$E = \frac{1}{2} m\omega^2 x_0^2$$

What is damping?

# What is damping?

Damping is the process by which the amplitude of the oscillations decreases over time. This is due to energy loss as a result of forces that resist motion, such as drag or friction.

Explain the difference between light damping, heavy damping and critical damping.

## Explain the difference between light damping, heavy damping and critical damping.

Light damping occurs naturally (e.g. pendulum oscillating in air), and the amplitude decreases exponentially. When heavy damping occurs (e.g. pendulum oscillating in water) the amplitude decreases much faster than in a lighly damped system. In critical damping (e.g. pendulum oscillating in treacle) the object stops before one oscillation is completed.

Draw displacement-time graphs of a lightly damped, heavily damped and critically damped oscillating spring.

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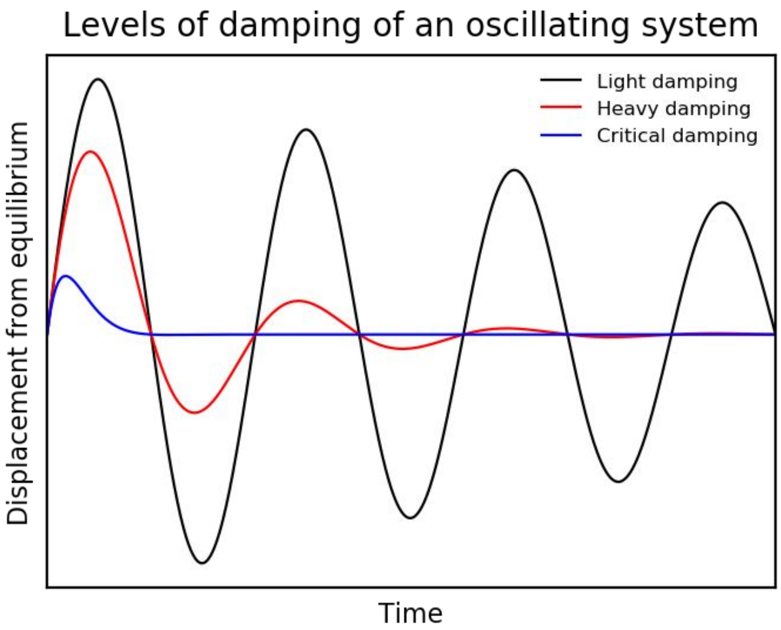

What is the difference between free and forced oscillations?

# What is the difference between free and forced oscillations?

When an object oscillates without any external forces being applied, it oscillates at its natural frequency. This is known as free oscillation. Forced oscillation occurs when a periodic driving force is applied to an object, which causes it to oscillate at a particular frequency.

What is resonance?

# What is resonance?

When the driving frequency of the external force applied to an object is the same as the natural frequency of the object, resonance occurs. Resonance involves a rapid increase in the amplitude of oscillation. If the system is not damped, the amplitude will continue to increase until the system fails.

Describe an experimental technique to investigate the resonance of an object.

# Describe an experimental technique to investigate the resonance of an object.

Suspend a mass between 2 springs attached to an oscillator.

Place a millimetre ruler parallel to the spring-mass system to measure the mass's amplitude. Increase the driving frequency from 0 so the mass oscillates with increasing amplitude until the driver frequency reaches the natural frequency of the system (max amplitude as resonance), the amplitude of oscillation will decrease again as frequency is increased. The air will damp the system.

To increase accuracy, the system can be filmed and the amplitude value recorded from video stills.