WJEC A-Level Physics

3.2 Vibrations

Flashcards

What is simple harmonic motion?

What is simple harmonic system?

Simple harmonic motion (SHM) is a type of motion defined by a simple rule. In words, the acceleration of the body is directly proportional to and in the opposite direction to its displacement from an equilibrium point.

Mathematically, we have:

$$a = -\omega^2 x$$

The negative sign shows the opposite direction.

What is the equation for the time period of a mass - spring simple harmonic system?

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$$T = 2\pi\sqrt{(m/k)}$$

m: kg

k: Nm^{-1}

T: s

What is the equation for the time period of a simple harmonic pendulum?

What is the equation for the time period of a simple harmonic pendulum?

$$T = 2\pi\sqrt{(l/g)}$$

g: ms^{-2}

l: m

T: s

Draw and explain a graph for the variation of acceleration with displacement during simple harmonic motion.

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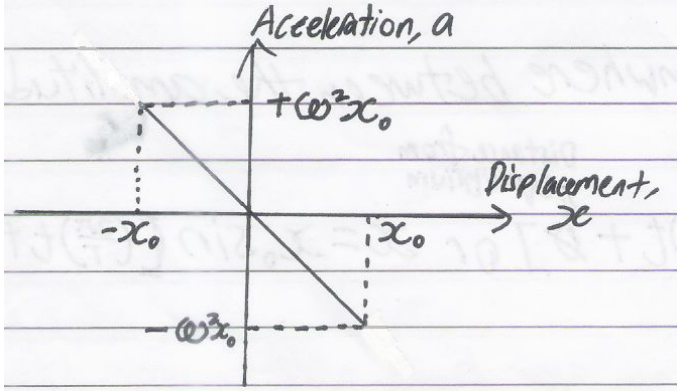

https://www.miniphysics.com/simple-harmonic-motion.html

The graph shows us the definitions of SHM. We have a straight line through the origin meaning the acceleration is directly proportional to the displacement. For all positive values of displacement, the acceleration is negative and vice versa, hence the acceleration is always in the opposite direction to the displacement.

What is the solution to the SHM equation?
What is the velocity?

What is the solution to the SHM equation? What is the velocity?

$$x = A\cos(\omega t + \varepsilon)$$

$$v = -A\omega\sin(\omega t + \varepsilon)$$

What is the frequency?

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Frequency is the number of oscillations a body makes per unit time (usually the second) and is given the symbol f.

What is the time period?

What is the time period?

The time period is the time that is taken for the body to make one oscillation and is given the symbol T. The relationship between frequency and period is simple. If the body makes f oscillations within one second then the time taken to complete each one is 1/f.

What is the amplitude?

What is the amplitude?

Amplitude is the maximum displacement from equilibrium that an object reaches. It is given the symbol A.

What is phase?

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Phase is the part that is added in the cos(ε) to make sure the mathematical description aligns with the physical situation. For example, if the body starts at its amplitude then ε = 0 but if the body starts at equilibrium then ε = pi/2 (as cos pi/2 =0).

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

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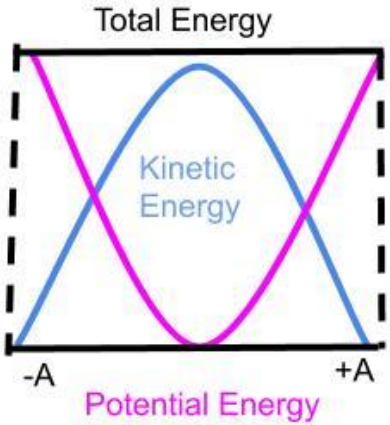

Using energy conservation, derive a formula for the velocity.

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In a mass-spring system, the kinetic energy is given by $1/2mv^2$. The potential energy is called elastic potential energy and it is stored in the spring when extended. When the spring is extended by x, the elastic potential energy is $1/2kx^2$ where k is the stiffness. Since the total energy must be the same we can say:

$$\frac{1}{2} kA^2 = \frac{1}{2} mv^2 + \frac{1}{2} kx^2$$

$$v^2 = k/m(A^2-x^2)$$

$$v = \pm\omega \sqrt{A^2 - x^2}$$

Define free vibrations.

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Free vibrations are oscillations that occur without an additional driving force. The frequency a system tends to vibrate at in a free vibration is called the natural frequency.

Define forced vibrations.

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A driving force causes the system to vibrate at a different frequency. For higher driving frequencies, the phase difference between the driver and the oscillations rises to π radians. For lower frequencies, the oscillations are in phase with the driving force. When resonance occurs, which is when it most efficiently transfers energy to the system, the phase difference will be π/2 radians.

Define damping and explain what critical damping, overdamping and underdamping are.

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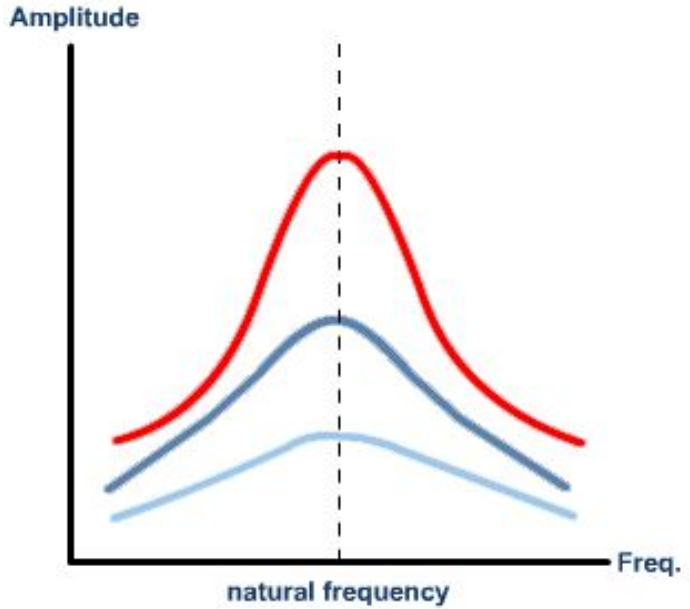
Damping occurs when an opposing force dissipates energy to the surroundings.
Critical damping reduces the amplitude to zero in the quickest time.
Overdamping is when the damping force is too strong and it returns to equilibrium slowly without oscillation.
Underdamping is when the damping force is too weak and it oscillates with an exponentially decreasing amplitude.

What happens to a vibration when damping is increased?

What happens to a vibration when damping is increased?

For a vibration with greater damping, the amplitude is lower at all frequencies due to greater energy losses from the system. The resonant peak is also broader because of the damping.



What are some uses and implications of resonance in real life?

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Uses include circuit tuning, microwave cooking etc.

Implications of resonance include that soldiers must break stop when crossing bridges and vehicles must be designed so there are no unwanted vibrations.