Physics Society - Waves (Part 1)

Aditya C

November 2025

1 Introduction

Waves show up everywhere. From water waves, to sound, to light, and, since the 1920s, we have realised that **all matter particles** exhibit wave nature. It is imperative that we understand waves to progress to a better understanding of physics. There are some key components of waves that we should be aware of. First recapping the fundamentals, waves have an **amplitude, frequency, wavelength, speed and time period**.

Question 1 Recall the definitions of these wave properties and label them on a diagram.

Sinusoidal waves are comprised of sine and cosine functions. Mathematically speaking, waves in two dimensions can be considered as **functions** of x-position and time, like so:

$$y(x,t) = A\sin(kx \pm \omega t) + B\cos(kx \pm \omega t)$$

Usually, we will only deal with either a sine or a cosine, so in the case of a sine wave, the equation reduces to:

$$y(x,t) = A\sin(kx \pm \omega t)$$

Where $k = \frac{2\pi}{\lambda}$ and $\omega = 2\pi f$

Question 2 From the sinusoidal wave equation above, derive the wave speed, v, in terms of k and ω.

We can observe wave interference when two waves combine. We can add a phase difference term into the wave equation:

$$y(x,t) = A\sin(kx \pm \omega t + \phi)$$

What happens if we add two waves together? Their equations will add to give a new wave!

Question 3 If two waves have the same amplitude and frequency, and have a phase difference of $\pi/2$, derive an expression for the combined wave using trigonometric angle addition formulae. Sketch this new function.

2 Extension

If you wish, you can take a look at the actual **wave equation**:

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

Confirm that the first sinusoidal wave equation is a solution to this classical wave partial differential equation by substituting for y.

As per usual, check out Isaac Science or the BPhO website for further resources.

The Schrödinger equation was derived from the classical wave equation. There is an excellent video by Welch Labs on YouTube about how this was done.

Before watching the video, try and think what substitutions can be made to get the classical wave equation into the form of the Schrödinger equation. Then watch the video to find out!

Thank you for coming!