Lecture 1

Wave Phenomena

There are three types of wave that we are interested in:

1. Mechanical Waves: waves on a string, waves in an organ pipe, waves on a rod, seismic waves, gravity waves
2. Electrical / Magnetic Waves:
   (a) In a material: alternating current of electrons (mains electricity), "spin waves" in magnetism
   (b) In free space (vacuum); propagation of electromagnetic waves; no disturbance of any material; light. Electromagnetic waves can travel through materials, e.g. glass, water.
3. Matter Waves (de Broglie Waves)
   (a) Important for microscopic objects, e.g. electrons, neutrons.

$$\text{wavelength} = \lambda = \frac{h}{p}$$

   where h is the Planck Constant, and p is the momentum
   $\rightarrow$ wave-particle duality
   $\rightarrow$ foundation of quantum physics

Concepts and Definitions

The Waveform

In general, we have:

$$u(t) = f(x \pm ct)$$

where u is the displacement caused by the wave, c is the speed of the wave, a minus sign indicates a **right-travelling** wave, and a plus sign indicates a **left-travelling** wave.

Consider a sinusoidal wave:

$$u(t) = A\sin(kx - \omega t)$$

where A is the amplitude of the wave, k is the wavenumber $= \frac{2\pi}{\lambda}$, ω is the angular frequency $= 2\pi f$. The speed of the wave, v, is given by $\frac{\omega}{k}$, which is also called the **phase velocity**. We also define the **group velocity**, $v_g = \frac{\partial\omega}{\partial k}$.

For a light string, $v = \sqrt{\frac{T}{\mu}}$, where T is the string tension, and μ is the mass per unit length.