

# Amplitude, Wavelength, Period, and Frequency

Imagine that the dots moving up and down are creating the waves that are travelling to the right (as we'll see later, this is kind of like how radio waves are created). Here are a few things to notice:

1. The Blue wave is twice as "tall" as the green wave.
2. Both waves are travelling to the right at the same speed.
3. The Blue dot is moving up and down three times as fast as the green dot.
4. The Blue wave is three times as compressed as the green wave.

To quantify these observations more precisely, let's look at a snapshot of both waves frozen in time.



- the *amplitude* is the **vertical** height from the centre of the wave to its highest (or lowest) point. The blue wave has an amplitude of 2 and the green wave has an amplitude of 1.
- the *wavelength* is the **horizontal** distance of one full cycle. The blue wave has a wavelength of 2m and the green wave has a wavelength of 6m.

All EM waves (radio, light, etc) in vacuum travel at the speed, which is roughly 300,000 metres per second. Now, let's take a snapshot of the two waves

Look at the following two waves. How are they different?



At first sight:

1. the first one is "taller" than the second one. That is, it goes up and down higher and lower.
2. the first one is also "longer" than the second one. That is, it stretches sideways more. It's not as "tight".

These two observations can be quantified very precisely as:

1. the *amplitude*: **vertical** height from the centre of the wave to its highest (or lowest) point.
2. the *period*: **horizontal** length of one complete cycle.



So the previous two waves have:

1. Amplitude = 2, Period = 0.05 ms
2. Amplitude = 1, Period = 0.02 ms



The amplitude is normally related to the strength of the signal (like the volume for sound).

Since the period ( $T$ ) is the amount of time it takes to complete one cycle, and the frequency ( $f$ ) is the number of cycles in one second, the period and the frequency are inverses of each other:

$$f = \frac{1}{T} \quad \Leftrightarrow \quad T = \frac{1}{f}$$

In this course, we'll see a few formulas and it'll be tempting to memorize them but let's instead understand what they really mean...

For example:

- if the period is half a second, we can fit 2 full cycles in one second.
- If the period is a quarter of a second, the frequency is 4.
- If the period is a tenth of a second, the frequency is 10.
- If the period is  $T$  seconds, the frequency is  $\frac{1}{T}$  (  $\frac{1}{0.5} = 2$ ,  $\frac{1}{0.25} = 4$ ,  $\frac{1}{0.1} = 10$  )


Right?

So for the previous two waves, the frequencies would be:

- $f = \frac{1}{0.05 \text{ ms}} = \frac{1}{0.00005 \text{ s}} = 20,000 \text{ Hz} = 20 \text{ kHz}$
- $f = \frac{1}{0.02 \text{ ms}} = \frac{1}{0.00002 \text{ s}} = 50,000 \text{ Hz} = 50 \text{ kHz}$

Recall that  $\text{Hz}$  means “cycle per seconds”. That's why when we divide a number of cycles by time, we get Hertz.

Let's now look at three different ways to encode a signal on a radio wave.

 **Fix Me!** : add  $f = \frac{c}{\lambda}$