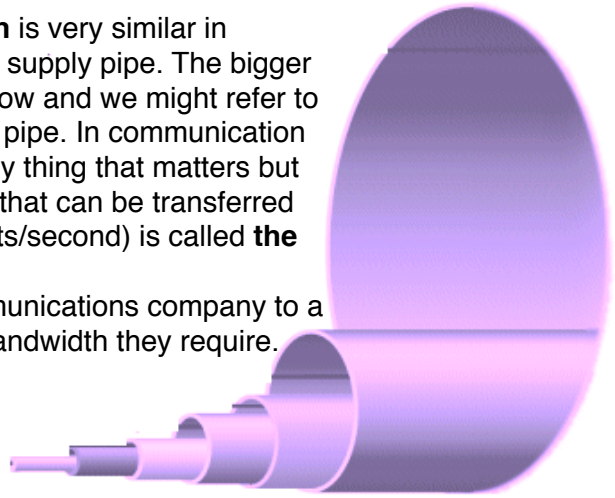
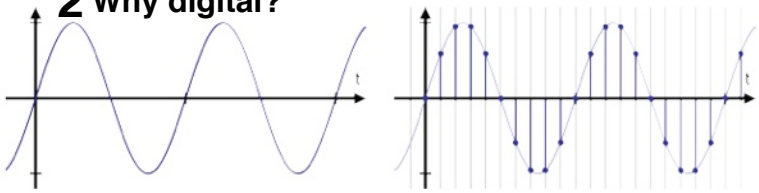
## 1 What is bandwidth?

In communications **bandwidth** is very similar in principle to the size of a water supply pipe. The bigger the pipe the more water can flow and we might refer to the cross sectional size of the pipe. In communication the physical size is not the only thing that matters but the maximum amount of data that can be transferred every second (measured in bits/second) is called **the bandwidth.**

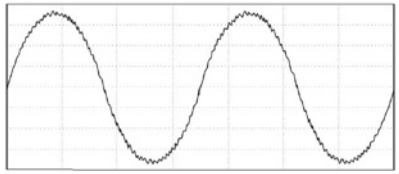
The charges made by a communications company to a customer are largely on the bandwidth they require.



## 2 Why digital?



When we digitize a signal we measure the analogue wave every small fraction of a second and send this measurement to the receiver as a number. That number is then converted back, the points are joined up and a wave is reconstructed. The disadvantage is that a wave can lose some of its detail when it is converted (see below). The big problem of an analogue signal is that it picks up noise. Instead of a sine wave looking nice and smooth it might look like this.



The digital signal is sent as a series of binary numbers and these suffer very little from noise.

**Digital Imaging and signaling 1**
**Bandwidth and sampling**
**The Fizzics Organization**
**www.fizzics.org**
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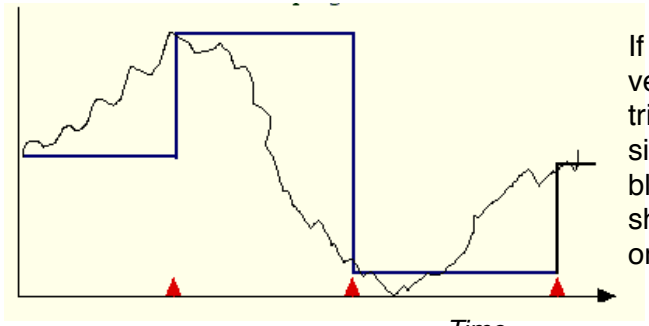
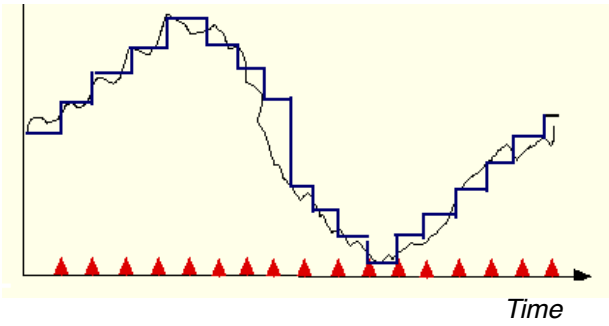
## 3
### Rate of sampling


If the samples are not taken very often (where the red triangles are) then when the signal is converted back (the blue line) it only very roughly shows the shape of the original signal.

## 4
### So, how often should samples be taken?

When samples are taken more often, as shown here, the conversion from the digitized signal is much nearer the shape of the original wave.
The greater the sampling rate the better the quality of the signal **but** that needs more information to be sent every second requiring a greater bandwidth and costing more.




How often sampling is done therefore depends on the quality needed. For example sampling on a telephone landline is only 8000 times per second, that is OK for voices although they do sound a little distorted.

Music, such as that stored on audio CDs is sampled at 44,000 times per second.

The **minimum sample rate** to reproduce a recognizable signal is generally taken as **equal to or greater than twice the maximum frequency** of the original signal.
**The bandwidth used** = samples per second x bits per sample