



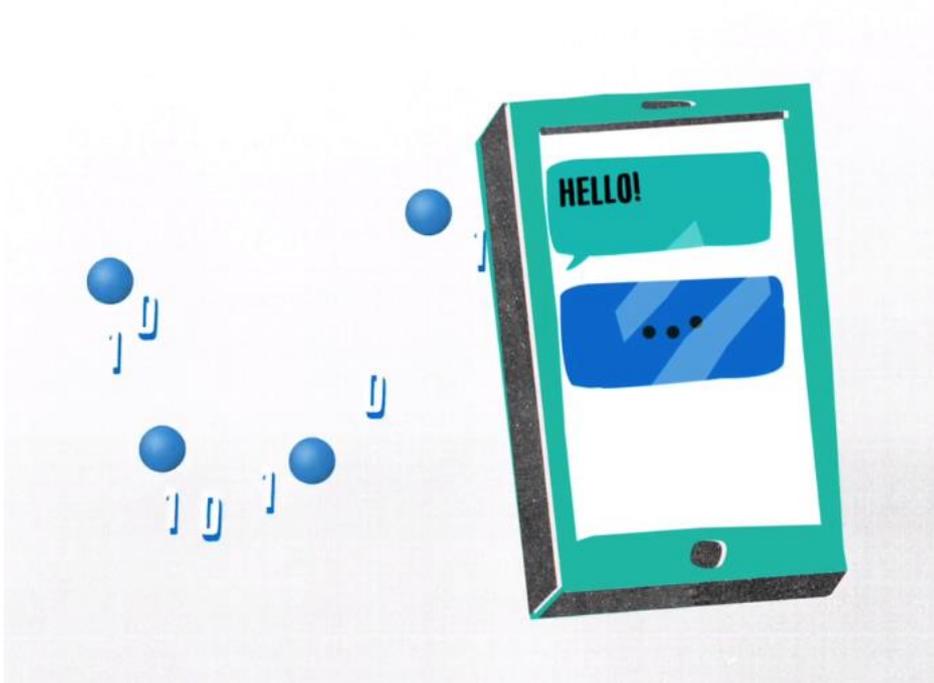
Key Stage 4 – Let's Get Digital

Notes for teachers

At a glance

Much of our modern life involves receiving and transmitting data; watching TV, posting on social media, sending emails etc. Although we might want to receive something complicated like sound and moving images, in order to process and send the information it is first converted into a set of numbers. The numbers are stored and processed on the computer as binary code which consists of only two options, usually written as 1 and 0. This is often referred to as binary or digital.

This lesson looks at how sound can be encoded into digital form.



Learning Outcomes

- Sound waves can be represented visually on an oscilloscope or similar.
- How amplitude and wavelength are related to volume and pitch.
- To store and process sound, computers have to convert analogue signals such as sound waves into numbers (digital).

Each student will need

- A copy of the student worksheet
- (OPTIONAL) Mobile device with oscilloscope app



Possible Lesson Activities

1. Starter activity

- Watch the Oxford Sparks ‘What are quantum rainbows?’ animation (see weblinks).
- Ask students to come up with as many types of information that is sent using phones, internet cables, satellites, etc. Ideally you want them to come up with things like pictures, text, sound, music, etc. Many of these feature in the very first part of the animation.
- Point out that in order to store or process information (pictures, sound, text, etc.) the computer has to convert them into numbers. These are then further processed into binary numbers (ones and zeroes/on and off). This is also mentioned in the video.

2. Main activity: Sound Waves

- Use an oscilloscope to look at different sounds – speech, a short section of a song, someone trying to sing/whistle a steady note, musical instrument, tuning fork, etc. There is a link to an online oscilloscope in the weblinks section (requires a microphone). There are also several free phone/tablet apps that do similar things.
- Get students to explore the effect that making the sounds louder has on the signal (increasing the amplitude). If you have a signal generator or a musical instrument explore the effect that frequency/pitch has on the wave form as well (high pitch waves: closer together. Low pitch: further apart). This can also be seen by signing high/low notes (but it is harder to produce regular looking waves).
- Get students to work through section 1 of the student worksheet. This introduces/reminds them of the definitions of wavelength and amplitude.
- Students are likely to be familiar with the terms high-pitched and low-pitched when applied to sound. Point out that for sound waves the pitch of the sound is determined by its frequency.
- OPTIONAL This is an opportunity to use the $c=f\lambda$ formula to show that for a wave travelling at constant speed if you decrease the wavelength you increase the frequency (pitch). This should match what they saw on the oscilloscope earlier.
- Answers to questions:
 - 1a) The second sound shown has the same amplitude, but a shorter wavelength than the first. This means it is higher-pitched/has a higher frequency but the volume level is the same.
 - 1b) The second sound shown has the same wavelength but a bigger amplitude than the first. So the sound is louder but has the same pitch/frequency.
- Sound Waves are an example of **analogue** data. Analogue data is continuous. However, to store or process data we need to find a way to represent it numerically.

3. Main activity: Sampling

- Get students to read section 2 of the student worksheet.
- In a computer the numbers generated from sampling would then also be converted to binary format.
- Get students to consider what would happen if the data was sampled at 1,3,5,7 instead of 0,1,2,3,4,5,6,7. For instance the information about the peak at 2 would be lost when trying to recreate the sound later from the numbers.



- For the questions at the end of this section they need to draw a made up sound wave (basically a wavy line) and create a table of values. They then plot a partner's values to try to recreate their partner's original sound wave (and compare the two).
- OPTIONAL In addition to losing information about the pitch of a sound wave by using sampling, amplitude information is also lost in a similar way. When recording the values for amplitude they are allocated to a band that includes a range of values rather than a specific one. This would be equivalent to saying that when creating a table from the wave on the student's worksheet, they could only use values for the amplitude of -4,-3,-2,-1,0,1,2,3,4 and nothing in between. So for instance an amplitude encoded as 2 could have been any amplitude from 1.5 to 2.49 on the original wave. The number of different available values for amplitude is known as the **bit depth**. If there were 16 possible amplitude levels this would be a bit depth of 4 as you could store the information in 4-bits (0000->1111 in binary) each corresponding to a different amplitude range.

4. Plenary

- Get students to think about the question posed at the end of section 3.
- When we listen to music it generally has a rich mix of high and low frequency sounds. If you consider the two sound waves in 1a) of the student worksheet, the second picture (higher frequency) would need more sampling points to accurately recreate the sound, than the first picture. So if you sample a sound at a lower rate you 'lose' the higher frequency sounds. Increasing the sampling rate means that more of the high frequency/high pitched sounds can be heard. Speech is generally lower pitched than music and although speech does contain higher frequencies, we can still understand it, even with the higher frequencies removed. We are also used to sound quality on phones being lower than in real life so land lines continue to use low sampling rates.
- (OPTIONAL) Between telephone exchanges several phone calls will 'share' the same fibre optic cable. If you have a low sampling rate then you can send more of them together at the same time as they take up less space (bandwidth).

Weblinks

- Online oscilloscope <https://academo.org/demos/virtual-oscilloscope/>
- Oxford Sparks 'What are quantum rainbows?' animation: <https://www.oxfordsparks.ox.ac.uk/content/what-are-quantum-rainbows>
- Oxford Sparks 'What is machine learning?' resources. This includes resources on converting pictures into numerical values: <https://www.oxfordsparks.ox.ac.uk/content/teaching-resources>