3.3.7 Representing sound

Lesson plan and printable activities

Materials needed

1. 3.3.7 Lesson PowerPoint.
2. Numerical conversion tests (Quiz 1, Quiz 2).
3. Live internet connection for research purposes.

Lesson aims

1. To get students to think about how natural (analogue) sound was historically captured in pre-computer technology days.
2. Explain the differences between storing data using analogue recording methods and using modern digital techniques.

Lesson objectives

1. Provide key dates when specific sound-capturing technologies were invented. (This is background information only and not a requirement of the specification.)
2. Describe the type of sound-capture media used at various points in history.
3. Explain the difference between analogue and digital sound capture giving definitions for what is meant by the terms analogue and digital data capture.
4. Be able to calculate sizes of capture files for specific data capture scenarios using the formula: File size (bits) = Sampling rate (Hz) x Resolution (bits) x Length of sample (seconds)

Starter activity (5 minutes)

1. Explain that this is the final instalment of the series regarding the conversion of naturally occurring data eg numbers, text, images etc. into a digital format.

   Explain that we are going to look at how sound is captured digitally. Try asking students who listen to music how many do this by download only rather than buying conventional media and calculate a class percentage – it is likely that almost all use only download methods. Ask them if they are aware of alternate means of storing recorded music and write these down for comparison with the main activity.

© 2016 AQA. Created by Teachit for AQA

Main activities (45 minutes)

1. You may wish to bring some alternate props if you have them eg CDs, DVDs, vinyl records, cassettes.

2. Go through the main presentation provided.

3. Don't show the props at first; instead get students to complete the first quiz working in pairs. Activity - Spend 10 minutes testing ability to do research and identify information of a specific nature using the resource Quiz 1. The students are asked questions ranging from straight copying of dates to some rather harder points to think about, they may need prompting with some of the answers hence the suggestion to use real-life media examples if you have them.

4. The activity is there to get students to look at traditional (and what were very popular at the time) mechanisms for storing music. Emphasise that all but the last one (CDs) are analogue capture formats. CDs effectively came in for audio use in the mid-1980s and found widespread use in computing several years later.

5. Move on to explain how it is that analogue and digital data differ – explain that to digitise a natural waveform, that compromises have to be made in order to keep file sizes down and that, in particular, a natural sound can never be fully captured to infinite depth using digitisation.

6. Explain how to do calculations using the required properties of sample frequency / bit-pattern. Spend 15 minutes testing ability to do calculate using the resource Quiz 2. There are harder questions included for more able students requiring the given formula to be rearranged and units calculated.

Plenary activity

1. Whilst the activities have shown the types of media and sizes of files captured, it is useful to end the session by drawing together the points raised into one last discussion topic. Remind students of a point made in one of the question sheets that in fact, sales of vinyl records are currently rising. Use this to prompt a discussion about why this might be. (This is introduced in section 3.7 of the specification.)

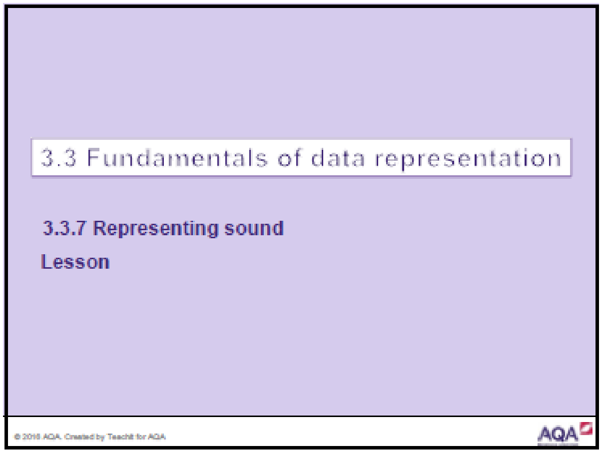
© 2016 AQA. Created by Teachit for AQA

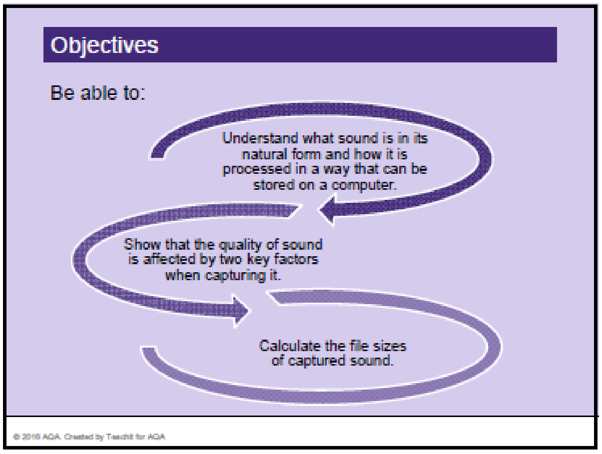
Media	Analogue / digital?	Advantages	Disadvantages
Vinyl record	Analogue	Richer sound loved by audiophiles. Packaging can be very attractive.	Bulky. Degrades if played too often. Can suffer from poor pressing quality.
Magnetic tape	Analogue (usually)	Relatively compact, players also portable. Could store up to 120 minutes of music.	Were seen as great at time of invention but prone to hissing and degradation.
Compact disc	Digital	Compact compared to vinyl. Durable.	Not easily portable.
Sound file eg MP3	Digital	Quick to download, easily stored – 'instant access'. No environmental damage for disposal.	Lack of packaging means they are impersonal in nature. Quality varies with format used.

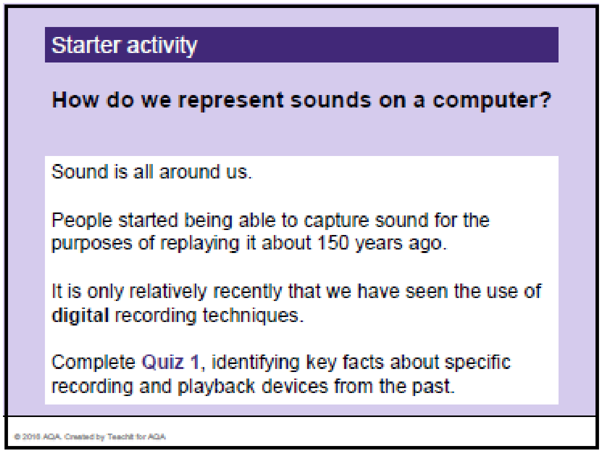
Ask students to consider: "Is digitisation always a good thing?"

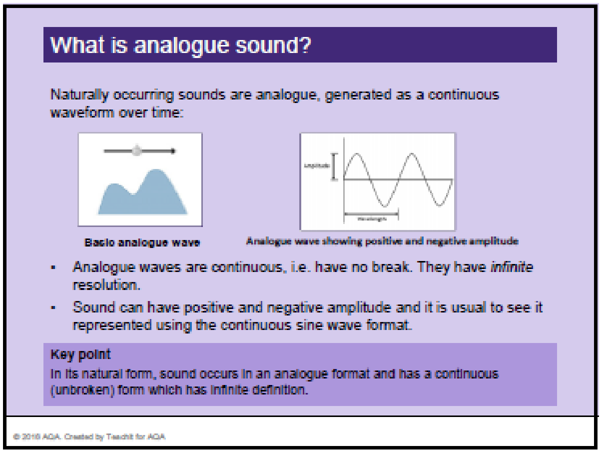
© 2016 AQA. Created by Teachit for AQA

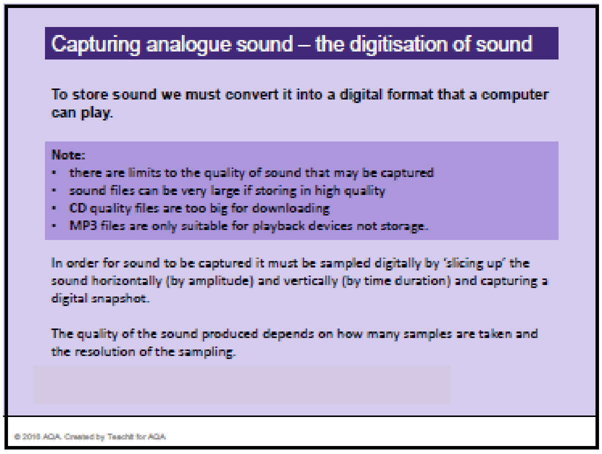
Lesson

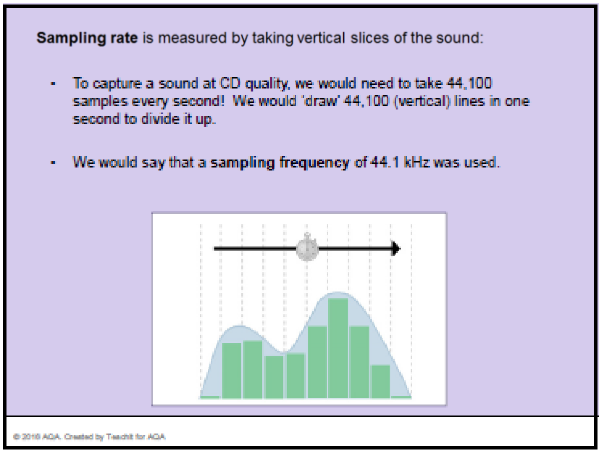








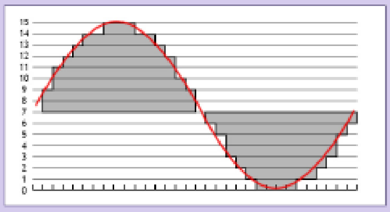




© 2016 AQA. Created by Teachit for AQA

Amplitude (sample resolution) is measured by taking horizontal slices of the sound:

As you can see here, it is divided into 16 slices and it is not that accurate.



© 2016 AQA. Created by Teachit for AQA

The resolution of the capture is determined by how many slices we take across the wave – we have got 16 here.

$2^4 = 16$ therefore 4 bits are enough to represent *every* possible level of this diagram.

Decimal value	Binary	Decimal value	Binary	Decimal value	Binary	Decimal value	Binary
0	0000	**4**	0100	**8**	1000	**12**	1100
1	0001	**5**	0101	**9**	1001	**13**	1101
2	0010	**6**	0110	**10**	1010	**14**	1110
3	0011	**7**	0111	**11**	1011	**15**	1111

If we use the CD as an example again, we would actually use a 16-bit sampling code, this would give not 16 possible levels but 65,536!

Key point
Digital sound is represented as discrete (single addressable) points captured by 'mapping out' an analogue sound wave – a binary value representing each point is stored in a recognised file format and reproduced by the digital media player used e.g. Windows Media Player.

© 2016 AQA. Created by Teachit for AQA

Determining the size of sound files

How do amplitude and frequency fit together to determine the overall size of captured sound files?

File size *(bits)* = **Sampling rate** *(Hz)* × **Resolution** *(bits)* × **Sample length** *(seconds)*

Example: Recording a song by an artist in stereo, the song lasts four minutes and the sound is CD quality.

Sampling rate:	**44,100**	**Resolution:**	**16 bits**
Length of sample:	4 × 60 = 240	**File size = 44,100 × 240 × 16 = 169,344,000** (bits)*	

* Much larger than a conventional MP3 file.

© 2016 AQA. Created by Teachit for AQA

To round things off…

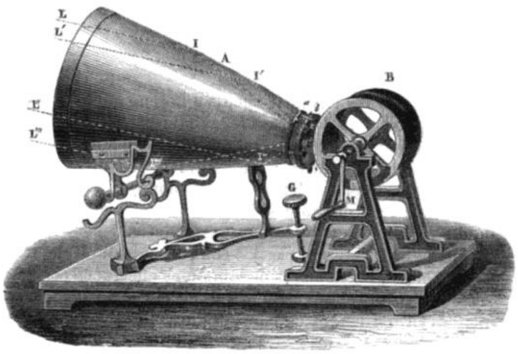
Complete Quiz 2 on file size calculations.

© 2016 AQA. Created by Teachit for AQA

© 2016 AQA. Created by Teachit for AQA

Quiz 1 Identifying historical ways of storing captured sound

Student name:... **Total score:**.....................

Question 1	Answer
When was the **phonautograph** invented? How did it work? What were its limitations?  Image in the public domain	
www.recording-history.org/recording/?page_id=2066	

Question 2	Answer
Phonographs, **graphophones** (pictured) and **gramophones** were all arguably variations of the same invention. When was the gramophone invented? What made the gramophone different?  Image in the public domain	
www.recording-history.org/recording/?page_id=2073	

© 2016 AQA. Created by Teachit for AQA

Question 3	Answer
In 1924, the techniques for recording sound became more advanced.  CC BY-SA 3.0 Shared on Wikimedia Commons by JacoTen The picture shows the actual cutting head on the master disc. Explain how this was made possible using electricity rather than pure sound to make the recording?	
www.recording-history.org/recording/?page_id=2075	

Question 4	Answer
The machine in question 3 cut 'LP' records from vinyl.  Image in the public domain If the original 'single' was the equivalent of two downloadable MP3 tracks, (one track on each side of the disc), what size record would you have been buying? What size would the equivalent of a CD album have been? **Note:** CDs almost killed off the sale of vinyl albums, then digital downloading resulted in a steady decline of CD sales. However, vinyl record sales are slowly making a comeback.	

© 2016 AQA. Created by Teachit for AQA

Question 5	Answer
Later, tape recordings took over from traditional wax disc and other media. This kind of recording was in use at home and in recording studios for many decades. What kind of material was the tape made of which made it quite different to previous media used?  CC BY-SA 3.0 Shared on Wikimedia Commons by Conscious	
www.recording-history.org/recording/?page_id=2085	

Question 6	Answer
When was the **cassette tape** invented? The cassette was a very popular product that again, lasted for many years. Though it was far from perfect, a cassette tape could store up to 120 minutes-worth of music. Can you suggest one problem associated with cassette tapes?  CC BY-SA 3.0 Shared on Wikimedia Commons by File Upload Bot (Magnus Manske)	
www.recording-history.org/recording/?page_id=2089	

© 2016 AQA. Created by Teachit for AQA

Question 7	Answer
Finally, we arrive at the era of the **Compact Disc** (CD). When was the CD introduced to the market? Which two manufacturers are credited with inventing the CD?  Image in the public domain Unusually, CDs are used for the storage of more than just music. Why else might you use a CD? **Note:** Compact discs are digital media.	
www.recording-history.org/recording/?page_id=2091	

© 2016 AQA. Created by Teachit for AQA

Quiz 1 Identifying historical ways of storing captured sound – answers

Question 1	Answer
When was the **phonautograph** invented? How did it work? What were its limitations?	Ca. 1857 **[1 Mark]** Directed sound through funnel **[1 Mark]** …towards a diaphragm at the end which captured it **[1 Mark]** Very poor quality **[1 Mark]** and short (recordings) **[1 Mark]**
www.recording-history.org/recording/?page_id=2066	

Question 2	Answer
Phonographs, **graphophones** (pictured) and **gramophones** were all arguably variations of the same invention. When was the gramophone invented? What made the gramophone different?	Ca. 1889 **[1 Mark]** It used flat disks to record onto rather than a cylinder as for previous inventions**[1 Mark]**
www.recording-history.org/recording/?page_id=2073	

Question 3	Answer
In 1924, the techniques for recording sound became more advanced. The picture shows the actual cutting head on the master disc. Explain how this was made possible using electricity rather than pure sound to make the recording?	The electricity served to drive the cutting head shown inset – this was much more effective and reliable than relying on sound waves alone to make the conversion as previous methods had used. **[1 Mark]**
www.recording-history.org/recording/?page_id=2075	

© 2016 AQA. Created by Teachit for AQA

Question 4	Answer
The machine in question 3 cut 'LP' records from vinyl. If the original 'single' was the equivalent of two downloadable MP3 tracks, (one track on each side of the disc), what size record would you have been buying? What size would the equivalent of a CD album have been? **Note:** CDs almost killed off the sale of vinyl albums, then digital downloading resulted in a steady decline of CD sales. However vinyl record sales are slowly making a comeback.	7" single **[1 Mark]** 12" album **[1 Mark]**

Question 5	Answer
Later, tape recordings took over from traditional wax disc and other media. This kind of recording was in use at home and in recording studios for many decades. What kind of material was the tape made of which made it quite different to previous media used?	It used a magnetised surface to hold the sound format. **[1 Mark]**
www.recording-history.org/recording/?page_id=2085	

Question 6	Answer
When was the **cassette tape** invented? The cassette was a very popular product that again, lasted for many years. Though it was far from perfect, a cassette tape could store up to 120 minutes-worth of music. Can you suggest one problem associated with cassette tapes?	Ca 1964 **[1 Mark]** They physically deteriorated over time / Were not always of a great playback quality (despite being seen as superior to some earlier formats). **[1 Mark either suggestion]**
www.recording-history.org/recording/?page_id=2089	

© 2016 AQA. Created by Teachit for AQA

Question 7	Answer
Finally, we arrive at the era of the **Compact Disc** (CD). When was the CD introduced to the market? Which two manufacturers are credited with inventing the CD? Unusually, CDs are used for the storage of more than just music. Why else might you use a CD? **Note:** Compact discs are digital media.	Ca. 1982/3 **[1 Mark]** Phillips / Sony **[1 Mark]** Data as well as music **[1 Mark]**
www.recording-history.org/recording/?page_id=2091	

© 2016 AQA. Created by Teachit for AQA

Quiz 2 Sound file size calculations

Worked example	Marks
Using the formula supplied: **File size** (bits) = **sampling rate × resolution × length of sample** (secs) **Calculate:** A sound engineer is recording a 30 second mono sound clip of some birds singing outside the studio. Her recording equipment samples at 10 kHz and she is using 8-bit sampling. How big will the sound file be in bytes? How big in kilobytes?	
10000 × 8 × 30 = 2,400,000 bits = 300,000 bytes = 300 kB	 **1 mark** **1 mark** **1 mark**

Question 1	Marks
The same sound engineer needs to record a small group of musicians performing a jingle for an advert – the jingle will last for 10 seconds. She calculates that it will need four microphones (ie four channels of sound needed) to do this and for a good quality of sound, she needs to use 16-bit sampling at a 5000 Hz frequency. How big will the sound file be in bytes? How big in kilobytes?	

© 2016 AQA. Created by Teachit for AQA

Question 2	Marks
Another sound engineer pulls out an old recording that has a size of 2.2 MB. The label on the box says that it was recorded in mono (one channel), that it had a recording sampling frequency of 20 kHz and used 8-bit sampling. How long would this piece of music last?	
Rearrange formula first.	

Question 3	Marks
In order to get highest quality on a sound clip for a file for downloading, a decision is made to take up to 256 samples of amplitude. The clip is to be 60 seconds long and it has been stipulated that the file should not exceed 240,000 bytes in size. What is the maximum possible sampling frequency that can be used?	
Rearrange formula with conversion of 256 levels to 1 byte encoding (= 2^8).	

Question 4	Marks
Given the formula for calculating file size, explain how the units for file size are derived?	

© 2016 AQA. Created by Teachit for AQA

Quiz 2 Sound file size calculations – answers

Worked example	Marks
Using the formula supplied: **File size** (bits) = **sampling rate × resolution × length of sample** (secs) **Calculate:** A sound engineer is recording a 30 second mono sound clip of some birds singing outside the studio. Her recording equipment samples at 10 kHz and she is using 8-bit sampling. How big will the sound file be in bytes? How big in kilobytes?	
10000 × 8 × 30 = 2,400,000 bits = 300,000 bytes = 300 kB	 **1 mark** **1 mark** **1 mark**

Question 1	Marks
The same sound engineer needs to record a small group of musicians performing a jingle for an advert – the jingle will last for 10 seconds. She calculates that it will need four microphones (ie four channels of sound needed) to do this and for a good quality of sound, she needs to use 16-bit sampling at a 5000 Hz frequency. How big will the sound file be in bytes? How big in kilobytes?	
5000 × 16 × 10 = 1,600,000 bits = 100,000 bytes = 100 kB	 **1 mark** **1 mark** **1 mark**

© 2016 AQA. Created by Teachit for AQA

Question 2	Marks
Another sound engineer pulls out an old recording that has a size of 2.2 MB. The label on the box says that it was recorded in mono (one channel), that it had a recording sampling frequency of 20 kHz and used 8-bit sampling. How long would this piece of music last?	
Rearrange formula first. **Length of sample** = **File size** ÷ (**Sampling rate × Resolution)** = 17600000 ÷ (20000 × 8) = 110 seconds	 **1 mark** **1 mark** **1 mark**

Question 3	Marks
In order to get highest quality on a sound clip for a file for downloading, a decision is made to take up to 256 samples of amplitude. The clip is to be 60 seconds long and it has been stipulated that the file should not exceed 240,000 **bytes** in size. What is the maximum possible sampling frequency that can be used?	
Rearrange formula with conversion of 256 levels to 1 byte encoding (= 2^8) 240000 = 4000 × 1 × 60 **Sampling rate** = **file size** ÷ (**resolution** × **length of sample)** = 240000 ÷ (1 × 60) = 4,000 Hz	 **1 mark** **1 mark** **1 mark** **1 mark**

Question 4	Marks
Given the formula for calculating file size, explain how the units for file size are derived?	
File size = **sampling rate**×**resolution**×**length of sample** Look at the units each quantity is measured in. 1 Hertz = 1 sample per second = 1 ÷ seconds = seconds^{-1} File size = seconds^{-1} × bits × seconds = bits (If wanting the file size in bytes then the resolution should be in bytes or the final answer should be divided by 8.)	 **1 mark** **1 mark** **2 marks**

© 2016 AQA. Created by Teachit for AQA