SYNTHESIS
REVISION PACK

<table>
<tr><td rowspan="2">Oscillator

Waveforms

Noise-generator</td><td rowspan="2">Envelope

Attack

Decay

Sustain

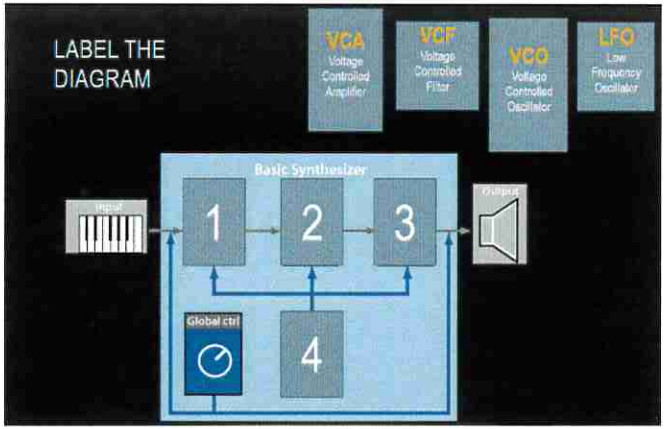
Release</td><td colspan="2">Types of Synthesis</td></tr>
<tr><td>Subtractive

Additive</td><td>FM

Wavetable

Physical Modelling</td></tr>
<tr><td></td><td colspan="2">Synthesis</td><td>What is it? Definition</td></tr>
<tr><td>Modulator

LFO

Vibrato</td><td colspan="2"> 
</td><td>Filter

Cutoff

Resonance

HPF

LPF</td></tr>
</table>

EXAMPLES OF EXAM QUESTIONS

Create a synth

It is important that you don't spend loads of time trying to recreate the synth exactly. Follow the basic instructions given and all busses and FX on your track are bypassed. You will lose marks if you include FX that are not required.

(c) Create a synth sound that matches the timbre "chords example.wav".

(i) Ensure that the octave matches the example. (1)

(ii) Use a square wave with no effects. (1)

(iii) Ensure the pitch bend range matches the example. (1)

(iv) Copy the amplitude envelope. (1)

(v) Copy the filter envelope. (3)

Acceptable Answers
"chords example" was 0:15-0:17 (or an equivalent location for candidate responses with more/less silence at the start of the CD track).
"Chords" timbre
(i) Correct octave and pitches throughout with polyphony (1)
(ii) Wave (1): Square wave timbre. Allow saw or pulse. *Award 0 if any FX are added.*
(iii) Pitch bend range is 2 octaves (1) Check at 0:16
(iv) Amplitude & pitch envelope (1): D=max, S=max, R=0 (release less than V) [ignore attack] AND No portamento
(v) A moving LPF is clearly audible throughout, or a static cutoff more muffled than J. (1) Slow attack (allow slow amplitude attack) (1) Sounds similar to 'task 2.wav'. Resonant LPF with slow attack giving a wah attack on every note. (3) Max. 3
If chords are not soloed, has effects, or the metronome is switched on, assess what can be heard clearly. If instrument is not a synthesiser (e.g. bass guitar/piano) then award (i) and (iii) only. If there is no evidence of the chords timbre outside of bar 9 then award 0.

Short Question

Often related to a sound file and you must deconstruct the sound into osc(waveform), filter(cutoff and resonance), envelope(ADSR) and modulation(LFO). Evaluate which component is creating the change in the timbre.

(c) Compare bar 7 with bar 11. Describe how synthesis is used in bar 11 to change the timbre on beat 3.

(4)

.....

.....

.....

.....

(d) Describe how the envelope is used to gradually change the timbre throughout bars 26-29.

(2)

.....

Question Number	Question	Mark
2(c)	Compare bar 7 with bar 11. Describe how synthesis is used in bar 11 to change the timbre on beat 3.	**4**
	Acceptable Answers	
	Low pass(1) filter (1) / LPF (2) Attack (time) (1) increased / longer / slower (1) of cutoff frequency (1) envelope/ADSR (1). OR Cutoff frequency (1) increases throughout the note (1) using automation (1). Allow 'reversed' (1).	

Question Number	Question	Mark
2(d)	Describe how the envelope is used to gradually change the timbre throughout bars 26-29.	**2**
	Acceptable Answers	
	Release (1) increased / longer / slower (1) Allow: Decay (1) increased / longer / slower (1) Sustain increased / higher (1), not 'longer' Apply SONC if change in attack is mentioned.	

Essay Questions

Figure 1 shows an analogue synthesiser from the 1970s. Many of the controls are similar to those of a software synthesiser plug-in. Explain the function of the controls seen in Figure 1. Identify the benefits of using a software synthesiser plug-in rather than 1970s analogue technology.

Figure 1 shows a synthesiser from 1982. Evaluate the suitability of the settings shown to produce a synth pad.

C4 ESSAY STRUCTURE

Section Heading:	
Identify(A03)	Explain(A04)
Section Heading:	
Identify(A03)	Explain(A04)
Section Heading:	
Identify(A03)	Explain(A04)

Section Heading:	
Identify(A03)	Explain(A04)
Section Heading:	
Identify(A03)	Explain(A04)
Section Heading:	
Identify(A03)	Explain(A04)

Figure 1

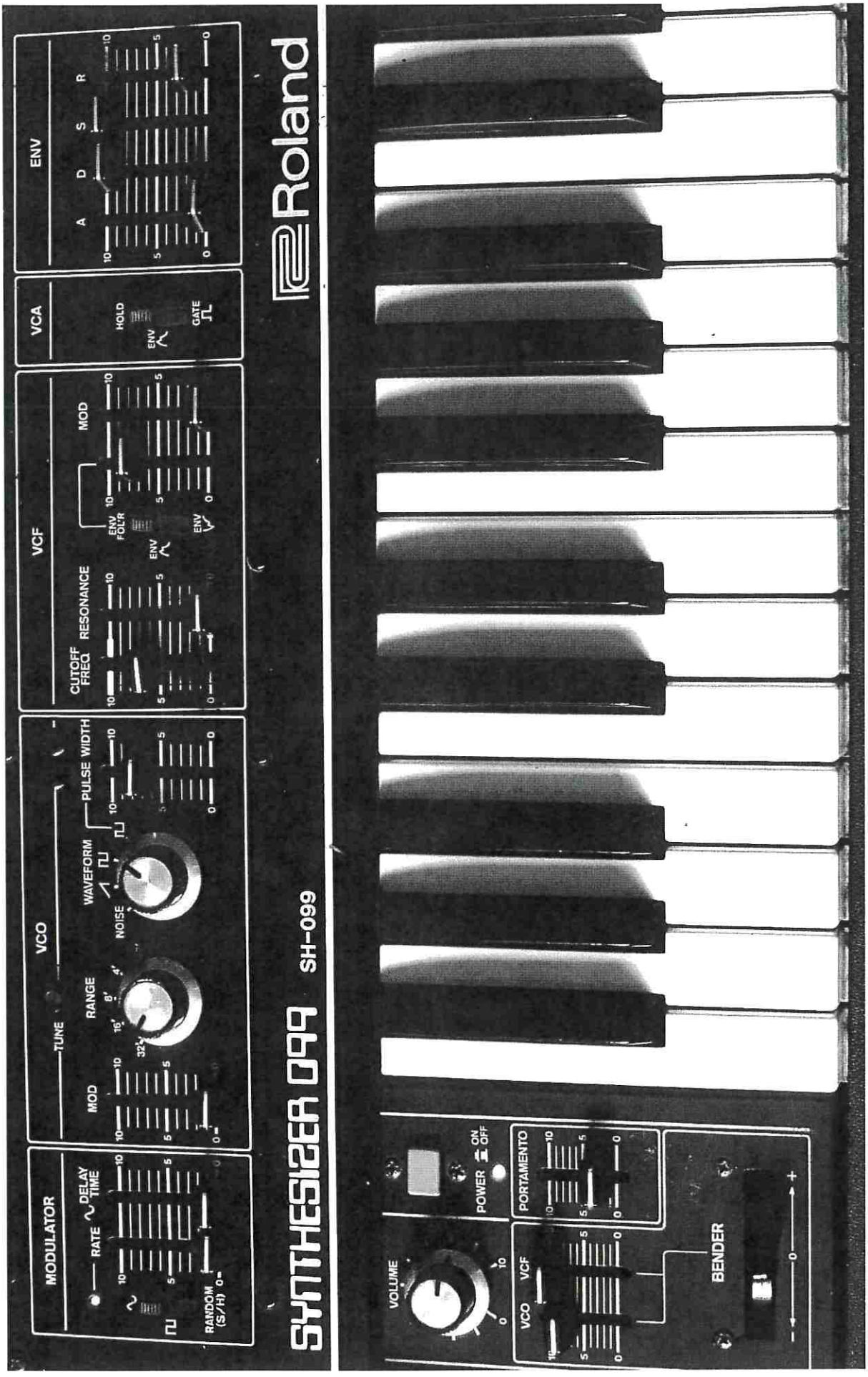

MODULATOR
RATE
DELAY TIME
RANDOM (S/H)
VCO
TUNE
MOD
RANGE
WAVEFORM
NOISE
PULSE WIDTH
VCF
CUTOFF FREQ
RESONANCE
ENV FOL'R
MOD
ENV
VCA
HOLD
ENV
GATE
ENV
A D S R
Roland
SYNTHESIZER 099
SH-099
VOLUME
POWER ON OFF
PORTAMENTO
VCO VCF
BENDER

Figure 1


LFO
DCO
HPF
VCF
VCA
ENV
CHORUS
RATE
DELAY TIME
TRIG MODE
AUTO
MAN
VIB
PWM
MANUAL
ENV
LFO
SUB OSC
NOISE
FREQ
RES
ENV
LFO
KYBD
GATE
A
D
S
R
OFF
I
II

Synthesis Basics
Sound synthesis is the combining and manipulation of waveforms to create a new sound.

A synthesiser is the device that enables this to happen, offering all the functionality required to be able to alter the waveform in appealing and interesting ways.

Whether you are using a software synthesiser or hardware, the principle is that multiple components can be chained together in order to create and manipulate sound.

The basic components used in synthesis are:

VCO
Voltage Controlled Oscillator
This is the tone generator which creates the initial waveform. A synthesiser may have several of these which you can combine to create new waveforms using waveform interference.

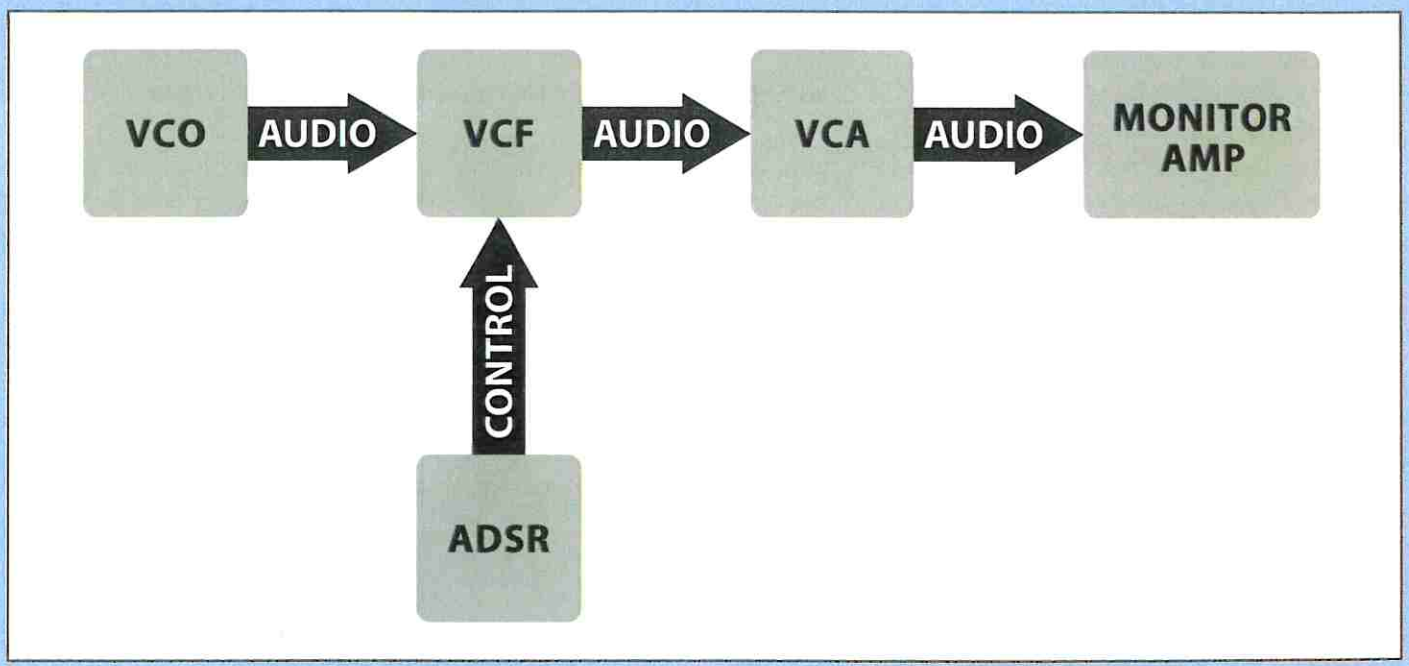
Some synthesisers will enable you to choose between several options for the initial waveform such as sine wave, square wave and sawtooth wave, each of which have different sounds and harmonic content which can then be manipulated.

VCA
Voltage Controlled Amplifier
This controls the level of the signal.

VCF
Voltage Controlled Filter
The VCF is a filter with a controllable frequency. The filter may be a high pass, low pass or band pass filter. Adjusting the frequency of the filter will alter what frequency content of the signal can be heard.

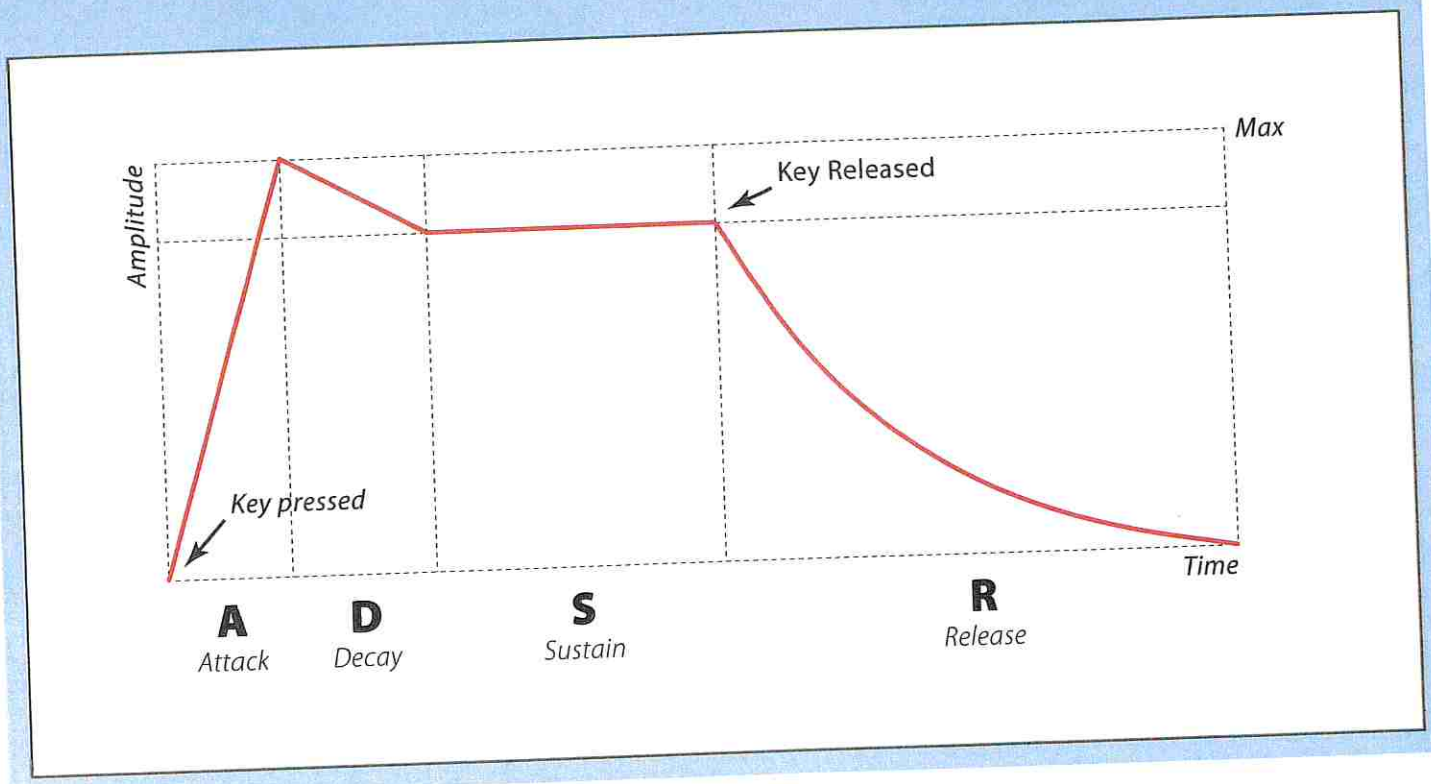
LFO
Low Frequency Oscillator
A low frequency oscillator is so called because it is a control which oscillates at a much lower frequency than the tone generator (VCO).

The LFO is used to modulate characteristics of other components such as the amplifier level or VCF frequency.



ADSR Envelope – Attack, Decay, Sustain, Release
The envelope can be assigned to operate other components such as the amplifier or filter. When assigned to the amplifier, the envelope controls the level of the signal in four phases:

- **Attack**
  – The initial impact of the sound when the sound is triggered.
- **Decay**
  – The recovery from the attack's peak phase.
- **Sustain**
  – The level at which the signal remains.
- **Release**
  – The dissipation of sound once the trigger key has been released.



If your DAW has a synthesiser, experiment with the use of these components. If you feel lost at first, load one of the presets and change the settings to help you understand what they do.

Sonic Fidelity

Signal to Noise Ratio (SNR)
SNR represents the relationship between the wanted signal and the unwanted noise. This might be referred to when discussing a piece of equipment or perhaps a cable in the case of a balanced system.

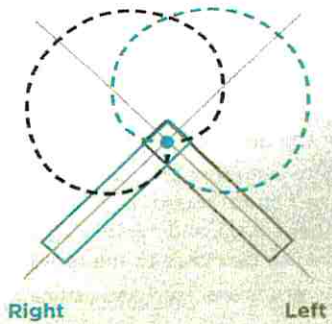
The higher the SNR, the less likely the noise is to cause a problem.

Noise Floor
The noise floor is the level at which background noise exists in a system. Generally a better designed piece of audio circuitry will have a lower noise floor which increases the dynamic range.

Dynamic Range
The dynamic range of a system is the difference between the noise floor and the maximum level that a system can operate with before distortion occurs.

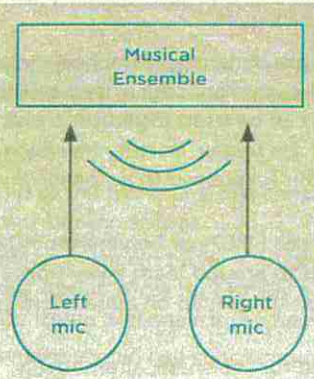
Stereo mic techniques

Coincident (XY) pair



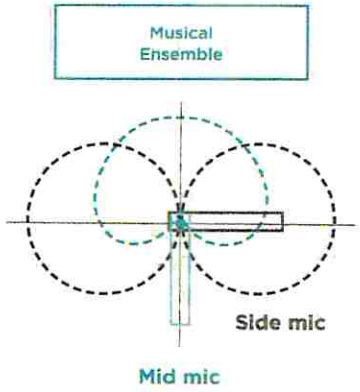
- Two cardioid microphones placed so that the **capsules** are right next to each other
- This combines the **polar pattern** of the two capsules to create a stereo image
- Because the mics are basically touching, a good **mono** compatibility is maintained.

Spaced (AB) pair



- Two **omnidirectional** microphones placed around 30-50cm apart (depending on ensemble size)
- Useful for the recording of large ensembles and performances that require a sense of **ambience**.

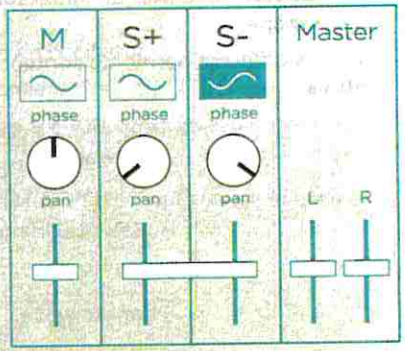
Mid-side (MS) pair



- A cardioid and a figure 8 microphone
- Set up at 90° to one another
- The cardioid microphone should point straight at the sound source, and the figure 8 microphone picks up the sound from the sides.

Processing mid-side recordings

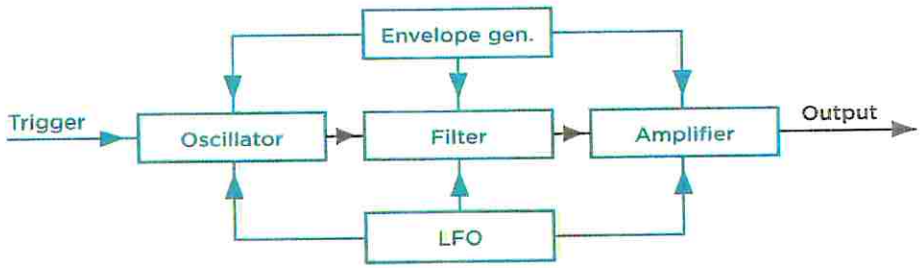
- At the mixer or on the **DAW**, the signal captured from the sides on the figure-of-8 microphone should be duplicated, and one version phase inverted
- They should then be hard panned in opposite directions at the same level
- If the side tracks are panned centrally, they will completely cancel out, and therefore mid-side recordings exhibit excellent **mono** compatibility
- Changing the volume of the side tracks will adjust the stereo width.



Synthesisers

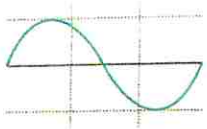
A synthesiser is an electronic sound generator capable of creating and manipulating synthetic sounds. It has become common to use synthesisers as DAW plug-ins, but the sounds, warmth and authenticity of vintage analogue equipment are highly regarded by many.

How does a synthesiser work?

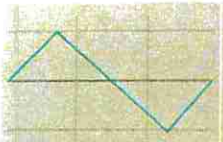


Oscillator

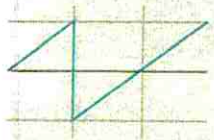
- The **oscillator** generates an initial sound at a pitch, and allows you to choose a wave shape
- Each has different harmonic content and thus can be used to create different **timbres**.



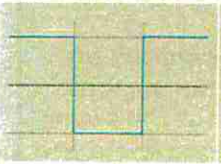
Sine wave
- Pure tone
- Basic building block of sound.



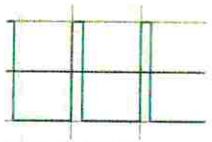
Triangle wave
- Slightly harsher than sine wave
- Flute-like sounds and **pads**.



Sawtooth wave
- Even and edgy sound
- Strings, basses, pads and brass/dance leads.

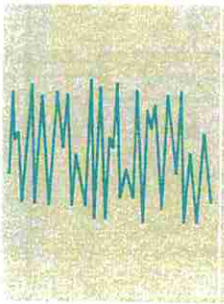


Square wave
- Hollow and woody
- Clarinets, oboes and bass sounds.



Pulse width 12.5%

Pulse wave
- Nasal sounding
- Variable pulse width/mark-space **ratio**
- Reed instruments and basses.



Noise
- A **noise** generator creates a random signal. White noise consists of all frequencies at an equal **amplitude**
- Other colours of noise have different frequency distributions
- Can be used to simulate wind or percussive sounds like cymbals
- Can be filtered to create a sweeping effect.

- An oscillator first allows you to select an octave. This is often achieved by choosing between numbers like 4,8,16 and 32 – these have their origins as the length in feet of pipes on an organ
- There are two further tuning controls on an oscillator:
  - Coarse tuning sets the pitch in semitones
  - Fine-tuning is measured in cents (there are 100 cents to a semitone).
- Many synthesisers have more than one oscillator
- Fine-tuning can be used to slightly detune multiple oscillators and create a '**chorus**-like' effect
- A synthesiser's polyphony tells us how many notes it can play simultaneously; a **monophonic** synthesiser can only play one note at once
- The **glide** or **portamento** control is used to alter the amount of time it takes to slide between two overlapping notes
- You can change a synthesiser's **pitch bend** range; this controls how many semitones the pitch bend wheel or **MIDI** data will bend a note up or down by.

Filter

- The filter removes frequencies from the initial signal to shape the sound
- Synths often incorporate a **low pass filter**, as shown in the graph on page 57, which removes all the frequencies above the cutoff **frequency**
- The cutoff frequency is the point at which the filter begins to remove frequencies
- Some synthesisers also include **high pass filters** or **band pass filters**.

For more about different types of filter, turn to pages 55-61.

- **Resonance** is often used on a synthesiser filter to add a characteristic narrow boost of frequencies around the cutoff
- It accents a small range of frequencies and creates a 'whistly' sound that makes the signal close to the cutoff seem brighter and harsher
- High resonance settings lead to self-oscillation; where the boost of a specific frequency is so loud, the filter 'creates' a pitched note.

Amplifier

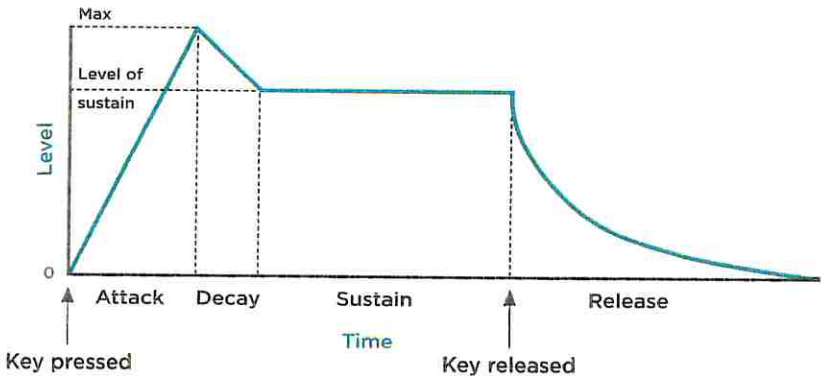
- The **amplifier** controls the sound's volume
- Control signals such as envelopes and **LFOs** can be used to alter the volume over time.

Envelope generator

The **envelope generator** can be used to control the **oscillator**, filter and/or amplifier, depending on the specific synthesiser.

The four envelope stages are:

Attack	The time taken for the parameter to increase from 0 to the maximum level.
Decay	The time taken for the parameter to decrease to the sustain level.
Sustain	The level at which the parameter is held whilst the key remains pressed.
Release	The time taken for the parameter to decrease to 0, once the key is released.



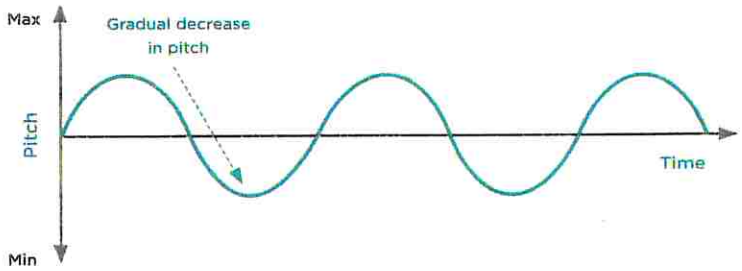
- Examples of parameters that could be controlled by an envelope include pitch, filter cutoff **frequency** and volume
- The envelope also plays a part in creating a sounds **timbre**; along with a signal's harmonic content, it is part of what helps us to tell a piano apart from a violin.

LFO

- Like an envelope, an **LFO** (**low frequency oscillator**) is a control signal used to alter a parameter over time
- Most synthesisers can use LFOs to control different modules; if controlling the oscillator, it can change the base pitch generated, creating **vibrato**
- If it is modulating the filter cutoff frequency, it will periodically change this according to the LFO wave shape.

Rate	Speed at which the **modulation** takes place; can either be synced to a note value in a **DAW** (e.g. 1/8 or quaver) or given an absolute value in hertz, often between around 0.05Hz and 15Hz.
Depth	How much the modulation affects the assigned element of the synthesiser; the greater the **depth**, the wider the range of values for the modulated parameter.
Shape	Type of **waveform** used to modulate the signal e.g. sawtooth, sine or square.

- The diagram below shows a sine wave being used to modulate pitch, creating vibrato:



- One of the most useful features of **LFOs** in a **DAW** is the ability to sync the LFO to the main tempo of the project, creating effects that are in time with your track.

Historically important synthesisers:

- **Moog Modular** (1965) Wendy Carlos – *Switched-On Bach*
- **Minimoog** (1969) Tubeway Army – 'Are 'Friends' Electric?' (lead line)
- **Sequential Circuits Prophet-5** (1977) Paul McCartney – 'Wonderful Christmastime', A-ha – 'Take On Me' (opening riffs), Jean-Michel Jarre – 'Fifth Rendez-vous'
- **Roland Jupiter-8 (JP-8)** (1981) Queen – 'Radio Ga Ga' (arpeggiated bassline after drum solo), Queen – 'I Want To Break Free' (synth solo from 2:06 – 2:34)
- **Roland TB-303** (1982) Phuture – 'Acid Trax' (fades in from approximately 1:05), Fatboy Slim – 'Everybody Needs A 303' (from 1:04, very audible from 2:33)
- **Yamaha DX-7** (1983) Vangelis – 'The Motion Of Stars' ('bell-like' opening synths), Brian Eno – 'Apollo: Atmospheres and Soundtracks' (most of Eno's work uses the DX7 extensively)
- **Korg M1** (1988) Des'ree – 'You Gotta Be' (acoustic guitar in opening), Black Box – 'Ride On Time' (piano from 0:20), Basement Jaxx – 'Never Say Never' (Mark Knight Remix) (piano chords).

Other electronic instruments

Theremin (1920)

- Played by moving your hands near one or two aerials
- Experienced something of a revival in the 1990s as people built them for their own use
- Creates a very pure sound with **portamento** appearing between notes because of its playing technique. Often played with a very obvious **vibrato**.

Listening
The Beach Boys – 'Good Vibrations' (0:26 -)

Hammond B3 organ (1954)

- Originally invented as a low-cost alternative to the pipe organ
- Widely used in many pop music genres from the 1960s onwards
- This tonewheel, drawbar organ is often played through a rotating **Leslie speaker** – the rotation speed can be altered, giving a chorus/phasing/tremolo effect.

Listening
Booker T. and The M.G.'s – 'Green Onions' (lead line)

Rhodes piano (1965)

- Produces a sound that sounds like a cross between a bell and a vibraphone (without **vibrato**)
- Often played through effects pedals to produce a variety of effects similar to that of an electric guitar
- A very similar (slightly harsher) sound is produced by its main competitor, the Wurlitzer.

Listening
Herbie Hancock/Miles Davis – 'Bitches Brew'
Ray Charles – 'Shake Your Tailfeather'

Hohner Clavinet (1968)

An amplified clavichord that became synonymous with the sound of funk.

Listening
Stevie Wonder – 'Superstition'

Arpeggiators

- An **arpeggiator** is a basic sequencer that plays or repeats a number of notes in a specific pattern
- These were incorporated into some **analogue** synthesisers, for example on the Roland Jupiter 8
- Arpeggiators on software synthesisers can be synced to the project tempo, and you can select a note value.

Software synthesisers

- As computers became more powerful, plug-in instruments became popular because of their ability to produce the sounds of their hardware equivalent without having to purchase more than one synth!
- This is especially true of the popular vintage synths that may be hard to get hold of in playable condition, and are often very expensive due to the popularity of vintage gear amongst enthusiasts
- There remains a demand for 'vintage' **analogue** synthesisers; equipment worth very little in the late 1980s and early 1990s now sometimes sells for thousands of pounds
- In recent years, the cost of manufacturing analogue synthesisers has decreased, and manufacturers have developed and released equipment that combines analogue technology and sounds with computer control.

Benefits of software synthesisers	Benefits of analogue synthesisers
▪ Can be automated, **MIDI** controlled and easily sequenced ▪ **DAWs** with a global tempo allow you to easily sync **LFOs/ arpeggiators** to a note value (this is much harder to do aurally on a hardware synth) ▪ Better **signal-to-noise ratio** ▪ Wide variety of presets available at the touch of a button ▪ Can create your own presets, and share on the internet ▪ Can use multiple instances of the plug-in ▪ Stay in tune reliably; it is common for **analogue** synthesisers to go out of tune when they heat up ▪ Can have more envelope stages, types of **waveform**, **oscillators** and filter types.	▪ Enthusiasts refer to the analogue sound as 'warm' when compared to 'harsher' or 'sterile' digital sounds; this is because of the 'flaws' associated with analogue technology – things like the tuning drifting, **noise**, aurally-pleasing **distortion** and subtle and random variations in wave shape, **amplitude** and **frequency** ▪ Possible to use **CV/gate** systems to sync analogue equipment together; converters exist to connect analogue synthesisers to **MIDI** equipment ▪ Your music can 'stand out from the crowd' – less reliant on presets and sounds others are using – sounds more individual ▪ Analogue synthesisers by definition have a 'hands-on' interface – with permanently routed controls, it is easy to change settings 'on-the-fly'.

Samplers

Sampling is when you take a part of a song, single note or sound and reuse it in another context. It is common to use a sampler to either record, manipulate or playback one of these pieces of audio material (or any combination of the three). The technique of using everyday noises in music began in earnest with the Musique Concrète movement of 20th century experimental music.

The tape recorder and early sampling

- The tape recorder was the main 'instrument' for early Musique Concrète composers
- They would use it to **capture** sounds and then manipulate them by cutting and splicing the tape, making loops (by splicing the ends of a length of tape together, forming a literal loop), **reversing** the playback direction, altering the speed of playback and combining/layering sounds
- There were limitations to what could be achieved with tape, for example, it is impossible to change the speed of playback without altering the pitch
- This process formed the basis for modern-day **sampling**, and the 1960s saw the first instruments used in pop music that could play back samples.

Listening
The Beatles – 'Tomorrow Never Knows'
This song showcases a variety of tape-based manipulations, from tape loops and changing the playback speed to reversing and using **tape saturation** as a creative tool.

Mellotron (1962)

It was the Mellotron that first achieved widespread acceptance as an early sampler. It used different banks of pre-recorded tapes (one tape strip for each key) giving several choices of sound (including strings, brass, flute and choir). It was expensive, and notoriously fragile.

Listening
The Beatles – 'Strawberry Fields Forever' (opening flute)
Led Zeppelin – 'The Rain Song' (strings from 1:36)

Digital samplers as instruments

- Samplers can record audio either as one-shot, single note samples or as short loops/musical excerpts

HISTORY AND DEVELOPMENT OF SYNTHESIZERS AND KEYBOARDS

Music Technology

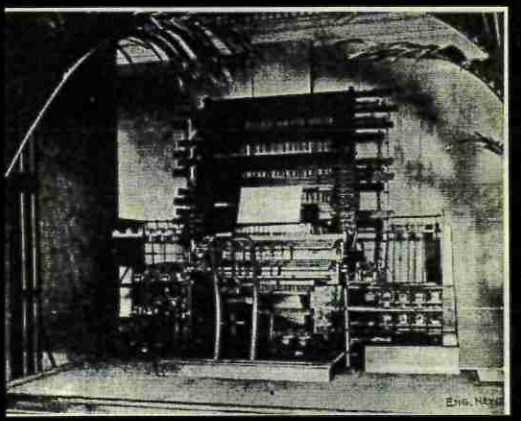
Monophonic

TELEHARMONIUM

Thaddeus Cahill invented the first electronic instrument in 1898. It was first exhibited in New York in 1906.

It consisted of massive rotary generators and telephone receivers, and was designed to transmit sound over telephone wire.

It weighed 200 tons and interfered with normal telephone services when played. The idea was soon abandoned.



Monophonic

THEREMIN

Leon Theremin invented a unique instrument in 1920.

It has a radio antennae to control dynamics and a rod project from the side to control the pitch. It is played by moving the hands around the antennae producing a ethereal sound. Used extensively in SciFi movies and was also used on Good Vibrations by the Beach Boys

Monophonic

Ondes martenot

Maurice Martenot invented the instrument in 1928.

It used oscillated sound and had a 5 octave range. It produced a similar sound to the theremin but had more variety of tone colours. It had a slide strip that allowed you to play a sweeping glissandi.

Classical composer like Messiaen used it extensively in his works.

Hammond organ

In 1933, the Hammond organ was the first polyphonic electronic keyboard. It uses revolving discs spinning in a magnetic field to produce a simple waveform that can be used in combination to produce a variety of tones colours.

Hammond introduced the B3 model in the 50s and established itself in jazz and popular music.

Hammond is usually played through a unique rotary speaker called a leslie

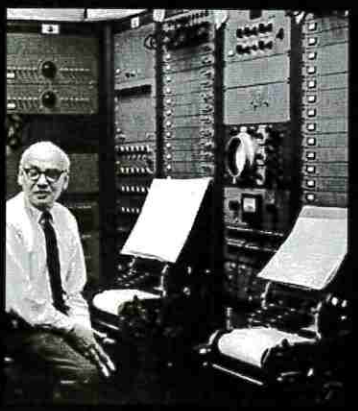
Mixtur-trautonium

Oskar Sala invented the instrument in 1952

The Mixtur-Trautonium allowed for the first time in music history the execution of sounds which had only been known in theory since the Middle Ages, but were never actually playable. Sala's invention opened the field of subharmonics, the symmetric counterpart to overtones, so that a thoroughly distinct tuning evolved.

RCA Electronic Music Synthesizer Mark 1

Harry Olson and Herbert Belar invent the instrument in 1956.



Moog

Robert Moog developed the first voltage controlled

Synthesizer in 1964. His modular synthesizer gained in popularity when Walter(Wendy) Carlos released *Switch on Bach* in 1968

Moog later developed a cheaper non-modular system called the Minimoog-1970

DEFINITION: A device that generates sound electronically

SYNTH BASICS

A classic synthesizer is made up of 4 elements:

Oscillators

Filters

Envelopes

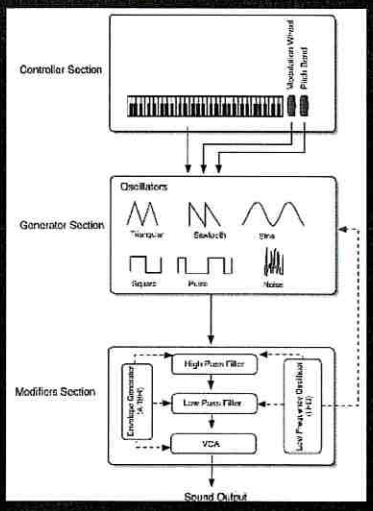
Modulators

This synthesizer technique is called subtractive synthesis

Subtractive Synthesis

This techniques uses a raw waveform as the starting point. The sound is then *sculpted* by shaping and filtering, *subtracting*, from the basic waveform.

Early analogue synthesizers could only play note at a time monophonic. It later developed to multiple oscillators and notes(chords)polyphonic



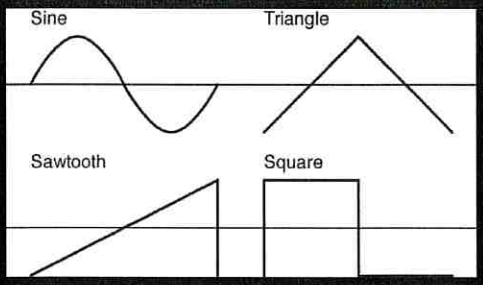
OSCILLATOR

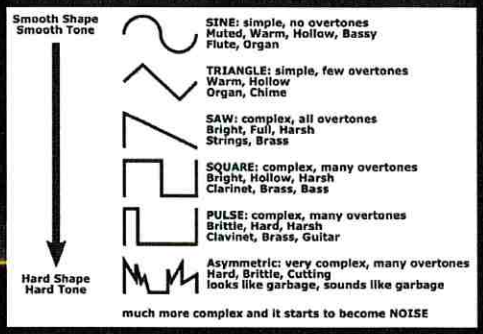
also known as VCO-voltage controlled oscillator

A synthesizer oscillator produces a continuous signal that forms the basis for your sound. Oscillators are capable of producing several different waveform shapes that have different tonal qualities.

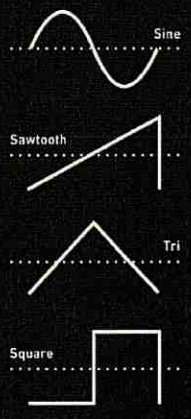
Oscillators are the most important part of the synthesizer because they create the sound that the other synth parameters will shape.

Basic Waveforms





IDENTIFY THE WAVEFORM



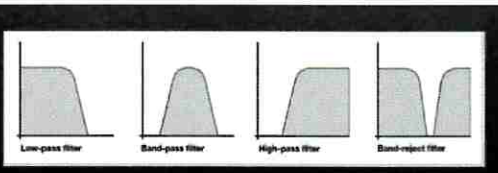
1. Square
2. Triangle
3. Saw
4. Noise

BLENDING WAVEFORMS

I will use 2 oscillators this time and mix the 2 together and detune 1 by 12 semitones(an octave)

1. Square and Saw
2. Square and Triangle
3. Noise and Triangle
4. Square and Square
5. Saw and Saw

FILTER



also known as VCF-voltage controlled Filter

Synth sounds are shaped through the use of filters. Filters remove parts of the frequency spectrum, allowing you to contour the sound.

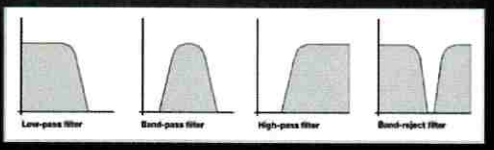
LPF low pass filter attenuates frequencies above the frequency cutoff point-transforming the initially bright output of the VCO into a rounded overall tone

HPF high pass filter works in reverse to the LPF, frequencies below the frequency cutoff point is attenuated, useful for thinning sounds out

BP band pass filter allows a small band of frequencies pass through

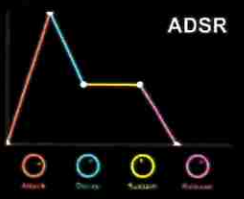
BR band reject filter attenuates a small band of frequencies

IDENTIFY THE FILTER



1. HPF
2. BP
3. BR
4. LPF
5. PEAK

ENVELOPE



A synth envelope shapes the beginning, middle, and end of your sound. The most common envelope adjusts the attack, decay, sustain, and release (ADSR). For example, a piano has a fast attack, fast decay, medium sustain, and fast release.

There is normally 2 envelopes, one ADSR for the amplifier section(VCA), which shapes the sound for the overall volume, and one ADSR for the the filter(VCF), which works the same way but affects the tone instead.

Attack how long the sound takes to reach maximum eg. Piano's attack is fast, while a violin's attack is slow

Decay how quickly the sound decays from the maximum to the sustain level

Sustain the continuous level of loudness while the finger remains on the keyboard

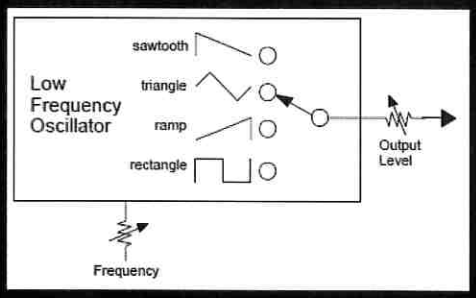
Release how long the sound takes to decay to silence after the key is released

MODULATORS

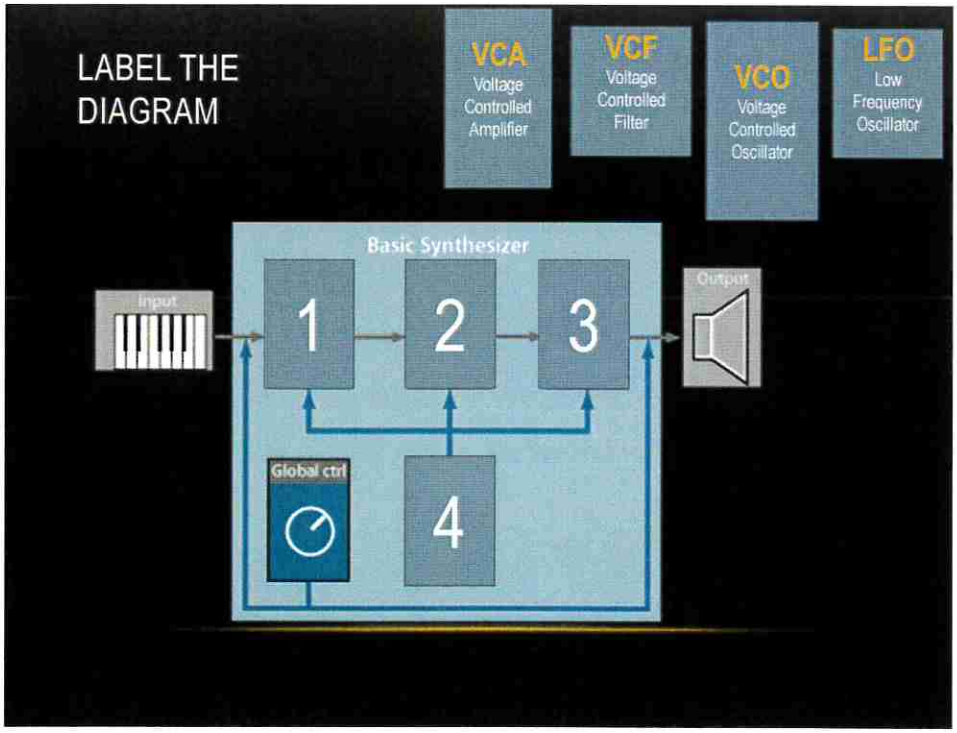
A static synth sound gains interest when it's varied in some way. Modulation is the process of varying synthesizer parameters.

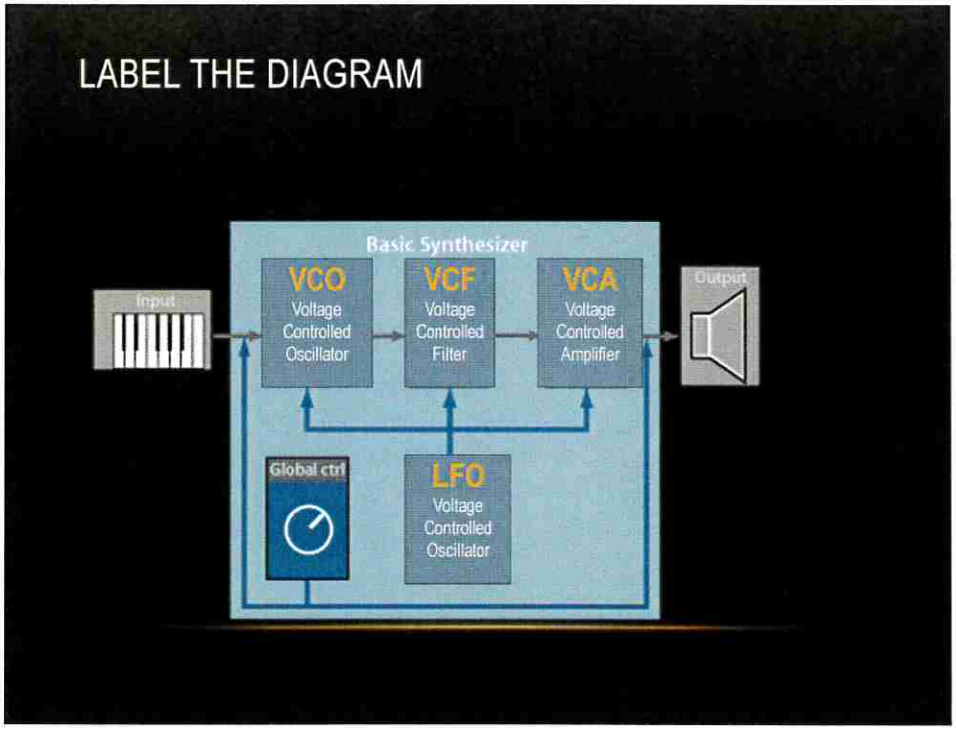
Vibrato is a common example of modulation.

A low frequency oscillator (LFO) is a signal, usually below the audible frequency spectrum, that modulates a signal. LFOs are used to alter the original signal in some way. A common use of an LFO is to create vibrato.



LABEL THE DIAGRAM

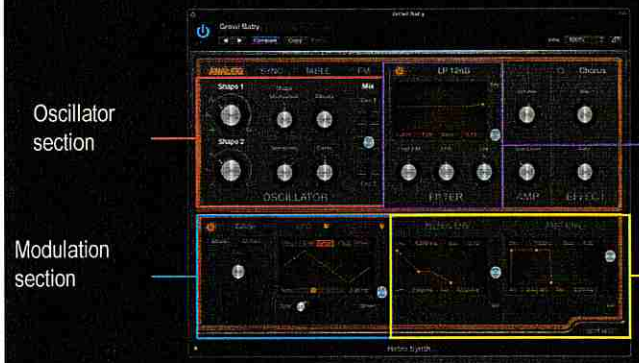



LABEL THE DIAGRAM
Basic Synthesizer
Input
VCO
Voltage Controlled Oscillator
VCF
Voltage Controlled Filter
VCA
Voltage Controlled Amplifier
Output
Global ctrl
LFO
Voltage Controlled Oscillator


VIRTUAL SYNTHESIZERS IN LOGIC PRO X
ES1
ES2
RETRO
ALCHEMY
EFM1
ES E
ES M
ES P

INTRODUCING LOGIC'S RETRO

Retro is a virtual synthesizer which models an analogue subtractive synthesizer and a good synth to learn the basics.



CREATE A SYNTH QUESTION

Using Retro create your own Component 4 style question.

(i) Ensure that the octave matches the example. (1)

(ii) Use a square wave with no effects. (1)

(iii) Ensure the pitch bend range matches the example. (1)

(iv) Copy the amplitude envelope. (1)

(v) Copy the filter envelope. (3)

Play a chord or a simple bassline.

List simple instructions in the notes section.
Create an audio file.
Delete the synth track and swap with your partner.
Try to recreate your partners synth.

TASK 1
Filtered Sweep

-select the noise generator on SHAPE 1

- adjust the MIX slider all the way up to Osc 1

-play a note on the keyboard and you should hear white noise

-in the Filter section drag the LPF from left to right while you play note, this should produce a sweep sound.

TASK 2
Wobble Bass

-select the sawtooth waveform on SHAPE 1 and SHAPE 2

- adjust the MIX slider to the centre so that you can both oscillators

-play a low note on the keyboard

-in the Filter section turn the LFO knob to centre.

-in the LFO section, select the reverse sawtooth waveform, adjust the slider all the way down and adjust the rate slider to give the desired wobble

TASK 3
Mario Bros

-import the Mario Bros Theme MIDI file in Music>AS Music Tech>Resources

-change the instrument on the tracks to the RETRO synth

-change the waveform to square wave

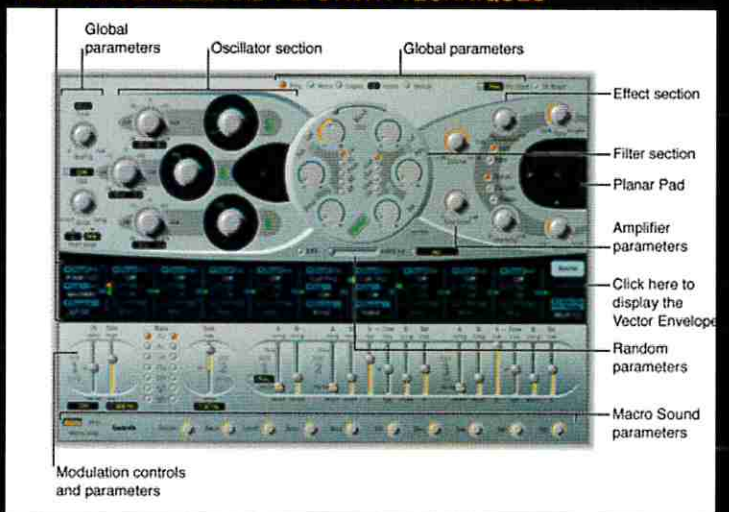
-insert a bitcrusher effect to get the full 80s game console effect.

CHALLENGE: CREATE YOUR OWN UNIQUE SOUND WHICH USES ALL THE ELEMENTS OF SUBTRATIVE SYNTHESIS e.g. OSC, FILTER, LFO, ADSR

SUPER CHALLENGE: RECREATE THE MUSIC FOR THE LEGEND OF ZELDA- MUSIC SCORE IS IN THE RESOURCE FOLDER IN THE MUSIC DRIVE

INTRODUCING LOGIC'S ES2

A HYBRID SYNTH THAT COMBINES SUBTRACTIVE SYNTH TECHNIQUES WITH WAVETABLE AND FM SYNTH TECHNIQUES



SYNTH LEAD

-used to play melodic lines(i.e. lead part)

-the same as any melodic instrument, which can on play one note at a time(monophonic)

-early synths were monophonic

-used for solos, riffs, arpeggiated passages

Super Saw Lead Recipe

1. Load the Analog Saw Init patch
2. Set all 3 Osc to Saw tooth
3. Detune Osc 2 and 3 by approx. +14 and -14 respectively
4. Turn up Analog to around 3 'o clock
5. Select mono mode and unison

Fat synth sound used in electronic dance music. Now make it your own. Adjust the EG and glide for a more expressive synth

SYNTH PAD

-used to play chords to create a rich texture or a "bed of sound"(padding out your sound)

-synth has to be polyphonic to playback all the notes in the chord

-the sound is usually made interesting by adjusting the EG so that the sound develops of time.

Try creating your pad synth by blending 2 oscillators. Adjust the envelope section to make the pad changes slowly over time. Add some modulation for movement. Make sure legato and poly is activated

SYNTH DRUMS

-synth drums are used in extensively electronic and hip hop music

-Provides an alternative to traditional drum sounds

-Used to fatten up existing drum sounds

Synth Snare Recipe

1. Load the Analog Saw Init patch
2. Mute Osc 1 and 2, and set Osc 3 to Noise
3. Adjust the envelope section setting a short attack and a short decay

Mess around with the distortion and cutoff and resonance to create your desired sound

SYNTH BASS

-used as an alternative to electric bass and used extensively in electronic music

-can adjust the sound to be aggressive or extremely mellow and sub heavy

SUBTRACTIVE

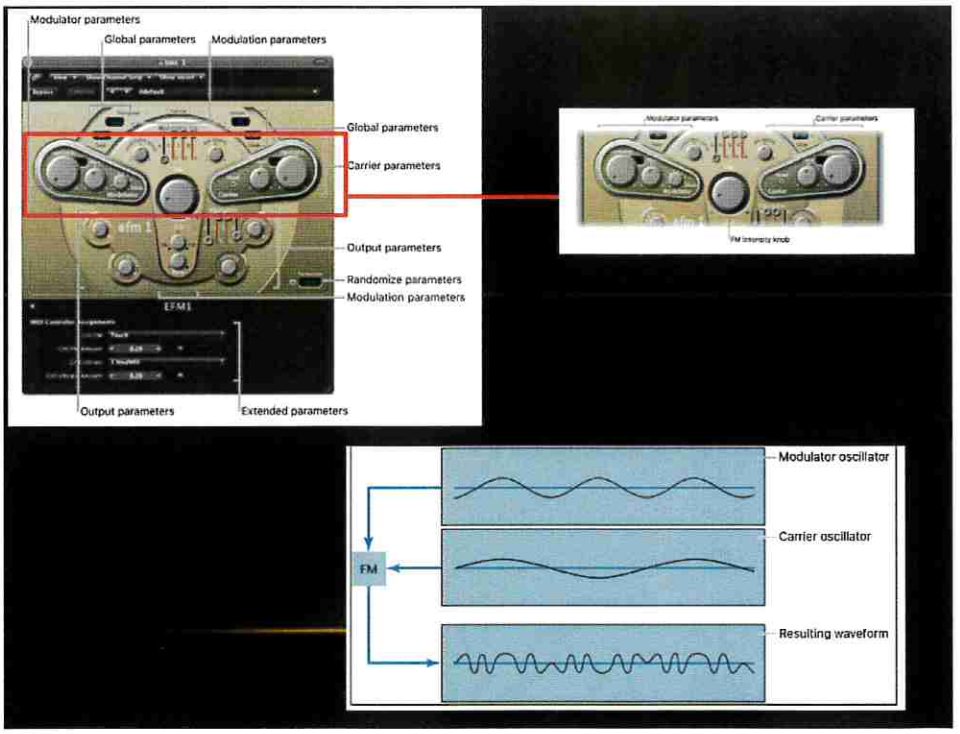
The basis of many forms of synthesizers and is commonly related to ANALOGUE synthesizers. It is achieved by combining sound waves or OSCILLATORS(VCO) to create a timbre rich in harmonics. This sound is sculptured using a series of modifiers, which includes a way of filtering out certain harmonics to create more complex and interesting timbre.

ADDITIVE

Complex waveforms are reproduced by summation of MULTIPLE SINE WAVES. This type of synthesis, using multiple sine wave generators(VCO), reproduces COMPLEX AND SOPHISTICATED TIMBRES by adding each waveform according to frequency and amplitudes determined by the programmer.

FREQUENCY MODULATION(FM)

Involves a multi-oscillator system(sine waves only). Each oscillator influences and change the output of the other. In its simplest form 2 oscillators, 1 called the MODULATOR and the other called the CARRIER. The MODULATOR changes and alters the frequency(pitch) of the CARRIER by constantly modulating the basic frequency at which the CARRIER operates.



RECREATE THE FM SYNTH SOUND

- Import the audio example and MIDI file at Music\A2 Music Technology\1 Extra Resources\C2\FM Synth
- Use EFM1 to recreate the sound

WAVETABLE

Sound generator stores sampled soundwaves of acoustic and electronic instruments stored in tables on a ROM (read only memory)chip.

GRANULAR

It works by building up sounds from a series of short segments of sounds called grains(usually around 30ms long). One sound can have anything from 200 to 100 grains. Due to its complexity this synthesis method is often found in software synthesisers

PHYSICAL MODELLING (PM)

This synthesis technique is based on the analytical study of how waveforms are produced. It is based on a series of complex mathematical equations and algorithms that describe the different stages of the sound-producing instrument. The principles of a VIBRATING OBJECT(string, reed, lip etc), the MEDIUM(air) and an AMPLIFIER(the bell of a trumpet, the body of a piano, cone of a speaker) interact to produce a particular timbre.

EVALUATE THE SETTINGS ON THIS RETRO SYNTH TO USE AS A PAD SYNTH

COMPONENT 2-MINIMUM REQUIREMENTS RECAP

Rule Number 2: Use a variety of synthesis techniques. Including different types of synths-subtractive, FM and PM

Assessment Grid 1: Synthesis

At the lower end of the cohort, students used minimal synthesis timbres in their work. When they were included they tended to be pre-set timbres with minimal/no editing. They also appeared as sporadic, fragmented token gestures, rather than being features of the work. Higher end students had used a good range of synthesis techniques and created most of the timbres themselves using subtractive soft-synths. Common techniques used were: Oscillators octaves apart and blended, sometimes with some subtle de-tuning. Filtering using a LPF with some cut-off movement. Attention to long/short attack and decay/sustain settings were used. Pitch bend and/or Glide were also common features. Envelope Generators on Filters were popular at the higher end as were creative uses of LFO's. Stylistically appropriate synthesis techniques were clearly researched in some pieces, which not only showed a clear demonstration of synthesis knowledge, but also demonstrated stylistic awareness and application.

SOUND DESIGN WITH ALCHEMY SYNTH

Alchemy is a powerful hybrid sampling synthesizer. It incorporates various synthesis techniques as well as allowing the user a significant amount of flexibility.

A few features:
4 sound sources A B C and D
Filters for each sound source and 2x Global Filter

Sound source options
Virtual Analogue
Sampler function
Spectral
Granular
Additive

Performance sections-change the start of your sound in real-time.

Arpeggiator-customise your pattern with powerful arp section

CREATING SOUNDS ANALOGUE SYNTH SOUND IN ALCHEMY

- Select the Advanced mode
- There are 4 sound sources-A, B, C and D and you should have a default sound
- To start creating your own sound, click on File>Initialize Patch
- By default a Saw waveform is loaded.
- Load a VA(Virtual/Voltage Analog) in Source A and choose a Waveform
- Each Source has 3 filters-tweak the filters to shape your sound. NB There is 2 Global filters for the overall sound.

Creating a 5th or 7th synth
-having 4 sound sources allows you to create a chord patch
-Load a Basic VA using the same waveform
-Switch on all 4 sound sources
-Tune B by 3 semitones(Minor 3rd)
-Tune C by 7 semitones(Perfect 5th)
-Tune D by 12 semitones(8ve)
This will create a minor chord. Change B to 4 semitones for a major or change D to 10 or 11 for a 7th chord.

ALCHEMY AS A SAMPLER

- You can use Alchemy as a Sampler by simply drag and dropping your audio sample into one of the sound sources.
- You can also load all of the EXS 24 and Alchemy sample library.
- Click the edit button to change the length of the sample and looping functions.

Spectral Synthesis

-Spectral synthesis is a really fun and complex way to explore new sound

-Import an Audio File and select Spectral

-The Real-time Spectrogram analysis your audio and you can shape the sound in a multitude of ways.

Granular Synthesis

-divides the sample into grains of audio

-you can decide how long the grains are and various different shapes

Click on source A and Import an Audio File
Choose EXS24 and drag the Choir Sound into the Drag area.
Choose Spectral and Import
Play the sound and change the filter and observe your Spectrogram

PERFORMANCE SECTION

This section allows you to take snapshots of different states of your synth by using the parameter knobs and 2 XYPads. You can access the section by clicking on Smart Control as well. This allows your synth to morph and continue to change to add interest to your sound.

- Time-based pair
- Filter pair
- Modulation pair
- X pair
- Click on the knob to change the setting

Create your own snapshot

1. Change the settings to create your desired sound
2. Right click on 1 and Store Current Snapshot
3. Right click again and Rename Current e.g. "Start "or "Phat"
4. Now move to another empty snap
5. Making changes to the settings and repeat 2 and 3

MODULATION IN ALCHEMY

Modulation is way a note starts and stops and how it changes volume or timbre over time or even repetitively. Basically it adds motion and interest your sound. It is important that your sound in not static and it changes over time. A key synth technique for component 2

Click on the knob(parameter) you want to modulate e.g cutoff
This will activate the modulation and you can assign a target eg. ENV or LFO

MSEG-Multi envelope generator, use this to customize your modulator

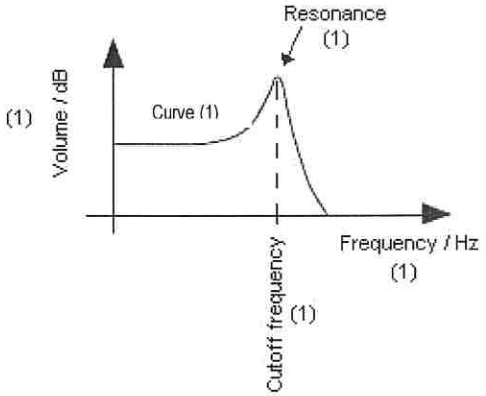
AHDSR-Your standard envelop section but it includes a hold stage.

LFO-The standard low frequency oscillator but with a huge amount of waveforms

SEQUENCER-You can program your motion with an arp styled step sequencer.

Question Number	Question	Mark
4b	• Figure 1 shows an analogue subtractive synthesiser from the 1970s. Many of the controls are similar to those of a software synthesiser plug-in. Explain the function of the controls seen in figure 1. Identify the benefits of using subtractive synthesiser software rather than 1970s analogue technology. • **Figure 1 is provided on a supplementary page.**	16
	Acceptable Answers	
	Comments must relate to the correct control given in ITALICS. Underlined technical terms must be spelt correctly Voltage controlled (1) **Modulator** LFO / low frequency oscillator (1) sine, square (both needed for mark 1) and sample and hold (1). *RATE* is frequency (1) shown by flashing LED (1) *DELAY TIME* is the time taken for the LFO to begin after a note on (1). **VCO** (Voltage controlled) oscillator (1). Pitch (1) *TUNE* is required because analogue synthesisers go out of tune / *POWER* needs to warm up to stay in tune (1). Fine / coarse (1) *MOD* is the amount of LFO applied to the pitch (1) giving vibrato (1). *RANGE* = octave (1) measured in feet / like a pipe organ (1) *WAVEFORM* = pink/white (1) noise. Saw, square, (pulse) (both needed for mark 1). Keyboard changes frequency / pitch (1) *PULSE WIDTH* is mark-space ratio (1) accept any clear explanation of mark-space ratio.	

VCF
(Voltage controlled) filter (1).
Low pass filter / LPF (1) apply SONC if HPF / BPF also.
Removes high frequencies / more muffled / brightness (1) **above** the *CUTOFF FREQUENCY* (1)
RESONANCE boosts the frequencies around the cutoff frequency (1)
Max 5 for correctly labelled diagram:
Allow a curve without resonance.



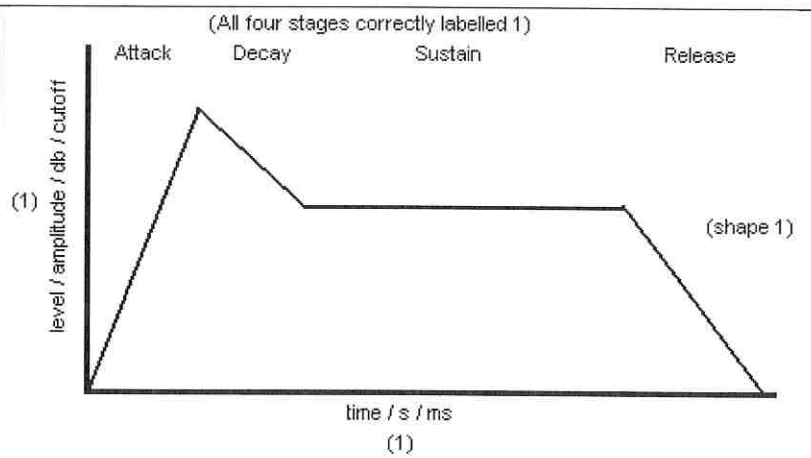
Envelope can control the filter cutoff frequency (1). The envelope can be inverted (1). *ENV FOL'R* envelope follower (1)

MOD is the amount of LFO applied to the filter cutoff frequency (1) giving wah-wah / any description of filter changing over time (1).

VCA
(Voltage controlled) amplifier (1)
HOLD = the note stays on forever (1)
ENV = control how the volume changes over time (1).
GATE = envelope can be switched off (1).
Keyboard triggers gate (1)

ENV
Amplitude (1) Envelope (1)
Attack, decay, sustain, release (1)

Credit written explanation or the graph to max 4
A = time taken for sound to reach maximum volume from 0 volume (1)
D = time taken for sound to reach sustain level from maximum (1)
S = level (held until note off) (1)
R = time taken for sound to reach zero after note off (1)



BENDER
Change the pitch (1) Change the filter cutoff frequency (1).

PORTAMENTO
Allows the pitch of the notes to slide into each other / glide (1).
Speed can be adjusted (1)

Benefits of plug-ins:
can be automated / MIDI controlled / sequenced (1)
velocity (1)
tempo sync LFOs / arpeggiators (1)
better signal to noise ratio (1)
presets / save sounds / new sounds over internet (1)
different settings on separate tracks / multiple use of the same plug-in with different settings (1)
stays in tune (1)
increased polyphony (1)
more envelope stages (1)
more types of waveforms (1)
more / multiple oscillators (1)
more filter types (1)
Other synthesis types (1) granular / additive / ring / AM / FM / wavetable / sample and synthesis / virtual modelling (1)
require less maintenance / no dirty pots / takes up less space / cheaper (1) (not less equipment / computer)

Question Number	Answer	Mark
6	**AO3 (5 marks)/AO4 (15 marks)** **Marking instructions** Markers must apply the descriptors in line with the general marking guidance and the qualities outlined in the levels-based mark scheme below. Responses that demonstrate only AO3 without any AO4 should be awarded marks as follows: • Level 1 AO3 performance: 1 mark • Level 2 AO3 performance: 2 marks • Level 3 AO3 performance: 3 marks • Level 4 AO3 performance: 4 marks • Level 5 AO3 performance: 5 marks **Indicative content guidance** The indicative content below is not prescriptive and candidates are not required to include all of it. Other relevant material not suggested below must also be credited. Relevant points may include:	20

AO3	AO4
LFO	
Low frequency oscillator.	
	Delay time is the time before the LFO is applied / LFO starts instantaneously on every note.
Rate is the frequency of the LFO. Hz.	Below 20Hz.
	LFO always applied, not via mod wheel.
DCO	
Digital controlled oscillator.	Stable pitch.
Vibrato.	Some vibrato could be added to create more movement.
Pulse wave on. Pulse width modulation.	LFO assigned to pulse width modulation. Give some movement to the sound / stop pad sounding static / accept flange/chorus/detuning. The LFO is on medium so the pulse width modulation would be a similar rate to a string section playing vibrato.
Saw wave off.	If this was switched on, there would be more power / thicker.
Sub oscillator adds an octave below. Square wave sub oscillator.	This would give the pad more weight, filling the mix. Cause low mid congestion / clash with the bass.
White/pink noise.	Unpitched. A little white noise would be good for a pad. Some white noise could have made the pad more 'breathy'/gritty/thicken.
HPF	
High pass filter / cuts low frequencies / low cut filter.	HPF off preventing the pad sounding thin. (Turning up HPF) to thin the pad would reduce low mid congestion.
VCF	
Voltage controlled filter.	
Low pass filter / LPF. Cutoff frequency.	Remove the high frequencies. Warmer / less harsh. A less bright sound would sit further back in the mix.
Resonance.	The high resonance will emphasise the (cutoff) frequency. High resonance will emphasise movement in the filter. This could be intrusive in a busy mix because a pad should sit behind the other mix elements.
Filter envelope invert switch.	Positive. The cut off frequency will slowly rise instead of falling, giving it a softer attack.
Envelope.	There will be evolution in the filter, adding movement. The cutoff frequency will change (throughout each note).
Low frequency oscillator.	There will be no cyclic modulation in the filter cutoff. Some LFO could be added to the filter to give more movement.
Kybd is filter keyboard tracking.	The filter cutoff frequency rises with pitch, so that higher notes do not become dull. (Allow reference to velocity sensitivity to the filter).
VCA	
Voltage controlled amplifier.	The envelope doesn't affect volume / envelope is bypassed / would begin at full volume (although it may sound quieter because the filter cutoff is low). Sudden start/end would be inappropriate for a soft pad. Release is ignored.
ENV	

Envelope. Attack, decay, sustain, release.	The long attack means that the cutoff (accept volume) would start low and gradually rise. The long decay means that the cutoff (accept volume) would then fall slowly (to the sustain level). The low sustain level means that note ends would be dull (accept quiet/silent). Medium release mean that the cutoff (accept volume) would fade. Long attack/release suitable for sustained chords.
CHORUS	
	Chorus makes detuned/vibrato/phase copies of the original sound. Ensemble effect / thicker texture / warm. Chorus would add further movement to the sound to prevent it sounding static. Stereo. Mode II is more intense.
Analogue	
Analogue.	Description of analogue character, e.g. warm / phat filter. Smooth movement of LFO, filters and pulse width.

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–4	• Demonstrates limited knowledge and understanding of production techniques/technology used, some of which may be misunderstood or confused. (AO3) • Shows limited analysis and deconstruction of production techniques/technology used with little attempt at chains of reasoning. (AO4) • Makes limited evaluative and/or critical judgements about the production techniques/technology used. (AO4) • Makes an unsupported or generic conclusion, drawn from an argument that is unbalanced or lacks coherence. (AO4)
Level 2	5–8	• Demonstrates knowledge and understanding of production techniques/technology used, which are occasionally relevant but may include some inaccuracies. (AO3) • Shows some analysis and deconstruction of production techniques/technology used with simplistic chains of reasoning. (AO4) • Makes some evaluative and/or critical judgements about the production techniques/technology used. (AO4) • Comes to a conclusion partially supported by an unbalanced argument with limited coherence. (AO4)
Level 3	9–12	• Demonstrates clear knowledge and understanding of production techniques/technology used, which are mostly relevant and accurate. (AO3) • Shows clear analysis and deconstruction of production techniques/technology used with competent chains of reasoning. (AO4) • Makes clear evaluative and critical judgements about the production techniques/technology used. (AO4) • Comes to a conclusion generally supported by an argument that may be unbalanced or partially coherent. (AO4)
Level 4	13–16	• Demonstrates detailed knowledge and understanding of production techniques/technology used, which are relevant and accurate. (AO3) • Shows detailed and accurate analysis and deconstruction of production techniques/technology used, with logical chains of reasoning on occasion. (AO4) • Makes detailed and valid evaluative and critical judgements about the production techniques/technology used. (AO4) • Comes to a conclusion, largely supported by a balanced argument. (AO4)
Level 5	17–20	• Demonstrates sophisticated and accurate knowledge and understanding of production techniques/technology used throughout. (AO3) • Shows sophisticated and accurate analysis throughout, and deconstructs production techniques/technology used with logical chains of reasoning throughout. (AO4) • Makes sophisticated and valid evaluative and critical judgements about the production techniques/technology used. (AO4) • Comes to a rational, substantiated conclusion, fully supported by a balanced argument that is drawn together coherently. (AO4)