MUS112 MUSIC TECH. 2

DR BRIAN BRIDGES (MODULE CO-ORDINATOR)

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WK1 HISTORY & KEY CONCEPTS

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INTRODUCTION TO MODULE

- This module **builds on the skills acquired in MUS111**, focusing in greater detail on **contemporary electronic music production** Digital Audio Workstation (DAW) - Apple Logic Pro.
- The module aims to introduce students to **more advanced sequencing, audio handling, arranging and production skills** while also enforcing their **real world understanding of working practice**, production styles, professional workflow and digital audio systems.

MODULE TEACHING STYLE

- ...transition to **more 'university'-style learning: lecture-driven**
- **Lectures on key concepts**: how it works in theory *informing how it works in practice*
- **Preparation for year 2 optional modules**: sound engineering and electroacoustic composition
- **'Last chance' to cover key music technology topics** for those who do not opt for tech modules in years 2 and 3

MODULE SUMMARY

- Introduction to acoustics and theory of sound synthesis
- Coverage of sound/instrument design using Logic Pro's software synthesisers and their key parameters
- More advanced mixing
- Coverage of digital audio editing and sampling techniques
- Coverage of digital audio effects and mixing techniques
- Discussion of aesthetic results of these processes/techniques

MODULE STAFF AND RESOURCES

- Dr Brian Bridges (bd.bridges@ulster.ac.uk): module co-ordinator and lecturer (I'm good about replying to email, not so great about phone messages!)
- See library-based and related resources (reading list)
- Where relevant, lecture slides and other module documents will be emailed to your Ulster account

MODULE ASSIGNMENT (SUMMARY OF BRIEF)

- Desktop audio production (100%) for Tuesday 9th May
- Each student is required to produce an original piece of music production of at least two minutes in duration which incorporates the following aspects or takes note of the following issues:

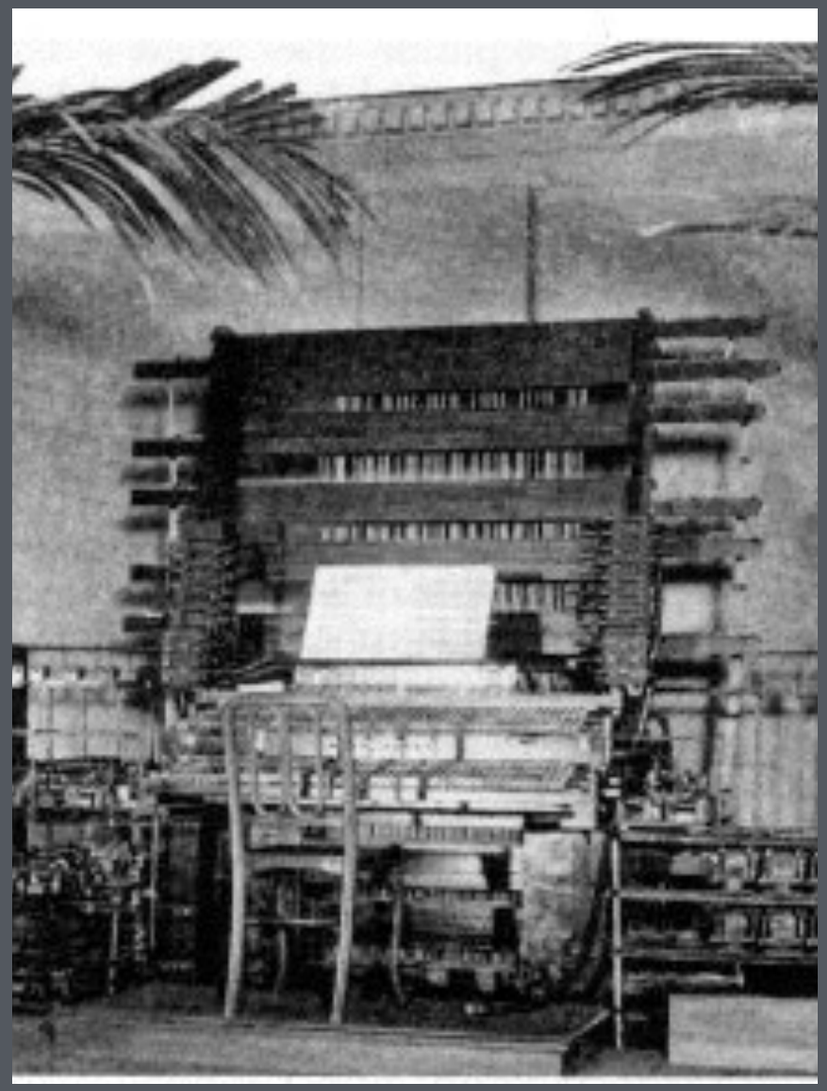
(1) sound design using synthesisers and samplers (2) self-created drum patterns/loops (3) integration of limited number of Apple loops (audio/software instrument) (4) use of effects (5) use of tone controls/EQ for balanced mix (6) coherent arrangement and compositional structure (7) suitable automation

BRIEF HISTORY OF ELECTRONIC MUSIC & SYNTHESISERS

Q1: When was the first electronic instrument invented?

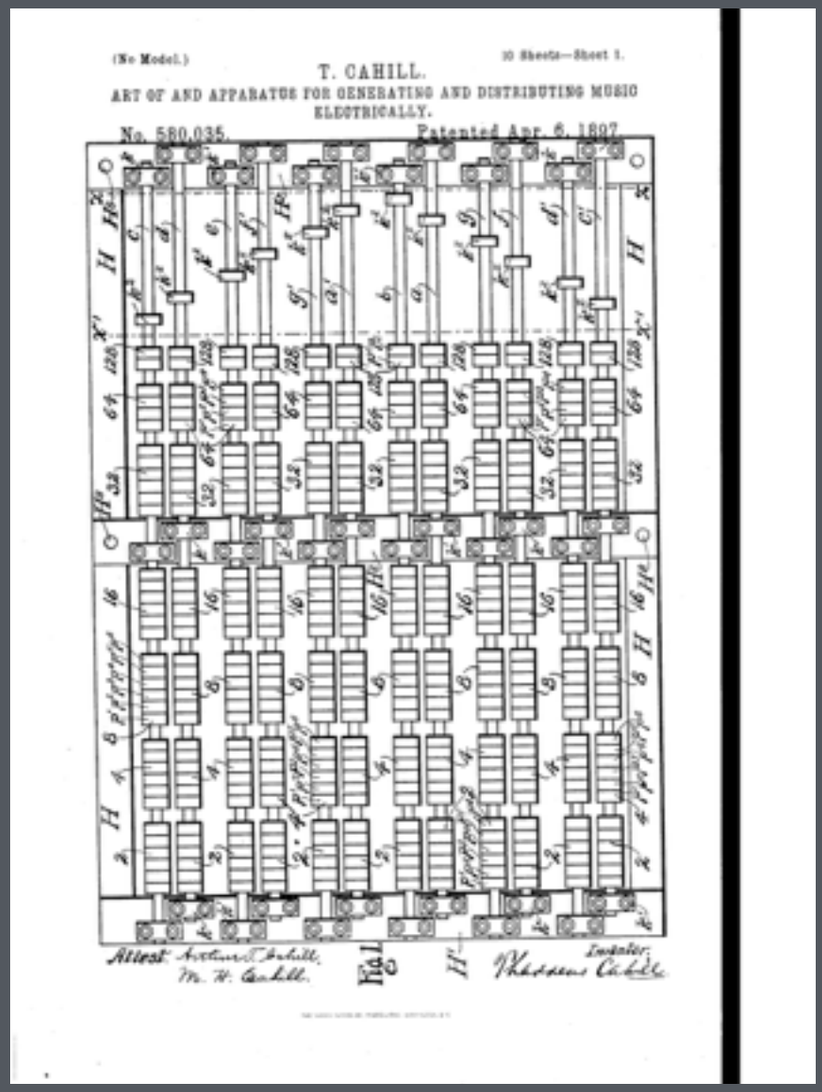
Genesis - Singing Arc & Telharmonium

- Electronic music begins earlier than you think
- Singing Arc - William Duddell - 1899
- Exploited side-effect of electric street lights - annoying whistle - designed as a scientific novelty for lectures - keyboard-controlled for demonstrations
- Somewhat unpleasant. No musical/ commercial development followed (Mackay, *Electronic Music*)
- More successful, however, was the **Telharmonium** - Thadeus Cahill - designed in 1897, completed in 1902



Telharmonium (contd)

- Pitch-generating mechanism anticipated tonewheels of Hammond Organ
- Used telephone lines to distribute music - ordinary telephone receivers were fitted with megaphones (no proper electronic amplification yet)
- Problems - size, reliability, telephone interference
- Radio would have brought about its demise in any case! But it was heroic!
- Want to know more? A documentary ‘Magic Music From The Telharmonium’ can currently be found on Youtube - http://www.youtube.com/watch?v=PPlbXl81Rs0&feature=related


(No Model.) 10 Sheets—Sheet 1.

T. CAHILL.

ART OF AND APPARATUS FOR GENERATING AND DISTRIBUTING MUSIC ELECTRICALLY.

No. 580,035. Patented Apr. 6, 1897.

Fig. 1.

Attest: Arthur L. Cahill, M. W. Cahill.

Inventor: Thaddeus Cahill

Futurists

- Italian art phenomenon of the early 20th C (parallel movements elsewhere)
- Worked in a number of artforms - sound, poetry, sculpture etc.
- Admired/idealised new technology
- One prominent Futurist, Luigi Russolo, published a manifesto entitled ‘The Art of Noises’ and constructed musical instruments to imitate the sound of industrial machinery - intonarumori.

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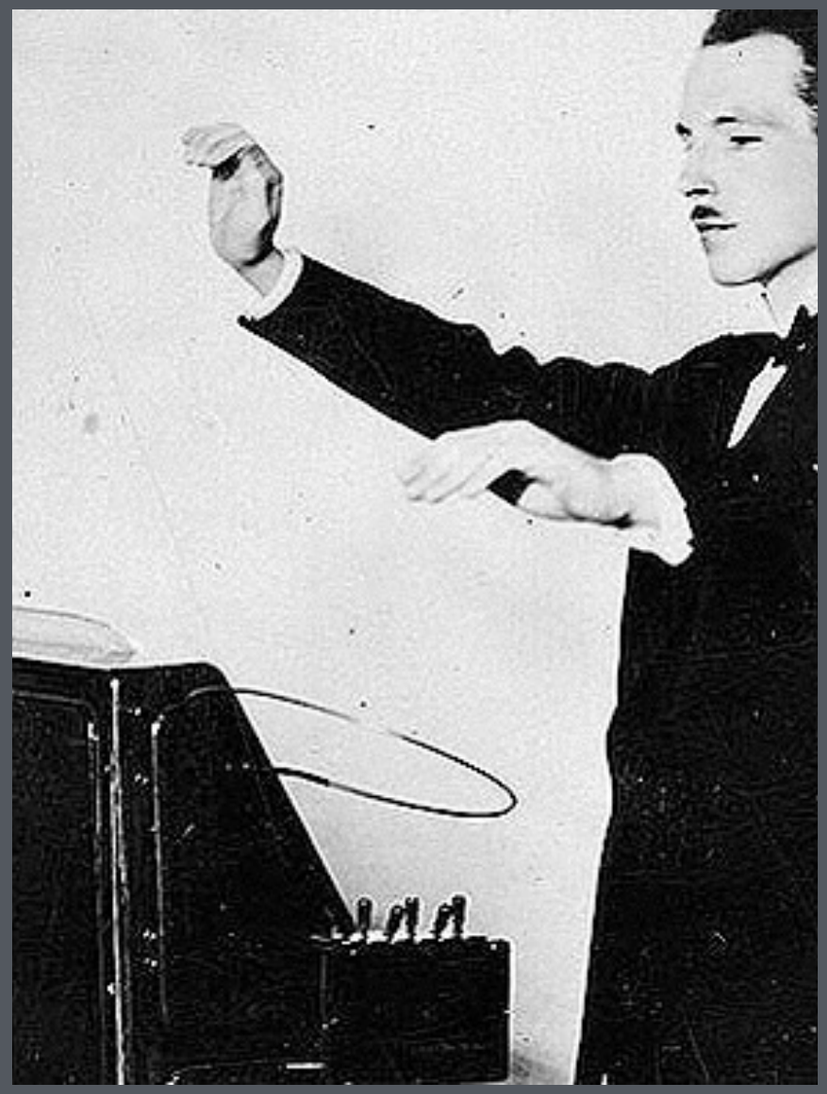
Theremin

- Arguably the first electronic instrument with widespread success
- Invented by Leon Theremin, in 1919
- Comparatively simple to construct
- Innovative interface, visually striking - practically iconic
- Somewhat difficult to control, though apparently Lenin was a natural!

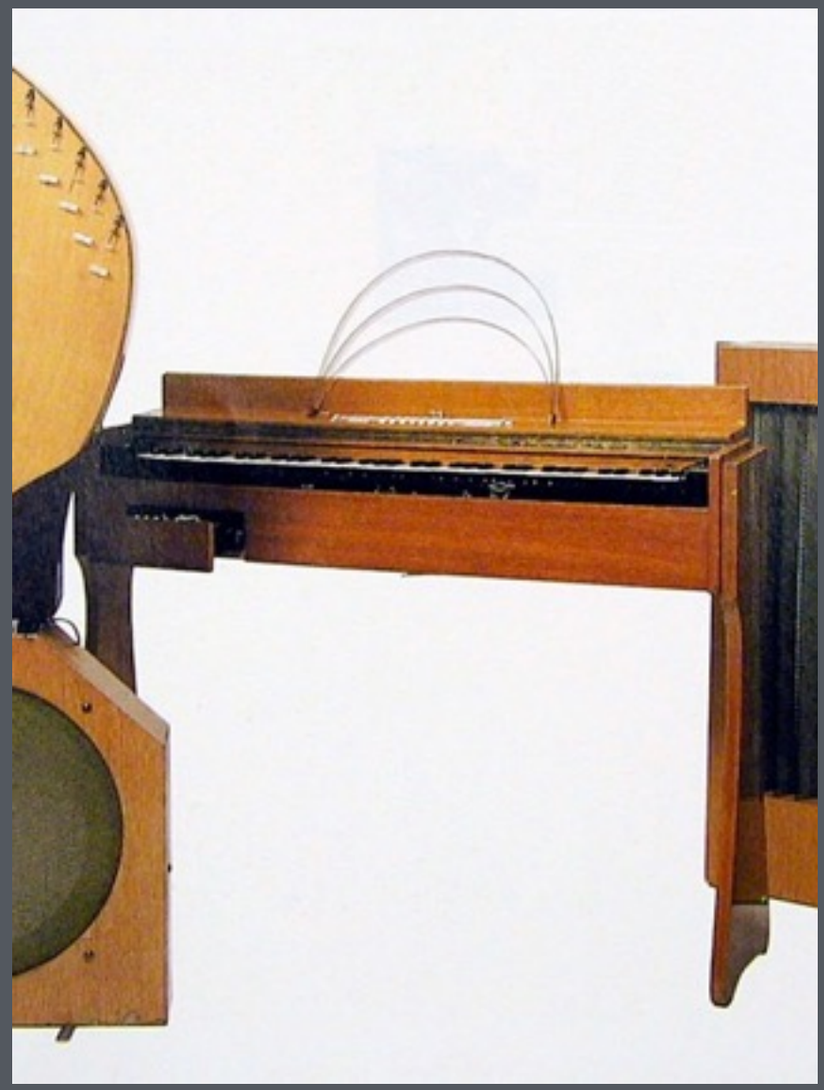


Theremin

- One early virtuoso was Clara Rockmore, a former violinist (who switched to the theremin because of problems with her hands)
- Developed a vocal-like vibrato style for performance of Romantic-era Western Music
- http://www.youtube.com/watch?v=pSzTPGlNa5U
- Some major works composed for theremin and ensemble such as *Ionisations* by Edgard Varèse
- Theremins also found in horror/science fiction movies and the odd 1960s record

Ondes Martenot

- French for ‘Martenot’s waves’ - invented in 1928 by Maurice Martenot
- A more controllable variation on the Theremin idea, which used a ring and wire to control pitch
- Music: Concerto for Ondes Martenot and Orchestra by Jacques Hétu



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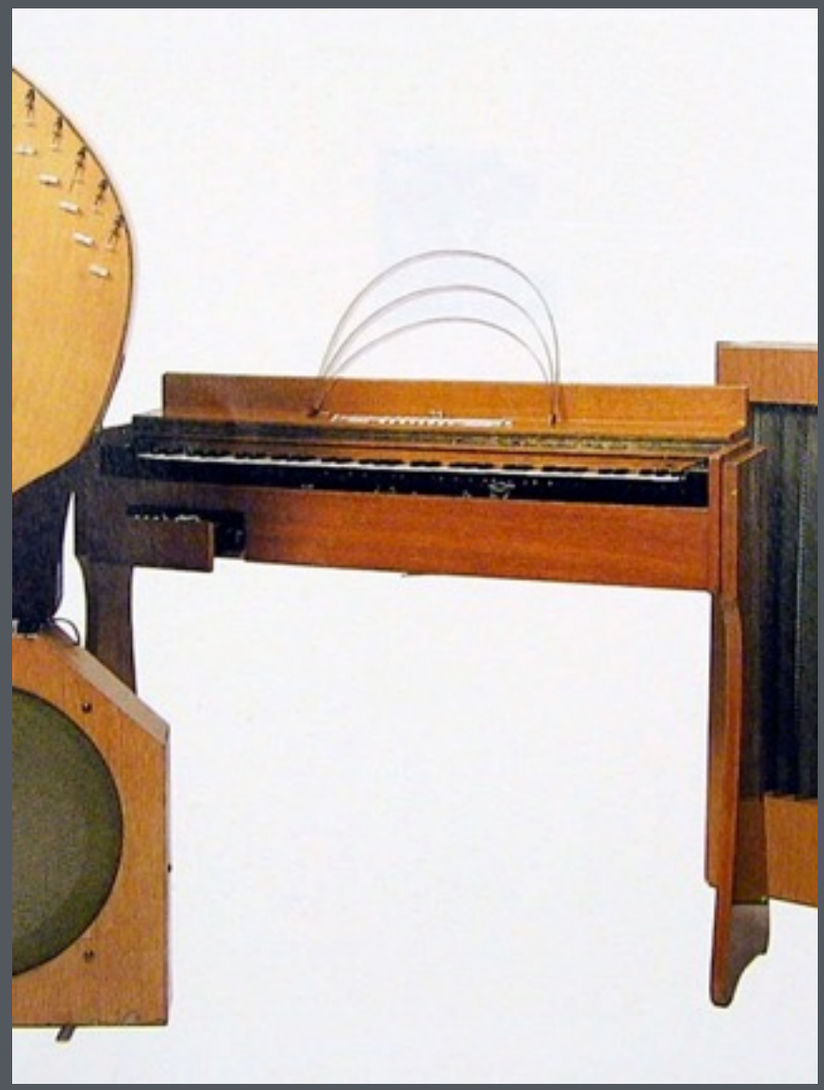


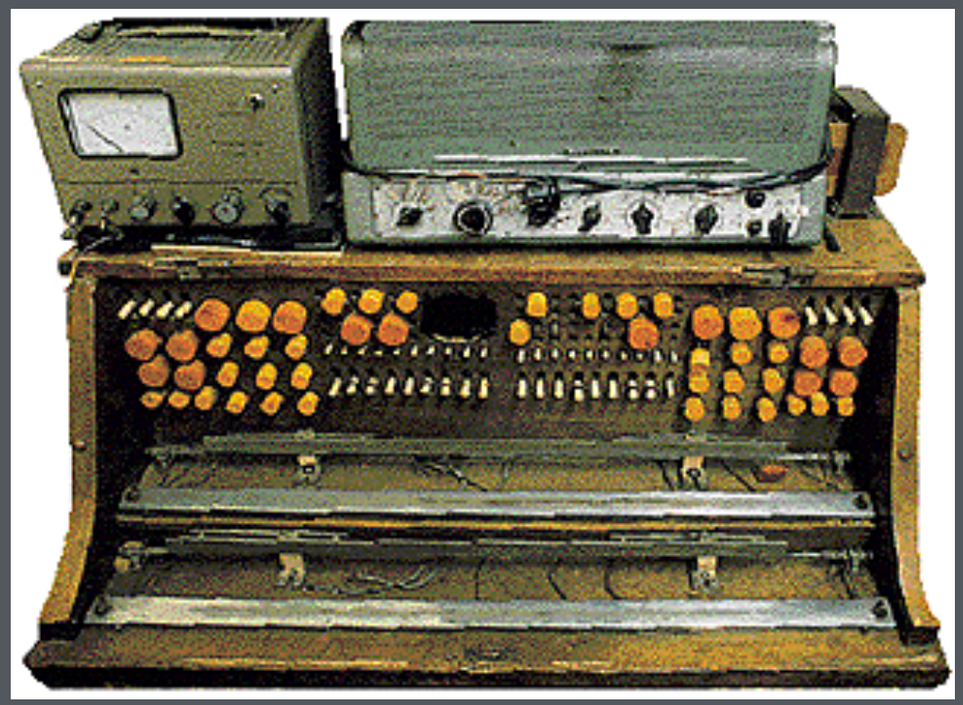
Trautonium

- Work begun by Friedrich Trautwein (1929), developed by Oskar Sala

- Control based on resistive wire (like previous example),

- electronic sound generator - oscillator - which had a richer sound so its output shaped by tone control - filter

- Here's the latter inventor himself demonstrating a later version of the instrument http://www.youtube.com/watch?v=-tQQEChMq1A

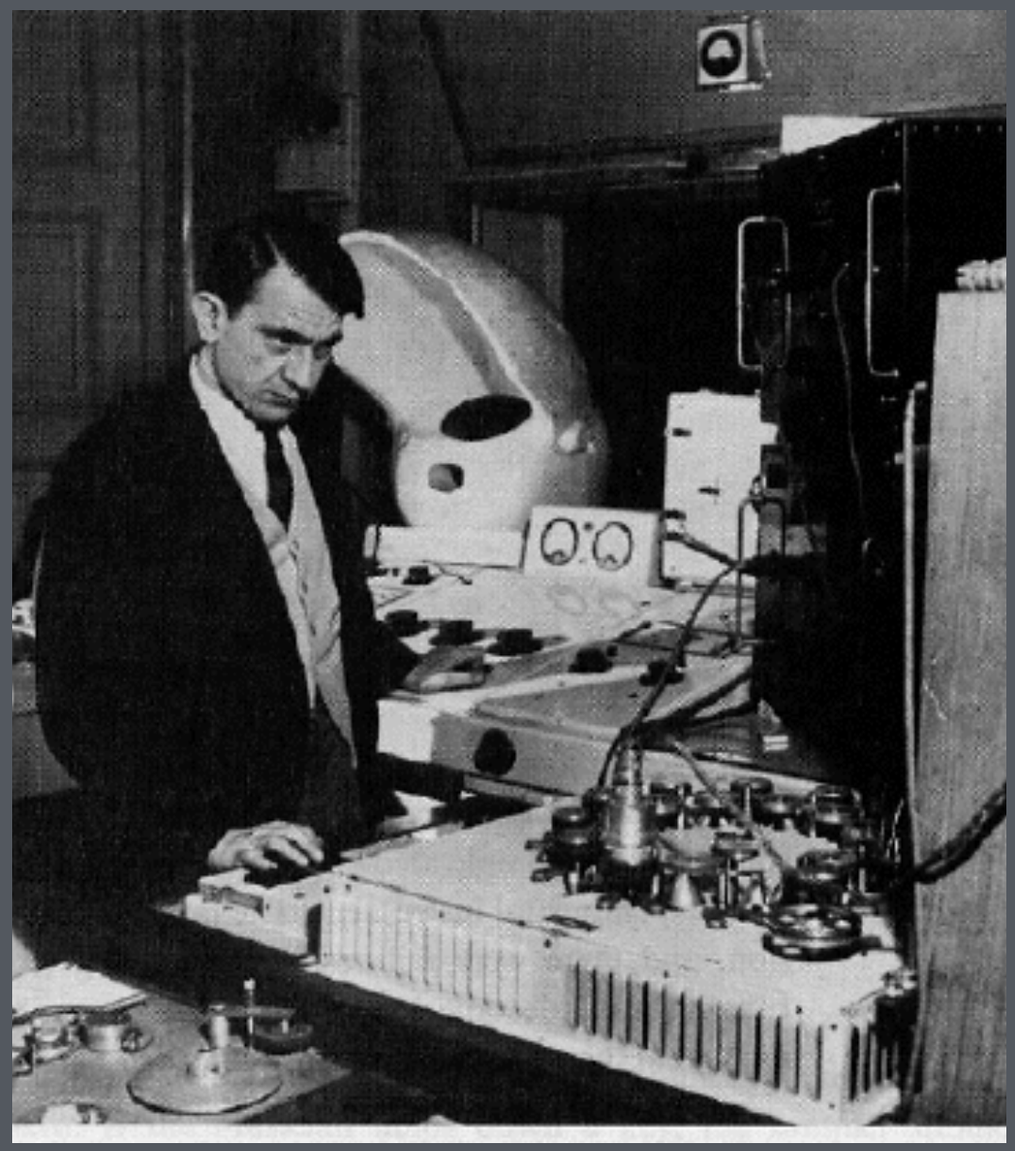


Musique Concrète

- Pierre Schaeffer was a French radio engineer who became interested in the possibilities of composition using recorded sounds. The sounds were drawn from the ‘non-musical’ world of everyday human and industrial sounds. He termed this type of music *musique concrète.*

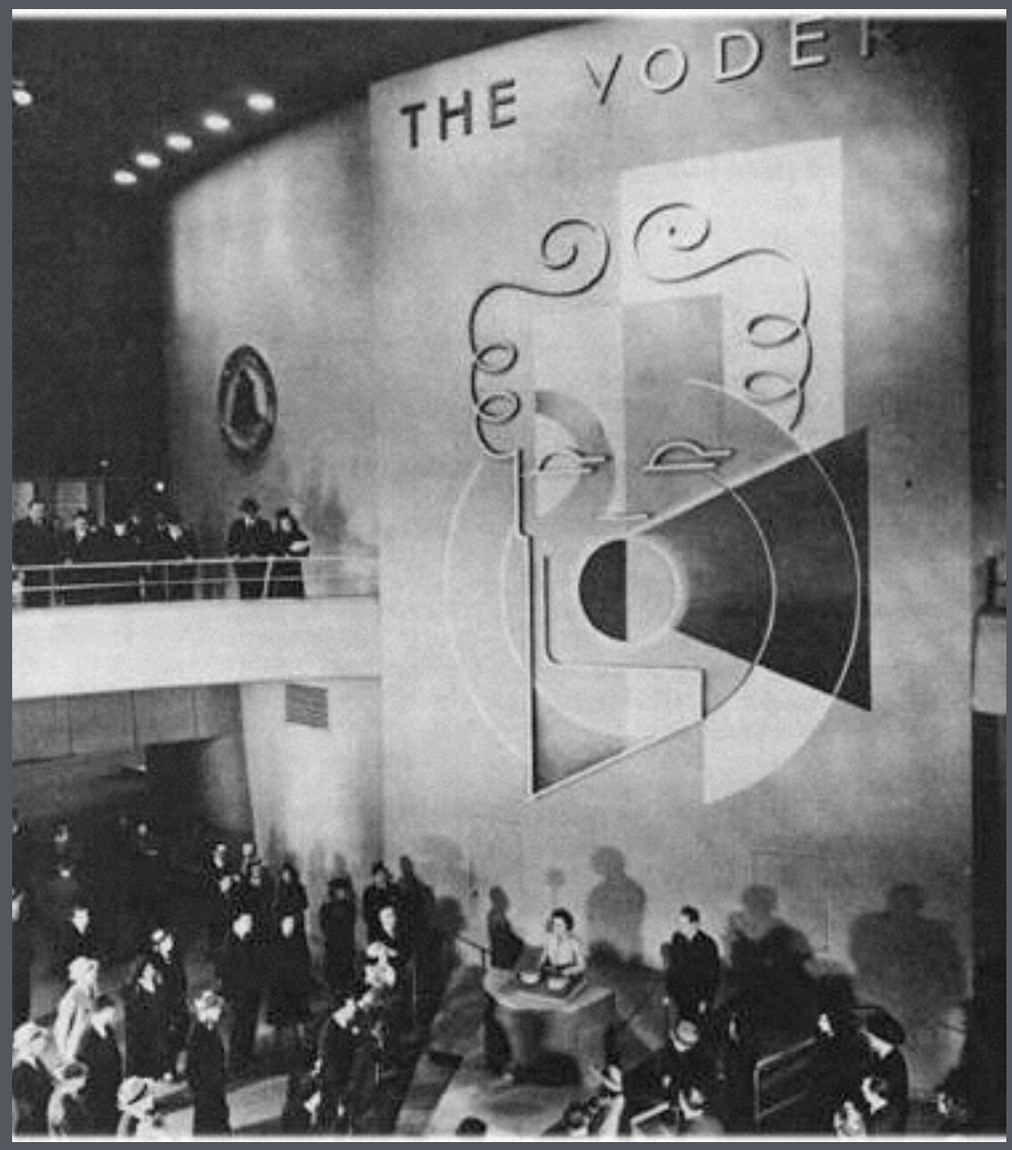
- He could be considered an ancestor of today’s sample-based musicians.

- Thanks to the wonders of Youtube (occasionally better than the library of Alexandria), here is Schaeffer’s first work - Etude aux chemins de fer (1948) - http://www.youtube.com/watch?v=N9pOq8u6-bA



The Voder/Vocoder

- The ‘robot voice’ effect led to some of the earliest developments in German *Elektronische Musik*!
- Really, here’s how it happened...
- Werner Meyer-Eppler, the director of Phonetics (i.e. speech science) at Bonn University witnessed a demonstration of the **vocoder** and realised that electronics could be used to **generate new sound materials for music composition**
- He gave a series of lectures on new possibilities in electronic music, leading to the setting up of the **first synthesis studio in Cologne in 1951**



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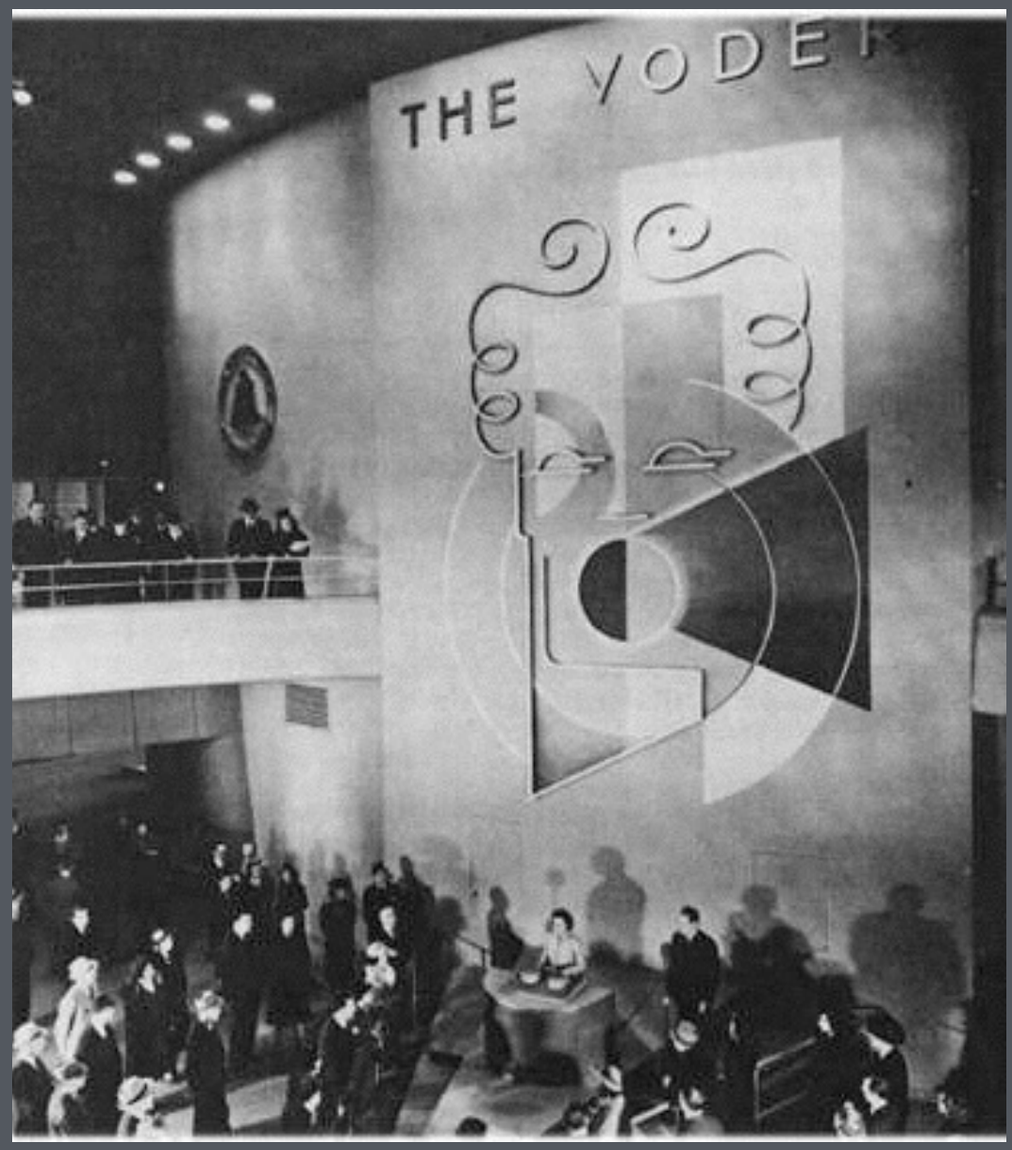


RCA Music Synthesizer

- 1957 -
  The RCA Mark II
  First **programmable** electronic synthesiser
- Analogue sound generation - quite simple - **programmable refers mostly to the ability to 'sequence' notes and specify sounds** - but the synthesizer was not a computer as such
- One example was installed at the Columbia-Princeton Tape Music Centre in New York - was used by composers interested in music of rhythmic and melodic complexity (though it was used on some pop records elsewhere!)

RCA Music Synthesizer

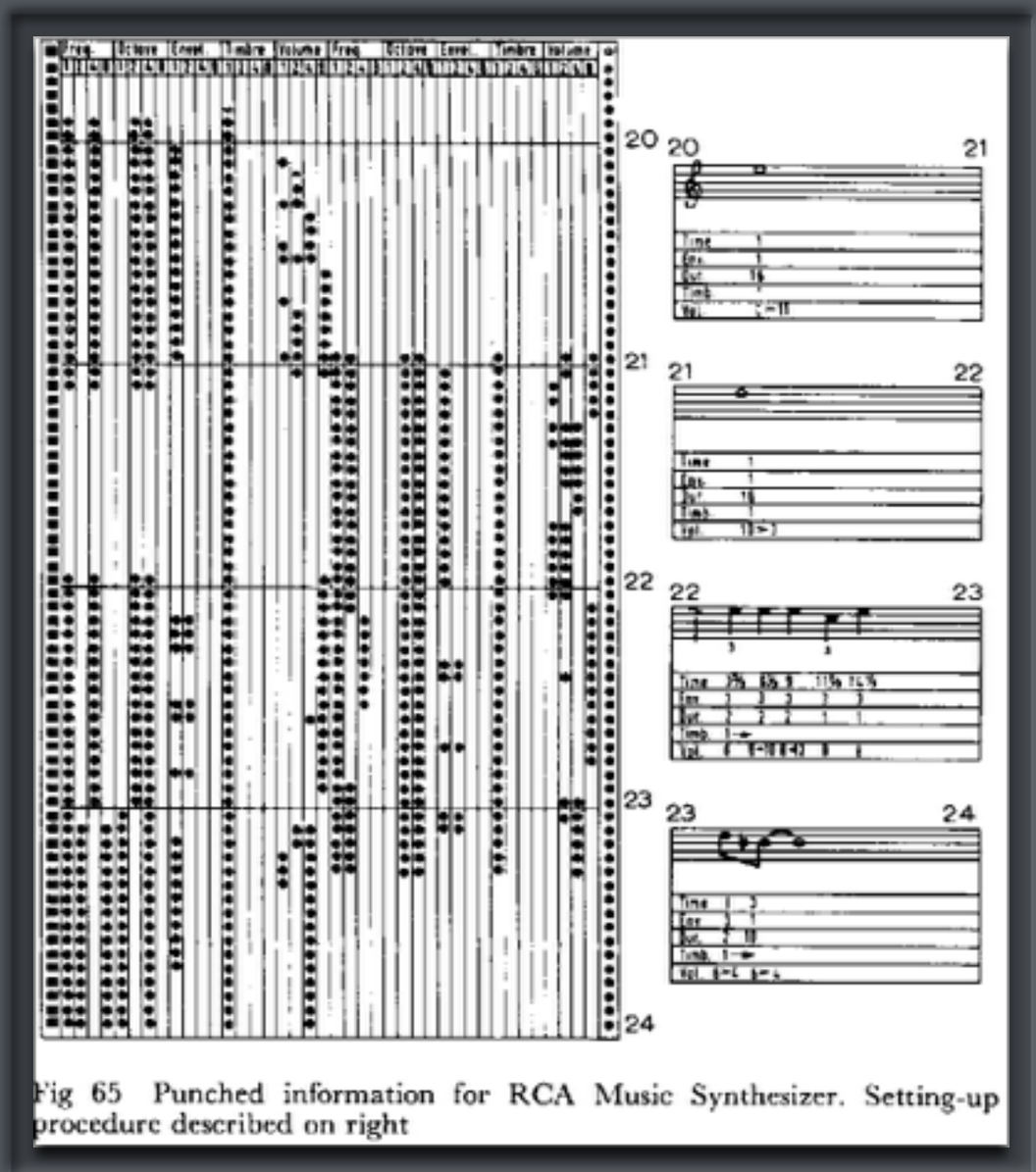
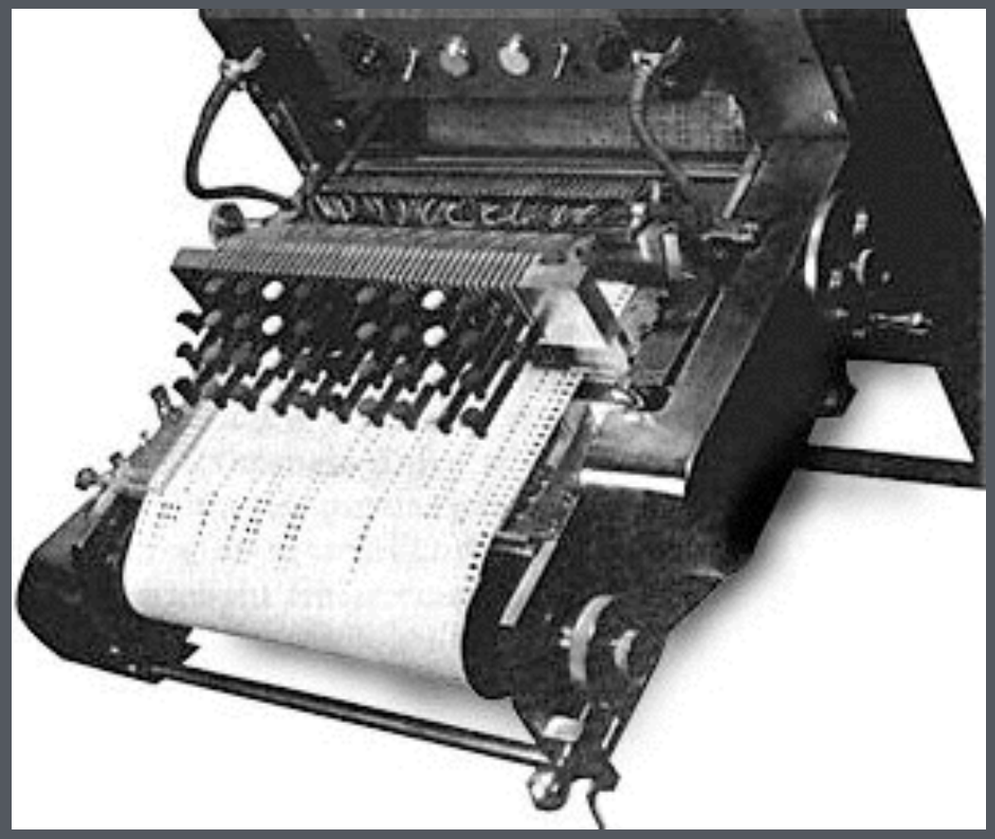


Fig 65 Punched information for RCA Music Synthesizer. Setting-up procedure described on right

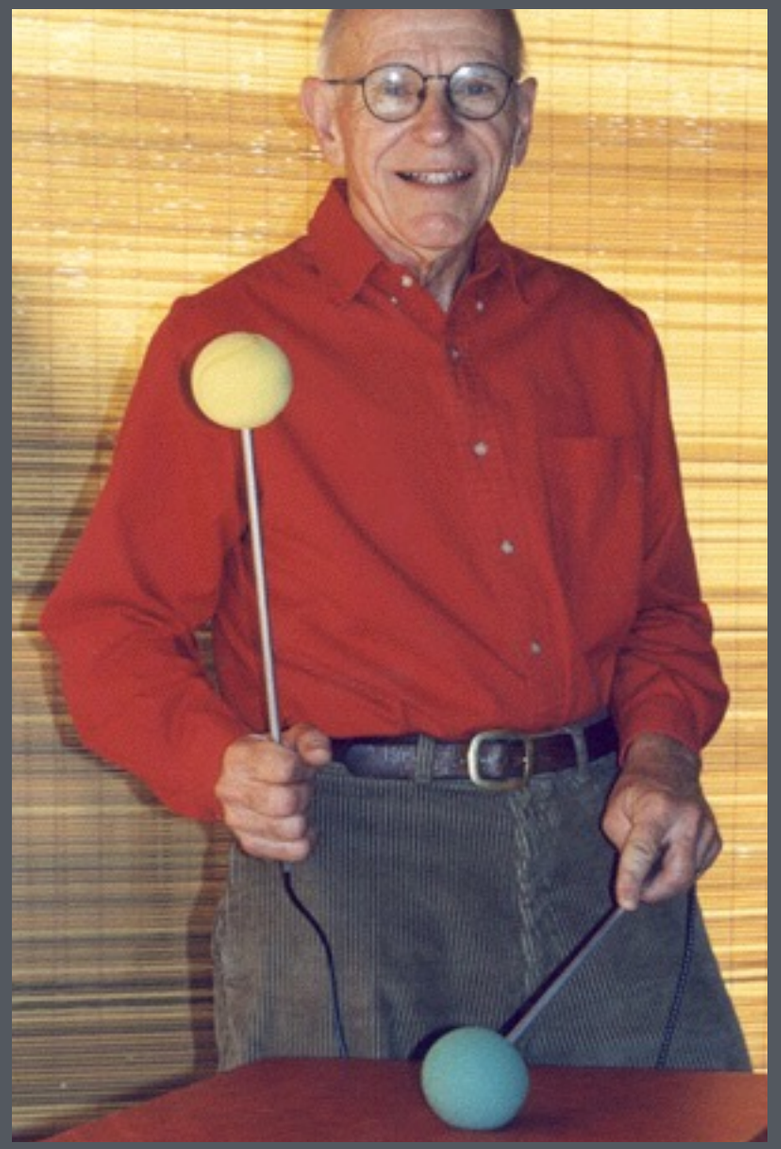


Bell Labs and Computer Music

- In common with other areas of digital audio, many developments in computer music were spurred on by work on telecommunications engineering

- Some staff at Bell Labs in New Jersey, including Max Matthews (right) began to experiment with computer programmes for sound synthesis and sequencing in 1957(!)

- This resulted in a family of music synthesis languages known as Music N - text-based files would control the synthesis (**orchestra files)** and sequences of notes to be generated (**score files**)

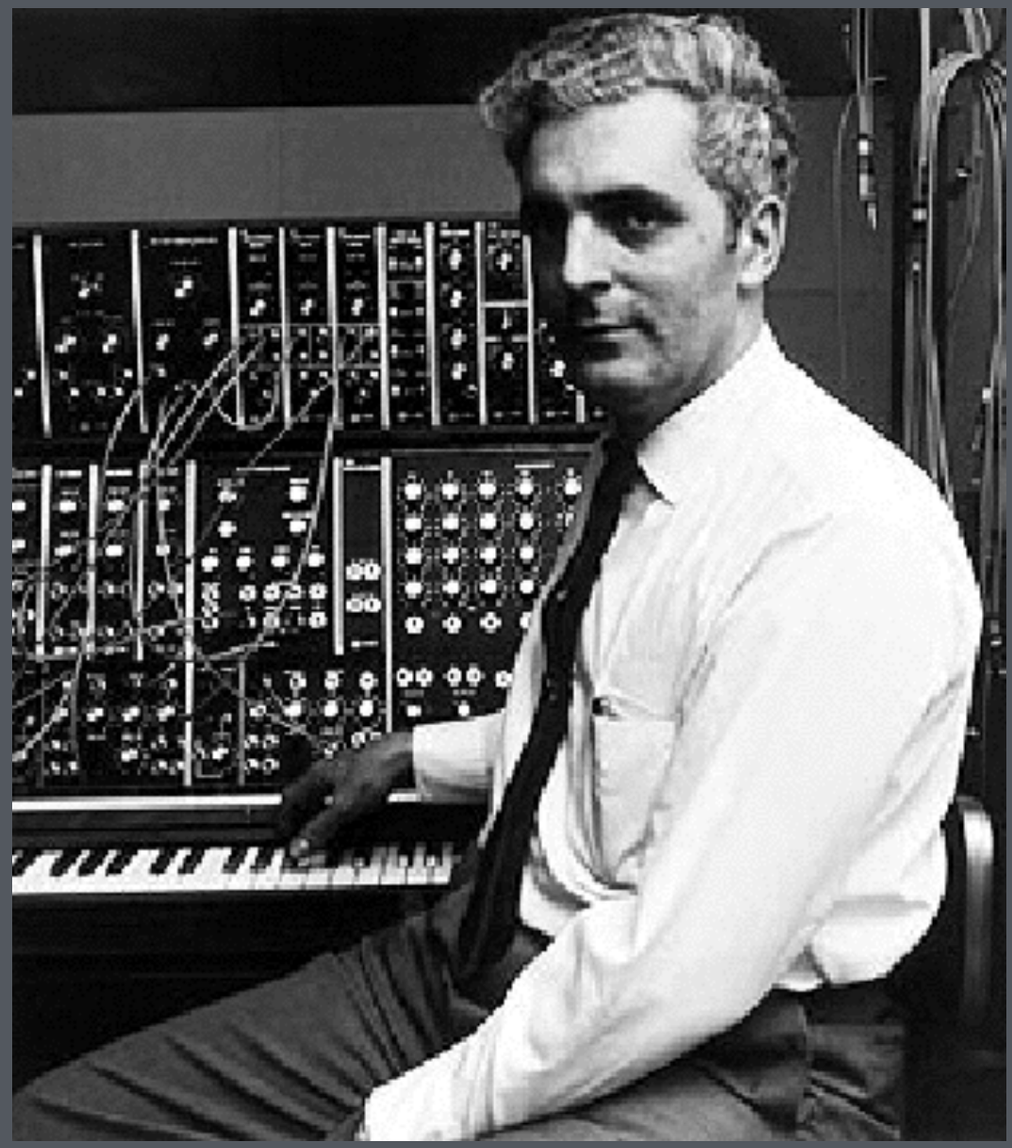


Moog and Voltage Control

- Robert Moog created one of the first **voltage-controlled** synthesizers, demonstrating it at the AES convention in 1964

- This system allowed for voltages to be sent between various synthesizer **modules** to control aspects of the sound - effectively acting like a complex remote control

- Moog sold one of the first successful synthesizers, which was based upon oscillators (sound generators) and filters (which shaped the sound), along with envelope generators (which changed the volume or filter levels automatically)



Minimoog

- Fairly straightforward analogue synthesizer based on subtractive synthesis (rich waveform generated by oscillators, processed by a filter)

- Released in 1970, one of the most successful synthesizers of all time

- Had the benefit of being easier to use (pre-patched rather than modular) and less expensive than other synthesizers

- A pretty in-depth demonstration of the Minimoog can be found at the link below

- http://www.youtube.com/watch?v=WY2AeD0Tn4Y

Polyphonic Synthesis

- Towards the end of the 1970s it became feasible (just about) to duplicate electronics such that polyphonic synthesizers were possible.

- They were big, bulky, heavy and expensive (some, like the CS-80 pictured here, might have costs comparable to mortgages of the day.

- The problem was that there was a lot of duplication of analogue circuitry within these devices. Analogue electronics did not lend themselves to easy duplication.

- Digital electronics, however, would make things easier - the next major development.

1980s - Digital, FM, MIDI

- The 1980s brought a new approach. Front panel and live control was reduced. Rather than a more limited range of easily customisable sounds, there was a move towards a more extensive range of ‘preset’ sounds.

1980s - Digital, FM, MIDI

- FM (Frequency Modulation) synthesis helped to encourage this approach, due to its comparatively non-intuitive programming.

- FM (briefly) is a form of synthesis derived from vibrato (variations in pitch) at very fast speeds. If this happens fast enough, frequency components (harmonics) are added to the sound. Two tone generators can be made to sound like many.

- Good for 1980s brass and bell sounds. Think ‘Last Christmas’! Like many things in the 1980s, it must have seemed like a good idea at the time...It should be noted that FM was used to more subtle effect by the likes of Brian Eno and its inventor, John Chowning.

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1980s - Digital, FM, MIDI

- MIDI stands for **Musical Instrument Digital Interface.** It was a standardised means of remotely controlling synthesizers and other music production and recording equipment.

- MIDI does not produce sound, it only tells a synthesizer module which notes to play using which preset, and when.

- Its wide adoption was facilitated by the new wave of digital synthesisers in the mid-1980s

Alternative approaches - Wavetable synthesis

- Yamaha owned the patents to FM. (They bought them off Stanford University and John Chowning, the process's inventor.)

- Other manufacturers tried other approaches. PPG tried a particularly interesting one with Wavetable synthesis - a series of different audio 'frames' were scrolled through, producing a dynamically evolving and 'morphing' in the sound.

- This particular example, the PPG Wave, still used analogue filters for 'warmth'. 80s synthpop band Depeche Mode liked them a lot.

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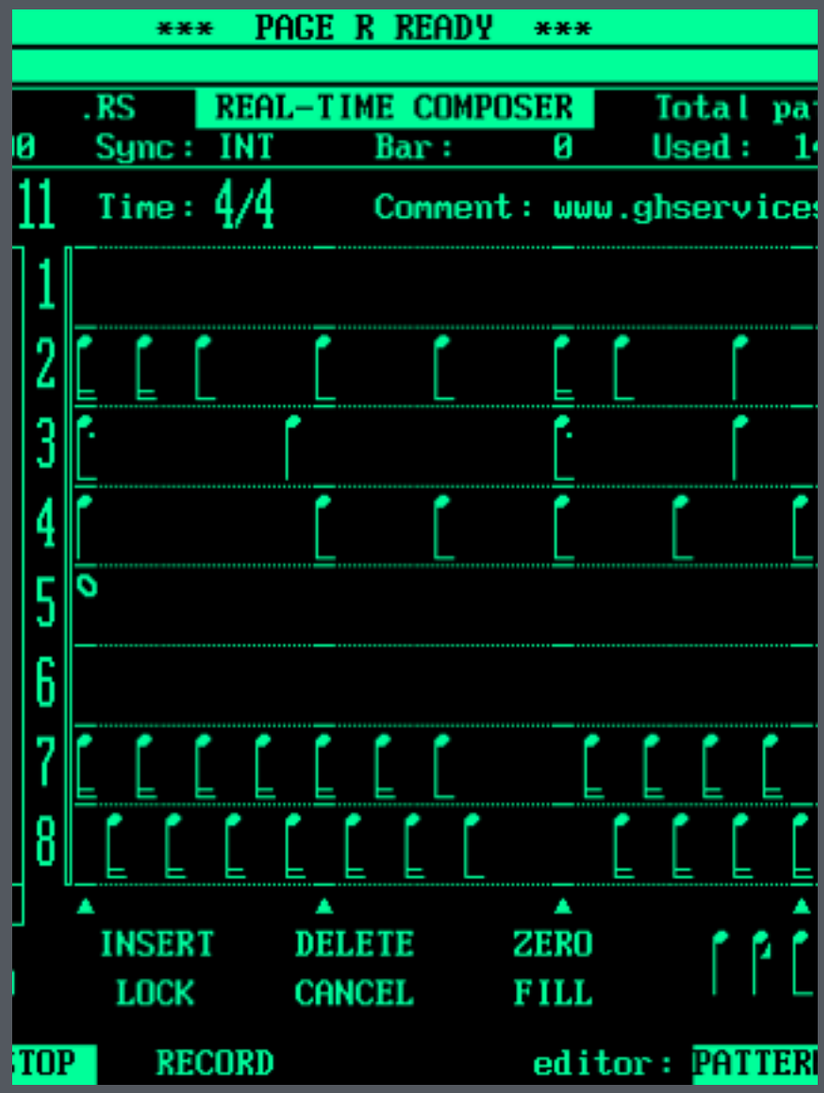
Sampling/sequencing - Fairlight CMI

- The Fairlight Computer Musical Instrument was an early sampler/sequencer.

- Samplers allowed snippets of sound to be digitally recorded, edited and arranged in various orders.

- It had very limited memory to store recordings, and was so expensive that only large studio facilities could afford to purchase it.



Drum Machines

- A much more specialised beast, the LinnDrum also used digital samples, but preset ones of drums. Compared to previous drum machines, it sounded very realistic.

- At around this time, the Musician's Union in England became concerned about the threat drum machines posed to the livelihoods of drummers!

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Drum Machines

- However, an unlikely success was to be found in the Roland drum machines of the day - the TR-808 and TR-909.

- These did not sound at all like acoustic drums, since they used basic analogue circuits, but they had a sound ‘signature’ which suited early dance music producers, and became quite sought-after.

- Many modern drum machines now offer copies of these sounds. They have become part of the music production ‘vernacular’.

Virtual Analogue Synthesis

- As the 1990s rolled around, Fashions changed, and analogue synths came back into fashion.

- However, analogue machines could be expensive, hard to find and unreliable.

- Clavia, a Swedish company, came to the rescue with their Nord line of synths, designed to use digital technology to 'model' the behaviour of analogue circuits.

- This approach became known as 'virtual analogue synthesis' or 'analogue modelling'.

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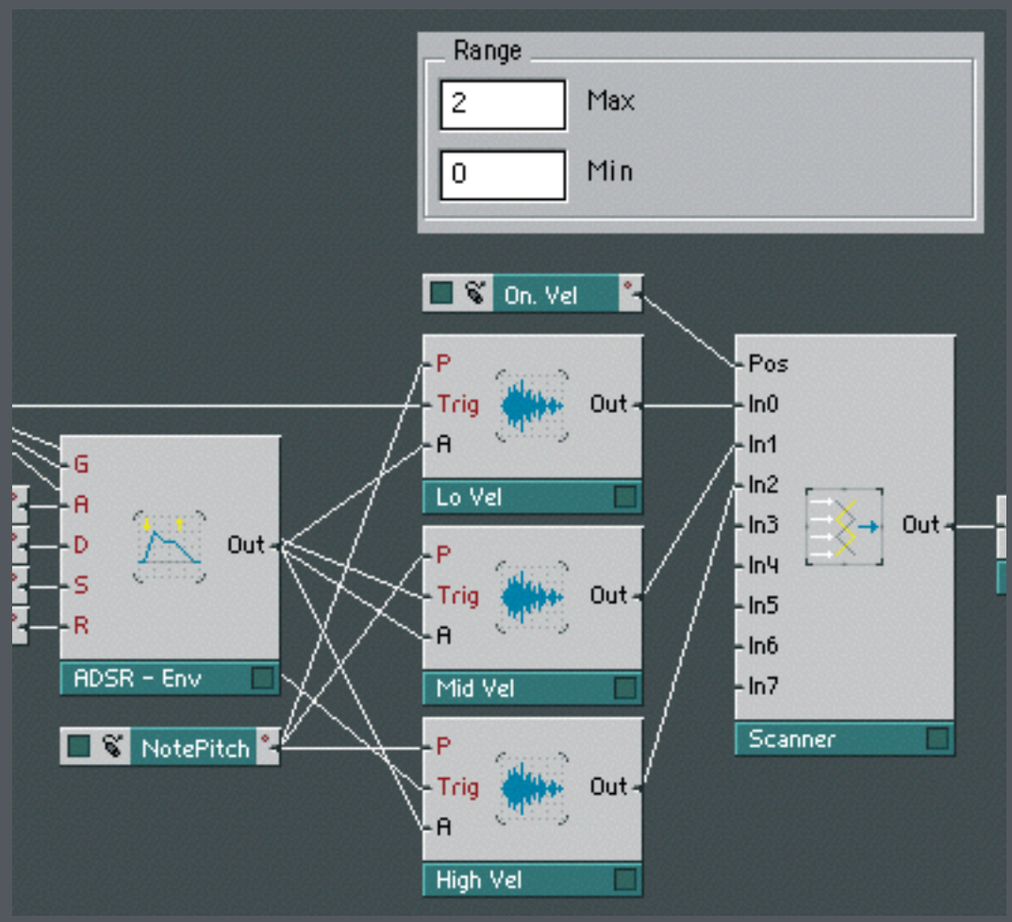
Computer Control and Synthesis

- Mid-late 1990s - computers get faster, capable of generating live audio data

- Software synthesis systems become more important - pre-built synthesizers such as FM8, Massive and Imposcar or more open systems such as Reaktor and Max gain in popularity and feasibility

- Sonically, the 21st century becomes a truly postmodern age! A range of ‘historical’ synthesis methods become instantly accessible, along with some new experimental ones



Want to know more?

The following books are available in the library

- *Electric Sound - the Past and Promise of Electronic Music* by Joel Chadabe
- *Electronic and Computer Music* by Peter Manning
- *Electronic Music* by Andy Mackay

For details on individual instruments:

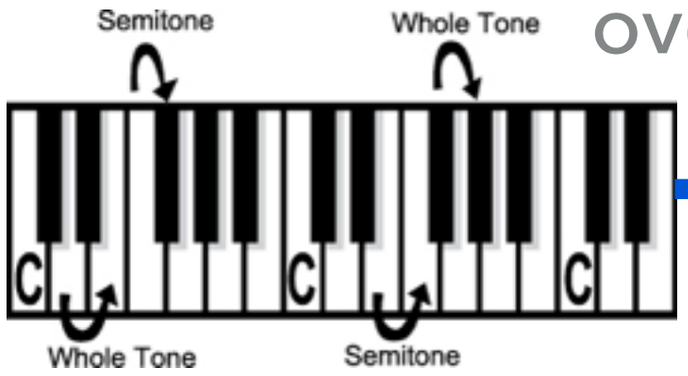
- www.synthmuseum.com
- www.vintagesynth.com
- www.sonicstate.com

KEY CONCEPTS: MIDI (MUSICAL INSTRUMENT DIGITAL INTERFACE)

MIDI AND DIGITAL AUDIO—FLOWCHART

MIDI messages

over USB lead



numbers describing audio

Audio interface

electrical signal describing audio

Computer running Logic

(Logic hosting software instruments)

interprets MIDI messages,

sends to software instruments

MIDI: MUSICAL INSTRUMENT DIGITAL INTERFACE

- Released in January 1983: control protocol to integrate control of synthesisers, controllers and other studio hardware
- ‘Remote’ control messages, *not audio signals* (i.e. may send instructions which contribute to triggering sounds, alteration of sound generation parameters)
- Small amounts of data/low bandwidth

MIDI STRUCTURE: BASICS

- **Event messages with modifiers**
- Play key= **MIDI note number** from 0-127, **MIDI note velocity** in same range *(note on)*
- **Release key= same MIDI note no, MIDI velocity=0** ***(note off)***
- e.g. send message from controller keyboard (*not synthesiser*) to software instrument (synthesiser) within Logic
- Q: Why design a MIDI message like this? Does it explain how a MIDI-related problem sometimes occurs when you stop playback in Logic?
- *The structure of these messages will become important when you work with Interactive Music Systems in year 3*

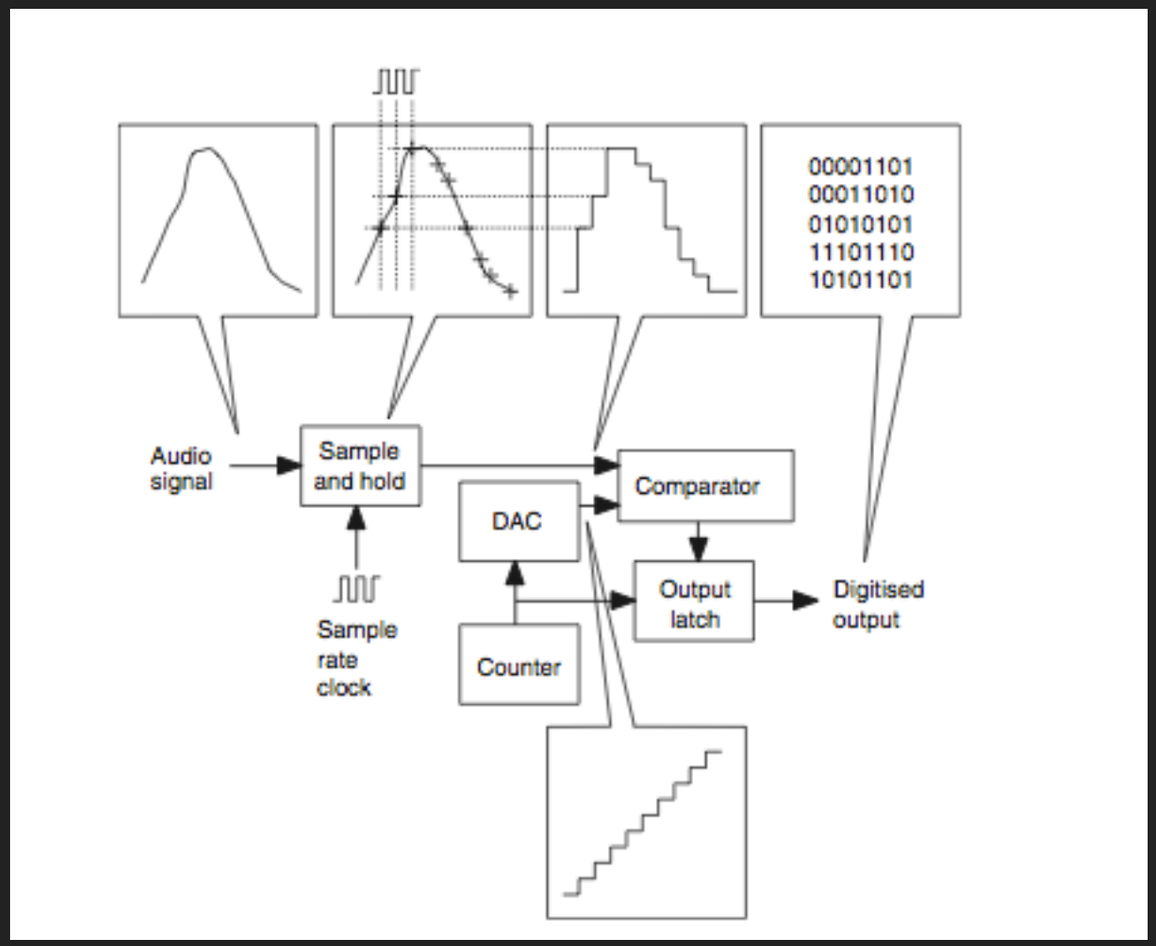
MIDI/SYNTHESISER TERMINOLOGY/JARGON

- A number of confusing pieces of semi-contradictory jargon have grown up with synthesisers over the forty-odd years they have been in common usage
- A **sound** setting on a synthesiser is known as a **patch** or a **programme** or a **preset** - *it is nothing more than a collection of settings which describe the sound* - the position of the knobs and sliders on a front panel of a software instrument
- **Patch** comes from the **patch-cables** which were once used to connect the different modules in an old-style analogue synthesiser to define the sound

KEY CONCEPTS: DIGITAL AUDIO

DIGITAL AUDIO: BASICS

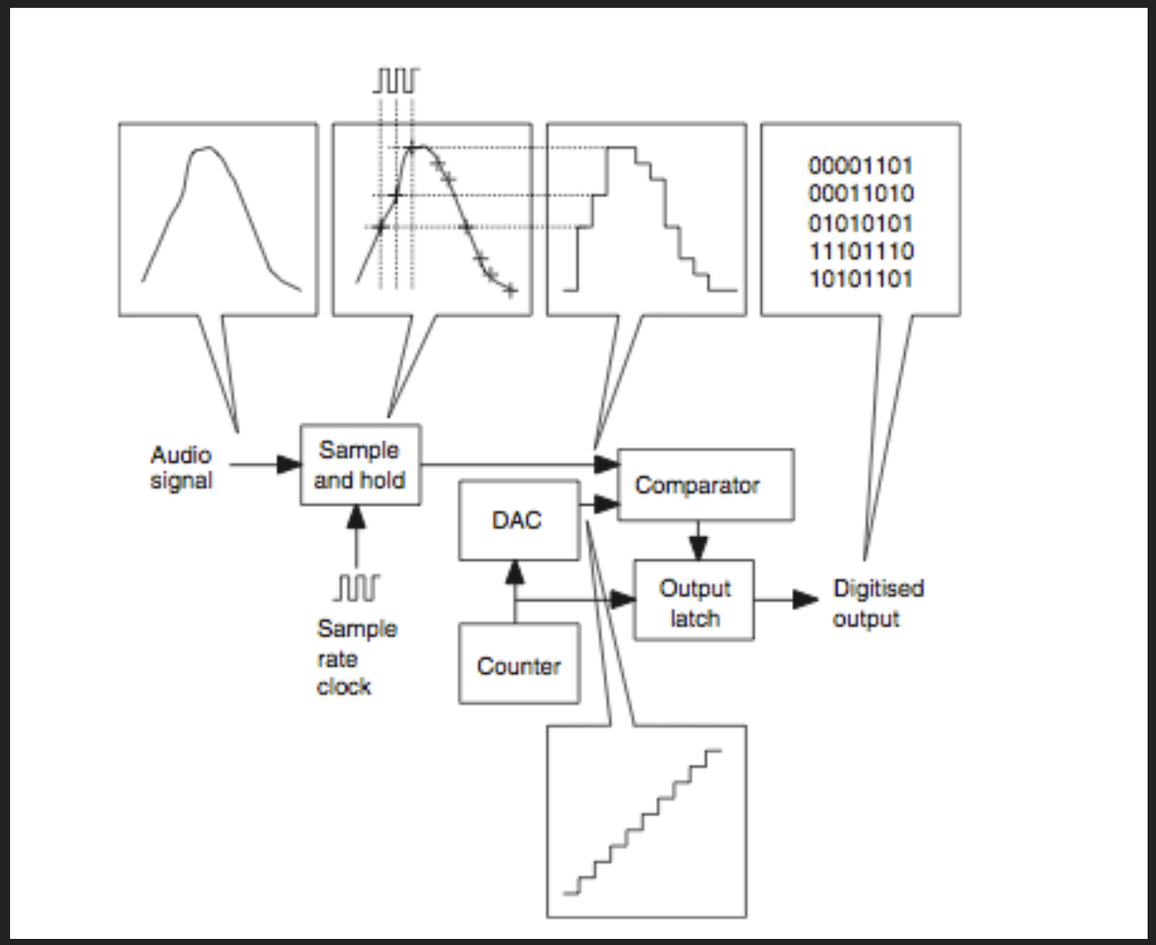
- Digital audio is simply ‘sound (accurately) described by numbers’
- *Sound is a vibration in the air around us which we receive at our ears (and decode in our brains)*
- Digital audio is simply another means of *encoding* the air pressure vibration that is sound so that we can transmit or alter it
- Digital technology is the key source of the power of modern audio production tools



From Russ, M. 2009. *Sound Synthesis and Sampling*. 3rd ed. Oxford, Focal, p. 61

DIGITAL AUDIO: BASICS

- Sampling is the process of changing the continuously-varying (analogue) signal into a discrete set of digital readings (number values for specified time intervals)
- The process here shows an audio signal being sampled at a regular rate: this reads off the size (amplitude) of the air pressure variation for each time interval
- We then have numbers which embody a simplified representation of the original audio (depending on how accurate our sampling system is)
- Accuracy in sampling depends on two things: amplitude resolution (bit depth) and frequency resolution (sample rate)



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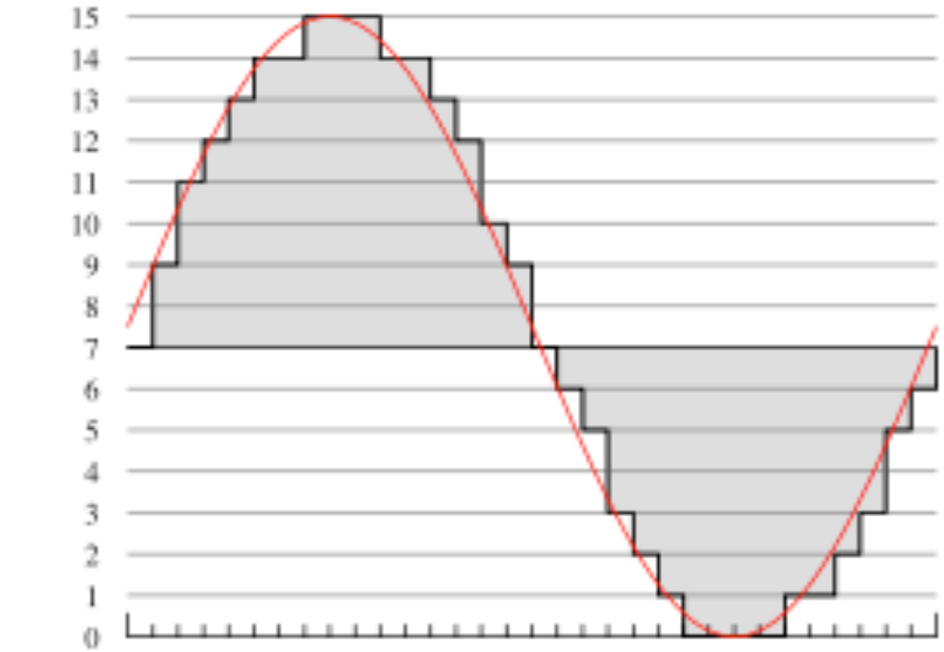
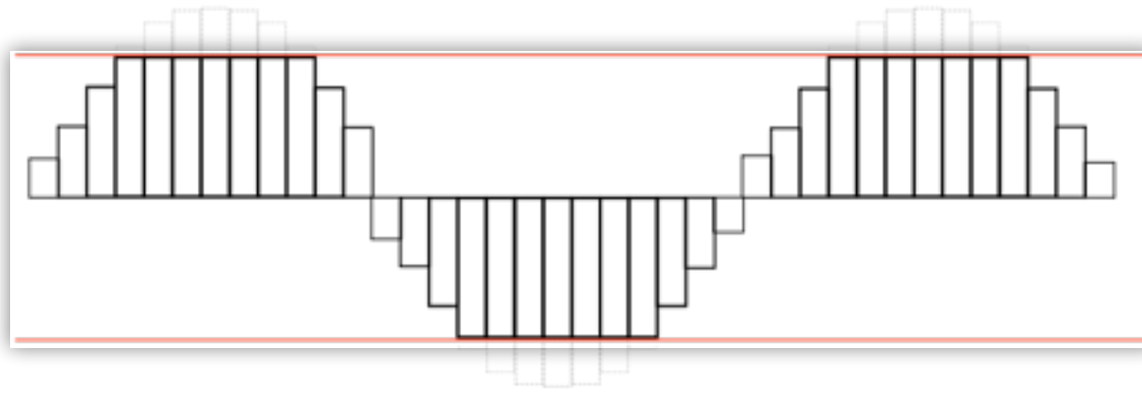
DIGITAL AUDIO: CLIPPING

- Our digital audio sampling system will have minimum and maximum signal levels which it can measure/record reliably

- If we go over the maximum level, we will not be able to record the signal accurately, we will simply record the maximum level (i.e. number), whatever the signal itself is doing—this is known as clipping

- This results in extreme distortion: rather than the wave being progressively bent out of shape (as is the case with analogue distortion), clipping cuts off the peaks of the wave abruptly (chops the 'heads' off), resulting in sudden and significant audible distortion which is particularly harsh





clipping

DIGITAL AUDIO: BASICS

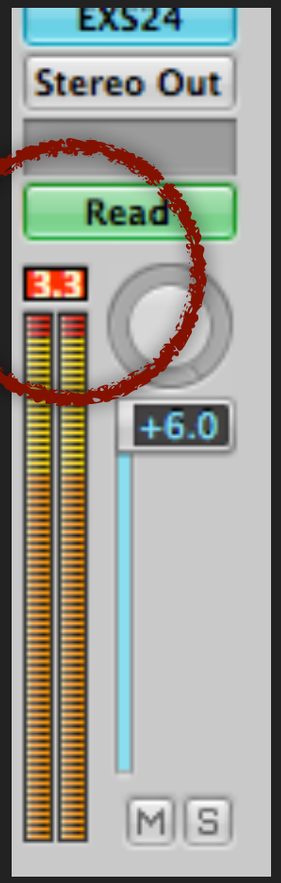
- **Resolution/bit depth gives us the amount of amplitude data and hence, dynamic range for recordings**, between minimum and maximum levels in a system: **expressed in bits**...numbers of on/off binary numbers needed to encode 'normal' decimal numbers ...**24 bit=pro recording**=16,777,216 level values, **16 bit=CD audio**=65,536 level values

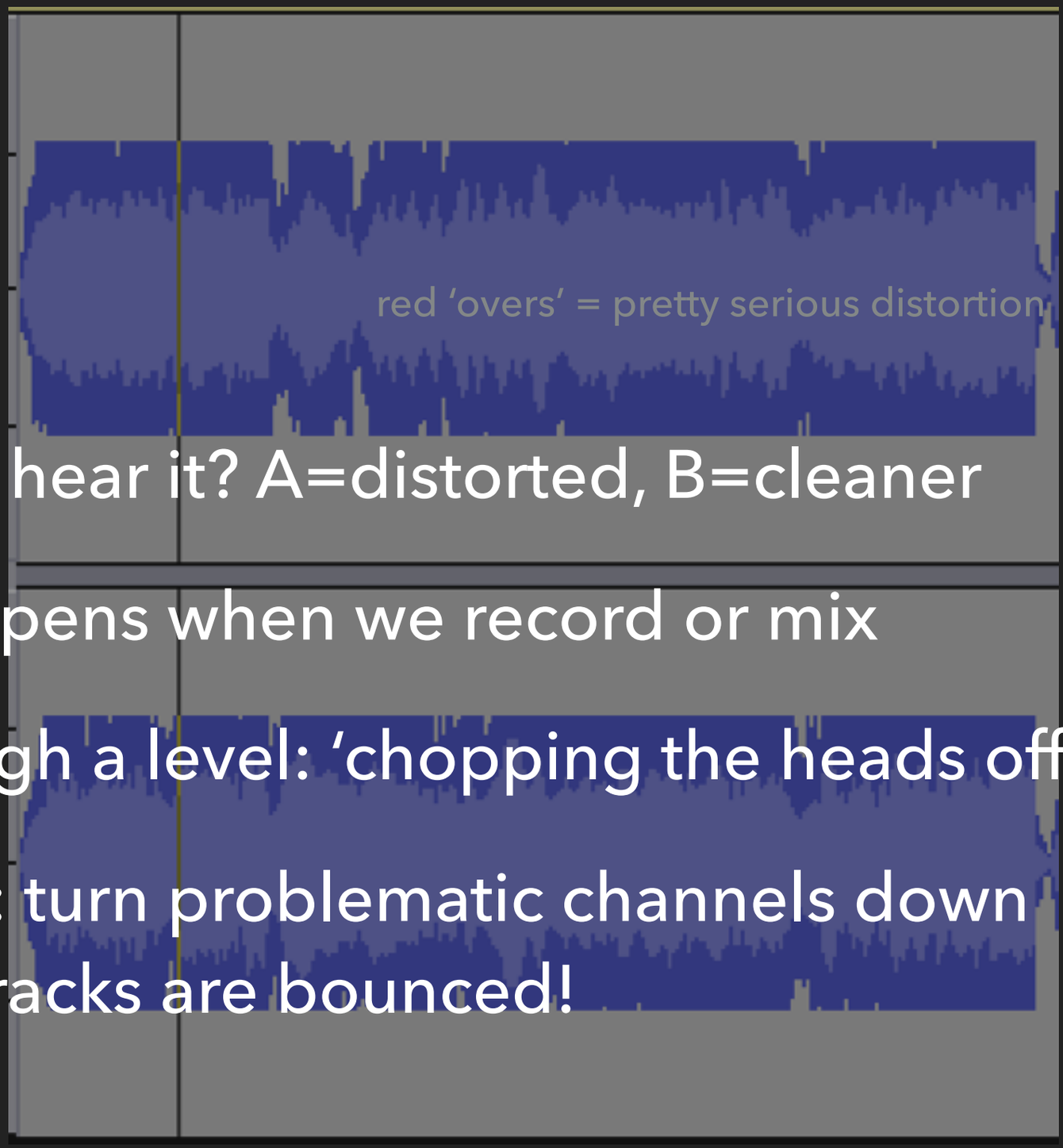
- **Sampling rate (for frequency resolution):** needs to be twice maximum audible frequency (c. 20 kHz), so rates of **44.1 kHz+** are commonly used

- **Uncompressed and compressed audio:** MP3 files are not full-quality audio, but use a lossy model based on our hearing abilities to reduce file size dramatically (nonetheless, many listeners can hear the difference between MP3 and uncompressed audio such as .wav or .aif/.aiff files)

- **About surround:** *don't* use surround plugins/bounce options unless you are using a multi-speaker surround sound facility (such as studio 2=> you will not be using this facility this year!)

DIGITAL AUDIO PROBLEMS: CLIPPING





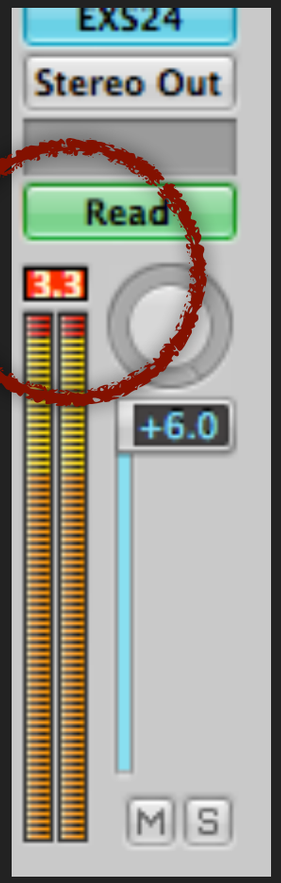
Can you hear it? A=distorted, B=cleaner

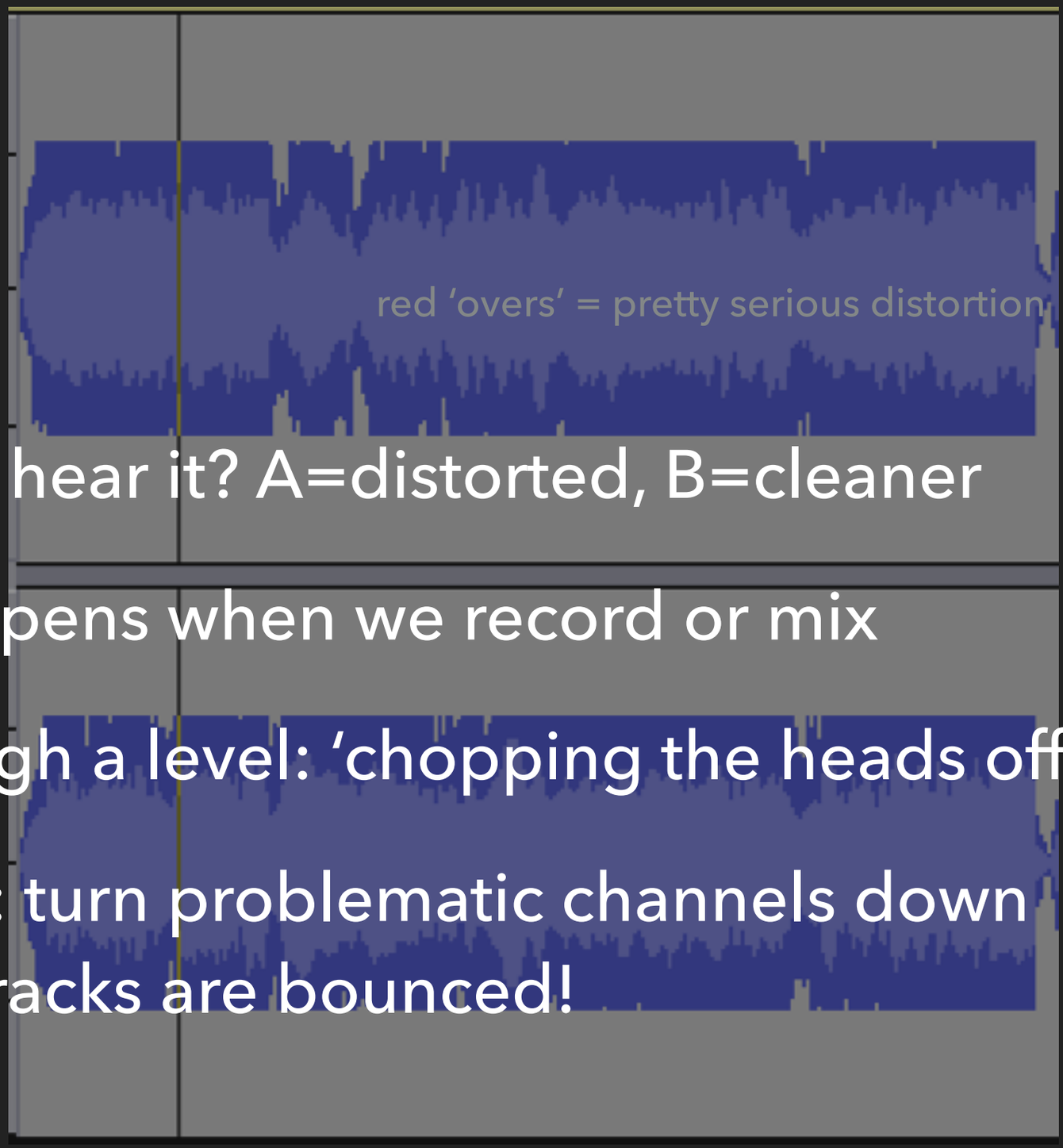
This happens when we record or mix

at too high a level: ‘chopping the heads off’

solution: turn problematic channels down before tracks are bounced!

DIGITAL AUDIO PROBLEMS: CLIPPING





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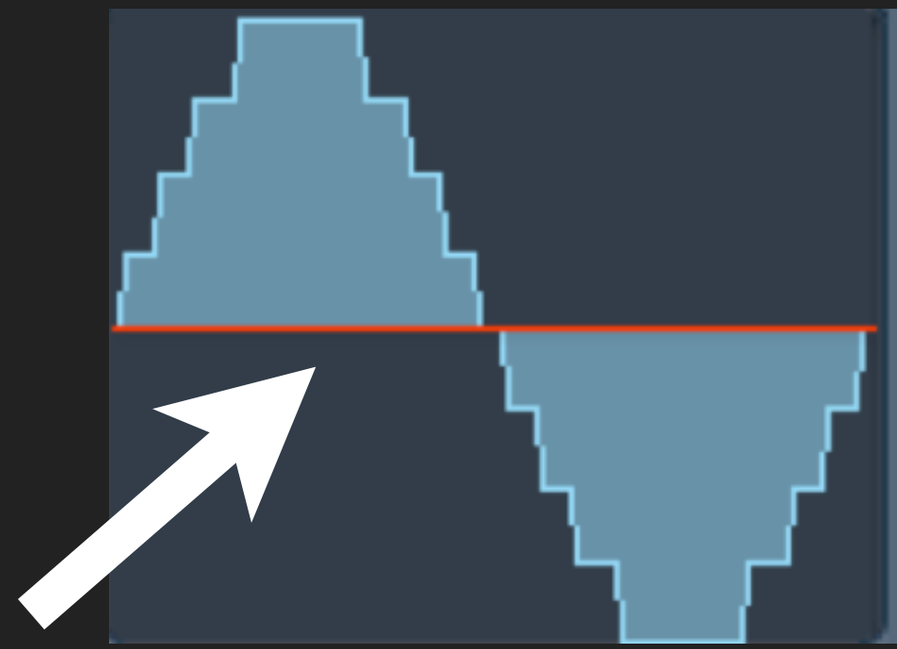
DIGITAL AUDIO PROBLEMS: LOW BIT DEPTH (AUDIO RECORD LEVEL TOO LOW)

If we record at too low a level, we may have problems at the other end: low-level/quiet sounds (e.g. the *decay phase* of a note or the *tail* of a reverb may become distorted: quantisation noise

This effect is exacerbated by lower sampling rates (16 bit, 12 bit...8 bit if you're feeling retro!)

Have you heard this effect before? Where?



sound wave becomes

'pixellated'

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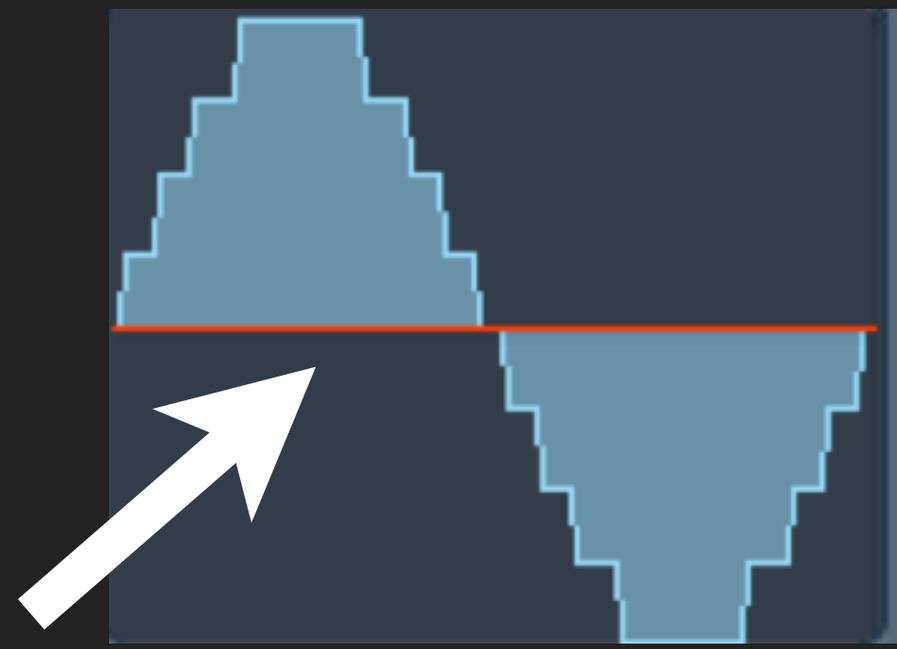

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ASIDE & TRIVIA: 8 BIT OR CHIPTUNE?

- Some people like to work with really low-fi digital recordings or synthesis
- So-called *8-bit* (AKA *chiptune*) music is generally not actually 8-bit: it's 4-bit (for even crunchier effects
- The name 8-bit comes from the main processor of old computers and games consoles, not their sound chip
- Chiptune is therefore a more accurate name!
- An example of the genre, here: www.youtube.com/watch?v=A5TqDx7iWvQ

DIGITAL AUDIO PROBLEMS: LOW SAMPLING RATE

- Sampling rate is how frequently a computer records or generates a number for changing level data in an audio file
- All sound is vibration: digital sound is a set of numbers storing or generating that vibration
- **We can hear vibrations in a range from 20 per second (20 Hertz) to an upper limit of 16,000 to 20,000 per second (16–20 kiloHertz)**
- Samping rates need to be **double** the highest frequency in a piece of audio: frequencies higher than this limit are ‘reflected down’ into lower ranges, ‘messing up’ the frequency spectrum (and making the sound ‘harsh’, ‘edgy’, or ‘metallic’...the technical term is **inharmonic**)
- Therefore, we use sampling rates of **44.1 kHz** plus to accurately encode audible sound

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DIGITAL AUDIO PROBLEMS: LOW BIT-RATE MP3S

- MP3 (MPEG 1, Layer 3) is an audio standard for **data compression** of an audio file so that it may be more easily transmitted over networks or stored on low-capacity devices
- Typically, it offers savings of 6:1 or greater on **uncompressed file sizes**
- However, there is a trade-off: it's a **lossy** compression scheme, removing audio data based on a model of the behaviour of our inner ear structures
- In some cases, **due to the structure of our ears, sounds in a similar frequency range may 'block' (mask) other sounds...**

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DIGITAL AUDIO PROBLEMS: LOW BIT-RATE MP3S

- Think of the effect of trying to listen to music in a car with a loud engine! You miss some of the lower frequencies because the car 'blocks' them
- MP3 works on this principle: certain sounds/parts of sounds in a mix will **mask** others, therefore you don't need to encode them
- MP3 **encoders** can even try to filter out sounds that you might here to reduce the file size further, but at a cost to audio quality
- Guideline: low bit-rate MP3s (e.g. 128 kbit or less) are likely to interfere with the quality of your audio (sometimes in unpredictable ways)
- Solution: use 148/196 kbit or higher for casual listening, but used **uncompressed file formats** (.aif, .wav) **for archiving**

DIGITAL AUDIO PROBLEMS: 'MORALS'

- Take care of levels when recording/mixing to prevent clipping
- Use at least 16 bit audio settings when recording (preferably, 24 bit) to prevent quantisation noise
- Use a sampling rate of 44.1 kHz or higher (opinion is still divided on the relative merits of higher rates, but that's a more advanced issue)
- **NB: Don't use compressed audio files (e.g. MP3s) as an archival format! Use uncompressed (PCM: .aif or .wav)**

SCHEDULE OF TOPICS

- Week 1: intro: history and key concepts
- Week 2: synthesis 1: waves, partials and subtractive synthesis
- Week 3: synthesis 2: hybrid, FM, physical modelling
- Week 4: synthesis: practical/self-test
- Week 5: feedback workshop on work-in-progress
- *Week 6: project week/ensemble week: no class*

SCHEDULE OF TOPICS

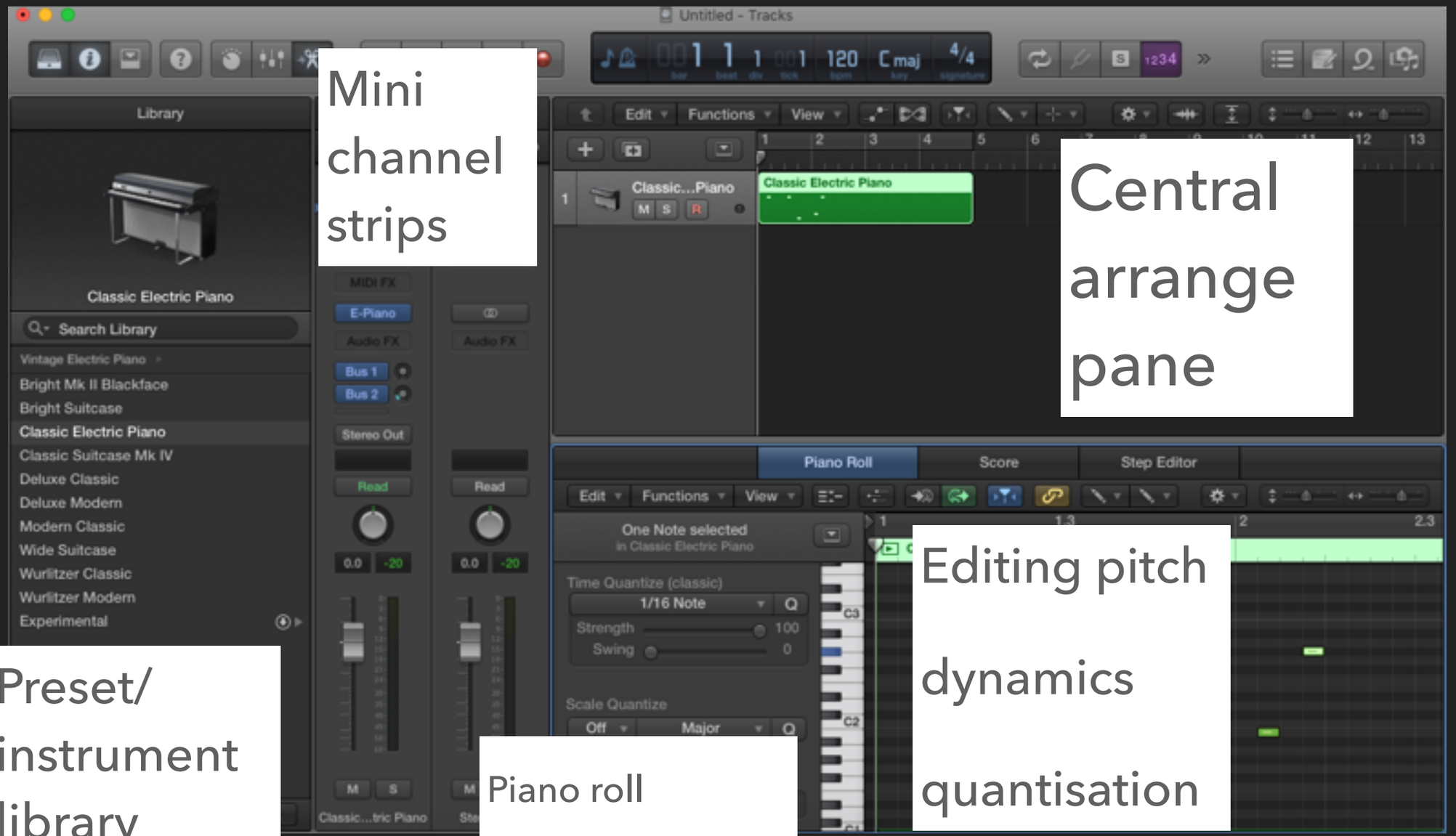
- Week 7: sampling
- Week 8: digital audio effects and production techniques - *may be rescheduled due to bank holiday/reading days*
- Week 9: mixing
- Week 10: feedback and advice workshop I
- Week 11: feedback and advice workshop II
- EASTER VACATION (2 weeks)
- **SUBMISSION: Tues 9th May**

RECAP: INTERFACE AND KEY FUNCTIONS

LOGIC'S INTERFACE: RECAP

- Setting up instrument tracks
- Arrange page panes (including mixer)
- Browsing for presets and Apple loops
- File management
- Bouncing

LOGIC'S ARRANGE WINDOW: OVERVIEW

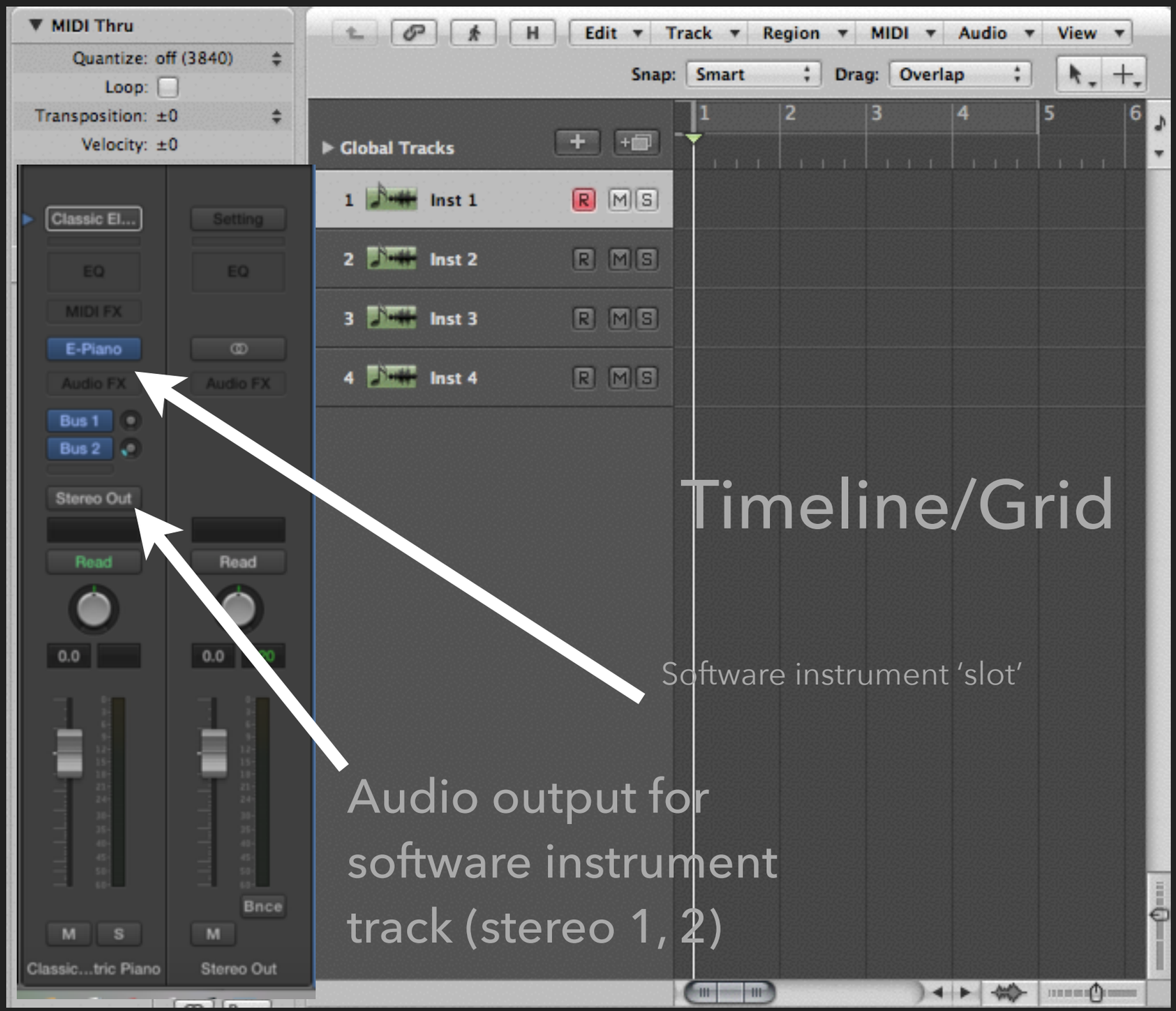


LOGIC'S MIXER PANE

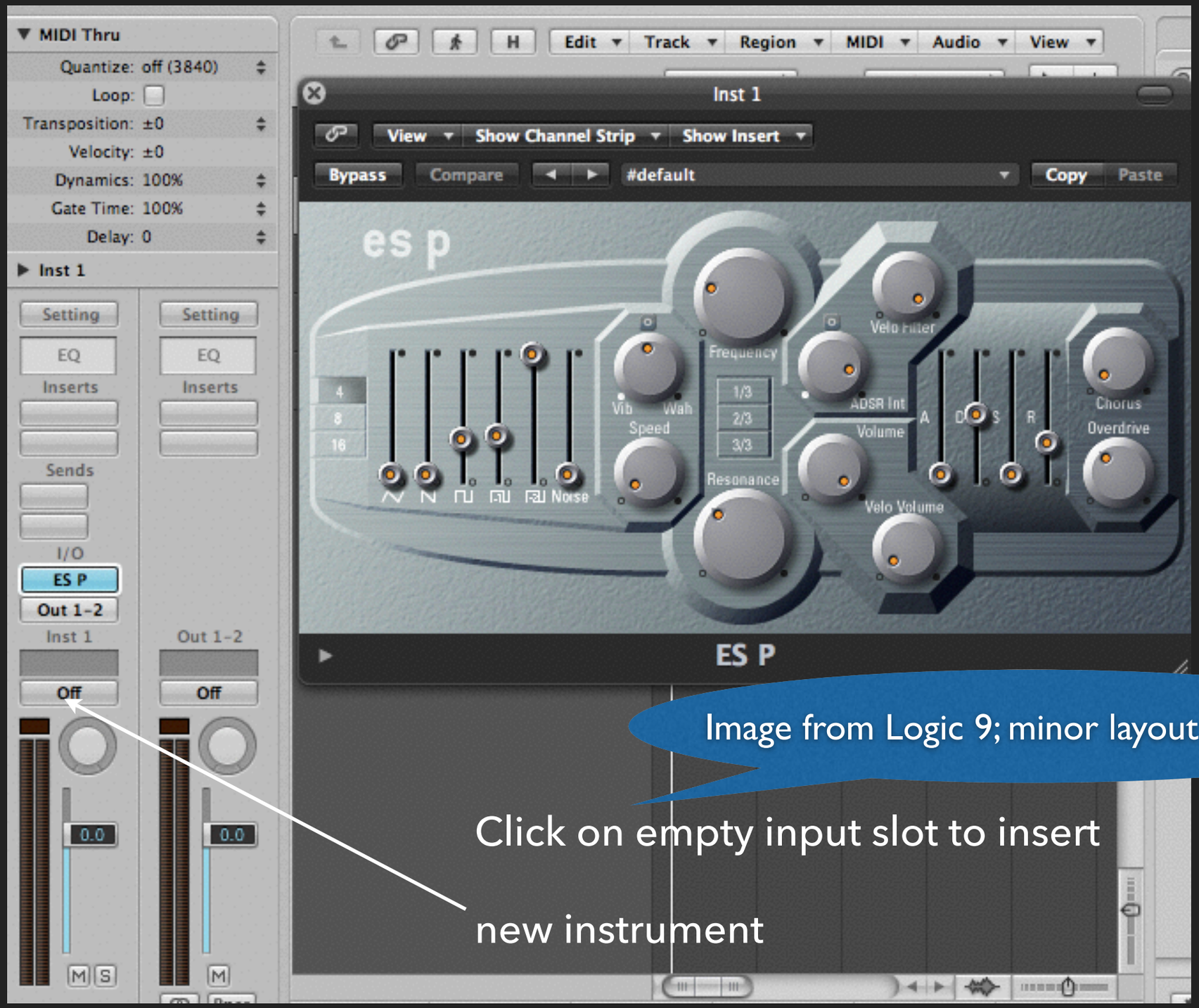
RECAP: CREATING PROJECT AND SETTING UP TRACKS

- Set up **software instruments** to play with Logic's internal synths
- (External MIDI for external synthesiser: we won't use this here)
- Audio tracks (for digital audio recordings made in Logic or imported into Logic)

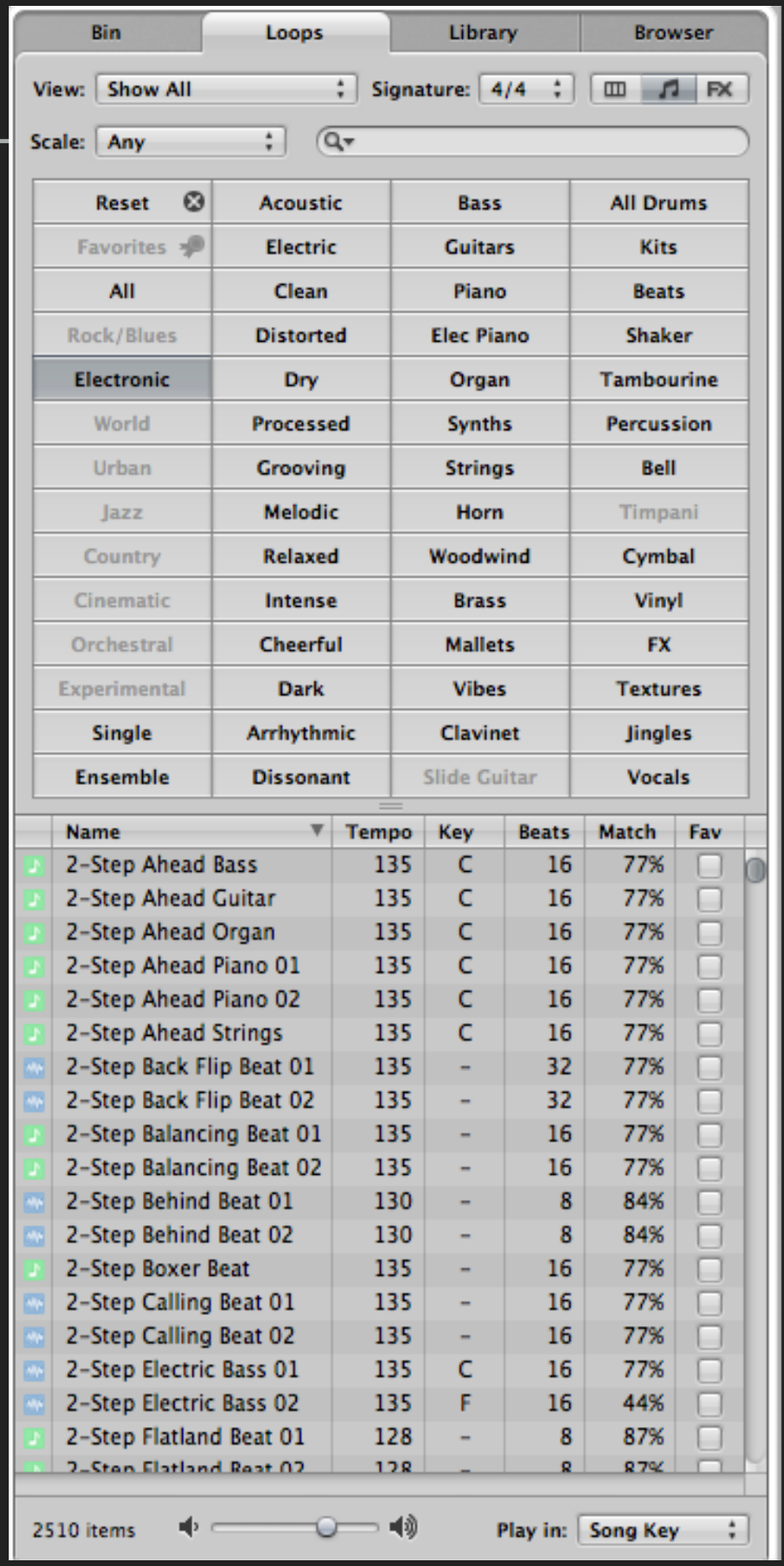
ARRANGE WINDOW AND INSTRUMENTS



INSTRUMENTS (SOFTWARE SYNTHESISERS)



APPLE LOOPS


Bin
Loops
Library
Browser
View: Show All
Signature: 4/4
FX
Scale: Any
Reset
Acoustic
Bass
All Drums
Favorites
Electric
Guitars
Kits
All
Clean
Piano
Beats
Rock/Blues
Distorted
Elec Piano
Shaker
Electronic
Dry
Organ
Tambourine
World
Processed
Synths
Percussion
Urban
Grooving
Strings
Bell
Jazz
Melodic
Horn
Timpani
Country
Relaxed
Woodwind
Cymbal
Cinematic
Intense
Brass
Vinyl
Orchestral
Cheerful
Mallets
FX
Experimental
Dark
Vibes
Textures
Single
Arrhythmic
Clavinet
Jingles
Ensemble
Dissonant
Slide Guitar
Vocals
Name
Tempo
Key
Beats
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Fav
2-Step Ahead Bass 135 C 16 77%
2-Step Ahead Guitar 135 C 16 77%
2-Step Ahead Organ 135 C 16 77%
2-Step Ahead Piano 01 135 C 16 77%
2-Step Ahead Piano 02 135 C 16 77%
2-Step Ahead Strings 135 C 16 77%
2-Step Back Flip Beat 01 135 - 32 77%
2-Step Back Flip Beat 02 135 - 32 77%
2-Step Balancing Beat 01 135 - 16 77%
2-Step Balancing Beat 02 135 - 16 77%
2-Step Behind Beat 01 130 - 8 84%
2-Step Behind Beat 02 130 - 8 84%
2-Step Boxer Beat 135 - 16 77%
2-Step Calling Beat 01 135 - 16 77%
2-Step Calling Beat 02 135 - 16 77%
2-Step Electric Bass 01 135 C 16 77%
2-Step Electric Bass 02 135 F 16 44%
2-Step Flatland Beat 01 128 - 8 87%
2510 items
Play in: Song Key

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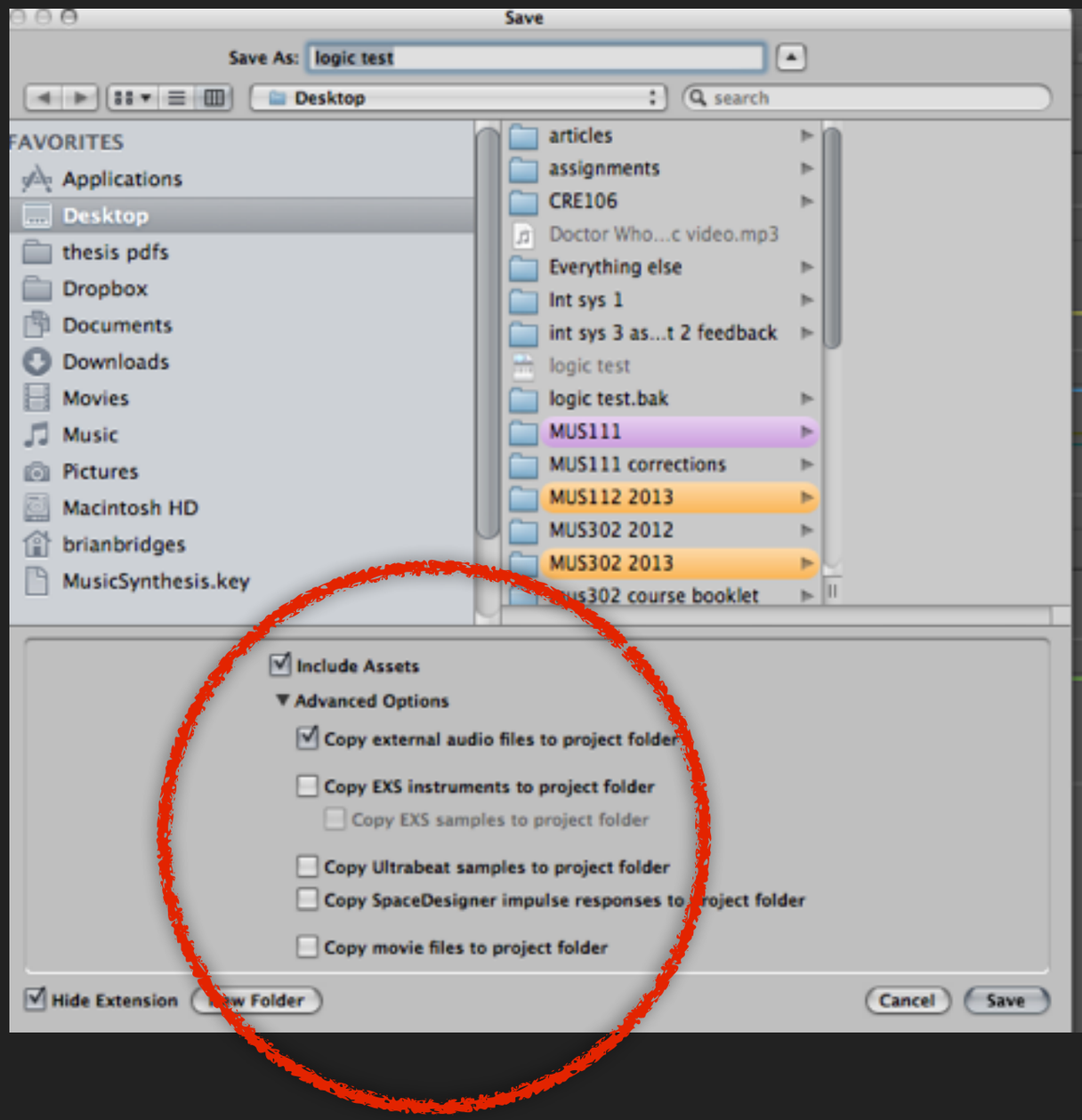
- See Chapter 2, *Exploring Logic Pro 9.*

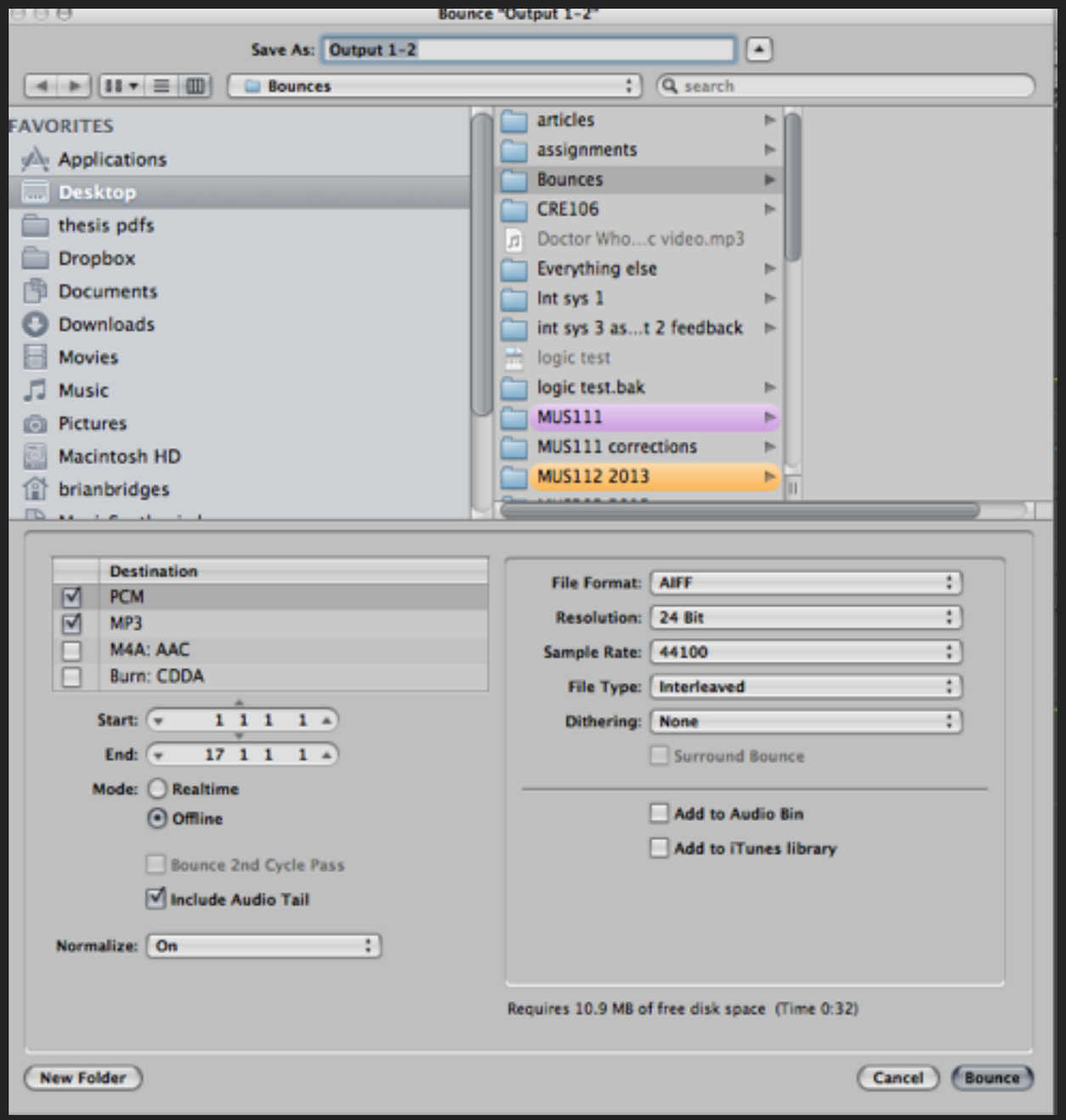
FILE MANAGEMENT

- **File management will become increasingly important to you as you begin as you begin to use digital audio recordings**
- Remember, the Logic project file will only contain MIDI and automation/layout data
- This is fine if you are using Apple loops/ sampler instruments, but if you use your own audio, you will need to make sure that everything your project needs is on your CD/DVD: **use the 'include assets' setting when you 'save as'**



MIXDOWN/BOUNCE

- Choosing file formats:
- Compressed - MP3 - or uncompressed - ‘PCM’
- Sample rate (44100 or above), resolution (24 bit for archiving, 16bit with dithering for CD output)
- Start/end points (and include audio tail)
- Normalise



REVISE/MEMORISE THESE KEY CONCEPTS

- We'll be moving on next week!
- Make sure you're clear on basic functionality, including quantisation and note editing
- Feedback from semester 1 will be released shortly; take note
- Remember: bring headphones and USB pen-drive to store your work

MORE INFORMATION

- Russ, M. 2009. *Sound Synthesis and Sampling*. 3rd ed. Oxford: Focal
- ASK Video Tutorials (software tutorial DVD in library)
- Logic tutorial texts (see module descriptor/reading list)

- Questions about this lecture? BD.Bridges@ulster.ac.uk

FOR NEXT WEEK

- Bring Headphones (preferably ‘over-ear’, not ‘in-ear’ kind)
- Bring USB drive (for your masterworks)