



# A History of Sound Recording



*First, the basics of*

## **The physics of sound**

*i.e. what recording equipment has to capture*

- Sound is made when something vibrates.
- The vibration disturbs the air around it.
- This makes changes in air pressure.
- These changes in air pressure move through the air as sound waves.
- The sound waves cause pressure changes against our ear drum sending nerve impulses to our brain.

*What are the three components of sound?*



## Pitch (how high or low)

- The vibration patterns of some sounds are repetitive (note vs noise)
- Vibration patterns are also called waveforms.
- Each repetition of a waveform is called a cycle.
- We can hear frequencies between 20 hertz or cycles (vibrations) per second (low pitches) to 20 kilohertz, i.e. 20,000 Hz (high pitches).
- When the frequency of a sound doubles we say that the pitch goes up an octave.
- We can hear a range of pitches of about ten octaves.
- Many animals can make sounds and hear frequencies that are beyond what we can hear.

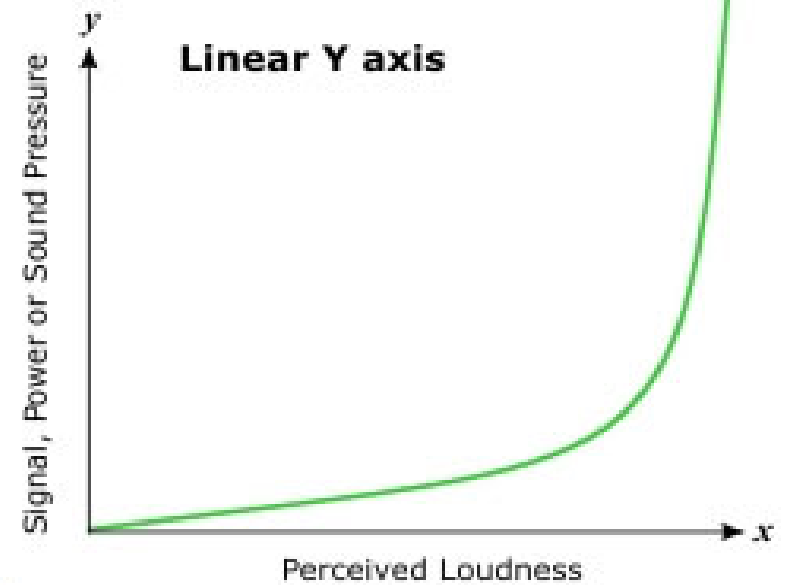
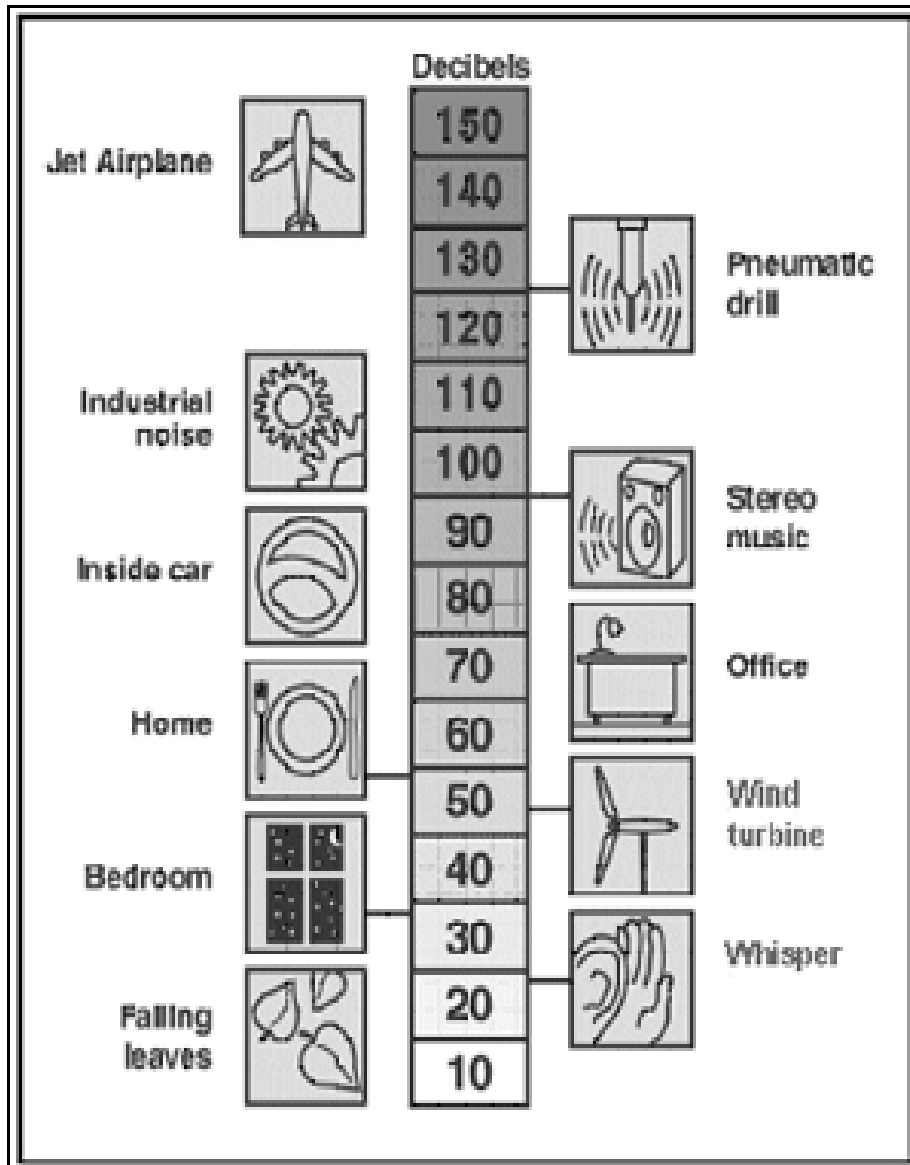
[http://www.mienet.com/music/frequency\\_generator.html](http://www.mienet.com/music/frequency_generator.html)

- Relevance to recording equipment?



## Loudness (volume)

- To create vibrations energy is used.
- The greater amount of energy used the louder the sound.
- The strength of the changes in air pressure made by the vibrating object determines loudness.
- As the sound spreads out from its source, the concentration of power becomes less. As the distance from the source increases the amount of power is spread over a greater area:
  - Twice the distance = a quarter of the volume (inverse square law)
  - Human ears have built in compensation mechanism.
  - Relevance to microphone placement?
  - The amount of power per square meter is called the intensity of the sound.
  - Humans do not perceive sound intensity linearly.
  - For us to perceive a sound as twice as loud its intensity must be ten times greater.
  - The perceived intensity level of sound is measured in a logarithmic scale using a unit called the decibel (dB):

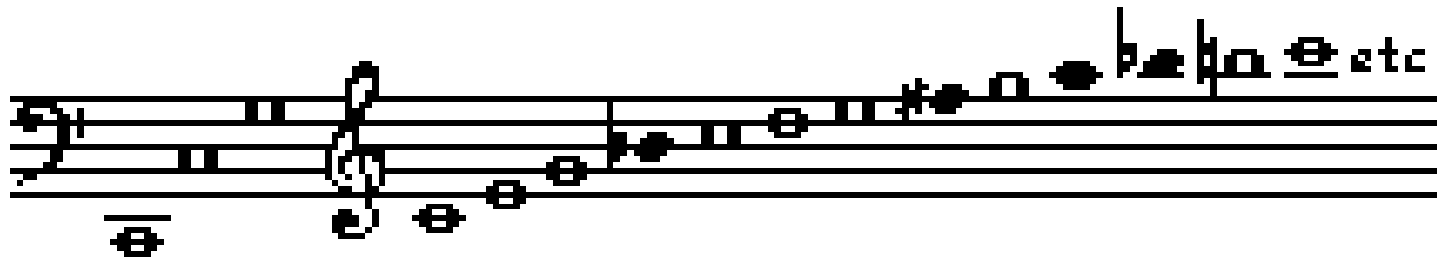


– Relevance to recording equipment?



## Timbre (tone 'colour')

- specific property/quality of sound that enables us to determine the difference, say, between a piano and a harp
- An extremely broad variety of tone colors exist because most sounds that we perceive as pitch actually contain many frequencies.
- The predominant pitch is called the fundamental frequency.
- The other frequencies in the sound are called harmonics.
- For example, when C1 is the fundamental the following pitches represent the next fifteen harmonics:



- The relative strength of the different harmonics change the quality of the sound
- Relevance to recording equipment?



- Demonstration (MidiCode)

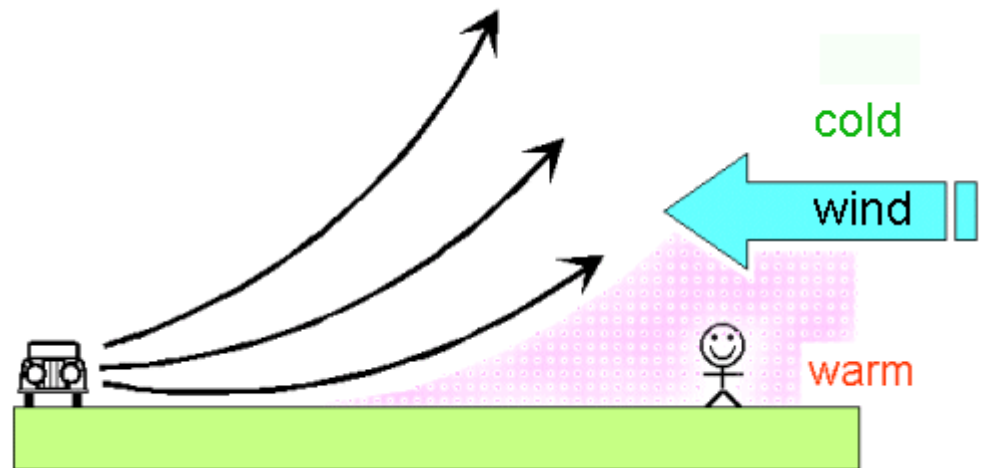
## Travelling Sound

- Low frequencies spread out from their source more than high frequencies.
- Relevance to microphone placement?

*Distortion* - unwanted change of shape

*Absorption and reflection*

Sound travels at different speeds in different media (depending on their density)





Prep: Physics of Sound summary questions (see sheet)



**Recording** is “a process of capturing data or translating information to a format stored on a storage medium”.

*Earliest known (9<sup>th</sup> century!) method of doing this...*

## Mechanical Instruments

- Barrel organs

<http://www.youtube.com/watch?v=4oRm1Dx5rDI>

- Player pianos

<http://www.youtube.com/watch?v=zXXw5LlvD7Q>

*In the mid 19th-century, acoustical recording, i.e.:*

- Diaphragm connected directly to cutting needle.
- Often diaphragm located at the apex of a cone.





*The earliest sound recorded was*

## The Phonautograph (1857, Édouard-Léon Scott de Martinville)

- membrane attached to a pen, which drew a waveform onto paper.

<http://www.youtube.com/watch?v=q7Gi6j4w3DY>

## Phonograph and gramophone

Thomas Edison, 1877

- Cylinder covered with an impressionable material such as tin foil, lead, or wax
- Depth of the grooves made by the stylus corresponded to change in air pressure created by the original sound.
- The recording could be played back by tracing a needle through the groove and amplifying, through mechanical means, the resulting vibrations.





A disadvantage of the early phonographs was the difficulty of reproducing the phonograph cylinders in mass production.

## Gramophone

Emile Berliner, 1887

- The gramophone imprinted grooves on the flat side of a disc rather than the outside of a cylinder.
- Instead of recording by varying the depth of the groove (vertically), as with the phonograph, the vibration of the recording stylus was across the width of the track (horizontally).
- Discs *vs* cylinders - same audio fidelity, but discs easier and cheaper to mass produce.
- The speed at which the disks were rotated was eventually standardized at 78 rpm. Later innovations allowed lower rotations: 45, 33 1/3 and as slow as 16 rpm for broadcast transcriptions and some rare consumer recordings.
- The material used was eventually changed to vinyl.





## Electrical recording (1925)

- Use microphones (more later) to capture the sound of the performance.
- Initially, the performance was still cut directly to the recording medium, so if a mistake was made the recording was useless.

## Magnetic Recording

- magnetizable medium which moves with a constant speed past a recording head.
  - electrical signal from microphone fed to the recording head
  - induces a pattern of magnetization similar to the signal
  - playback head can then pick up the changes in magnetic field from the tape and convert it into an electrical signal for amplifier/speaker (again, more later).
- 
- Steel tape (BBC, 1932)
  - Magnetic tape (1935)
  - <http://www.youtube.com/watch?v=YFRkhUMYiaY>





*How did magnetic tape revolutionize broadcasting and recording?*



*How did magnetic tape revolutionize broadcasting and recording?*

- Allowed radio programming to be prerecorded
- Allowed recordings in multiple parts
- Allowed mixing and editing with tolerable loss in quality
- Allowing unparalleled amounts of data to be mechanically created, stored for long periods, and to be rapidly accessed.
- More portable than vinyl, and was reusable.
  
- <http://www.youtube.com/watch?v=LkEfo4IVpjk>

Magnetic tape remained the main type of recording media until well into the 1990s.

*To what other major new technique did magnetic tape give rise?*



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**Multitrack recording!**



## Multitrack Recording

- Not entirely new concept (overdubbing)
- Magnetic tape enabled multitracking at an acceptable quality (1950s)
- Tape physically divided into strips which form the tracks
- Two tracks gave rise to the first stereo recordings in the mid 1950s
  
- Ampex (1955) produced the first commercial multitrack tape recorder
- "Sel-Sync" (Selective Synchronous Recording)
  - record on one track while listening back to previously recorded tracks
- Three-track machines emerged by 1960s (Ampex/Sel-Sync)
- As stereo records and stereo FM radio became popular, engineers used two tracks for a stereo image of the instruments, and the third for vocals (centered in the mix)
- Ampex had a 16-track recorder on the market by the end of the 1960s.
  
- Wendy Carlos: "Switched-On Bach" (1968, Moog synthesizer and an 8-track recorder) [http://upload.wikimedia.org/wikipedia/en/2/26/Carlos\\_brandenburg\\_3.ogg](http://upload.wikimedia.org/wikipedia/en/2/26/Carlos_brandenburg_3.ogg)



## Multitrack Recording

- 4-track was the studio standard for most of the later 1960s (inc. many of the most famous recordings by The Beatles and The Rolling Stones)
- Reduction mixes (or “bouncing down” in the US)
  - multiple tracks were recorded onto one 4-track machine and then mixed together and transferred (bounced down) to one track of a second 4-track machine
  - All of the Beatles classic mid-60s recordings, including the albums Revolver and Sgt Pepper's Lonely Hearts Club Band, were recorded in this way.
  - Disadvantages: build-up of noise during the bouncing-down process
- 4-track tape also enabled the development of quadraphonic sound
  - Each track was used to simulate a complete 360-degree surround sound
  - Pink Floyd's The Dark Side of the Moon and Mike Oldfield's Tubular Bells were released both in stereo and quadrophonic format in the 1970s.
- In the 1970s, TEAC introduced two four-track recorders designed for the home consumer market
- Studio norm became 24-track machines using two-inch wide tape.
- Compact audio cassette introduced by Philips in 1963.



## Tape 'Hiss'

- Analog magnetic tape recording introduces noise
- Tradeoff between noise and economics:
- Signal-to-noise ratio is increased at higher speeds and with wider tracks, decreased at lower speeds and with narrower tracks.
  
- 1970s saw attempts to reduce tape hiss through various forms of volume compression and expansion.
  - o Dolby
  - o Divided the frequency spectrum into multiple bands and applied volume compression/expansion independently to each band
  - o Dolby A (professional), Dolby B (prerecorded music), Dolby C (home)

### Prep question

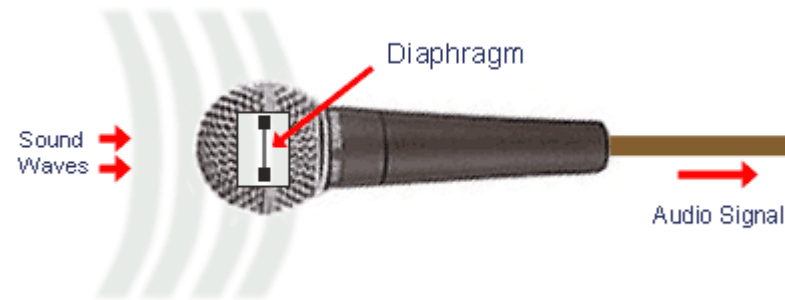
Outline the development of magnetic tape technology. To what extent did it revolutionize the music industry? Ensure that you refer to performers, engineers and consumers in your answer.

[16]



## Microphones

A microphone turns varying pressure waves in the air into varying electrical signals.

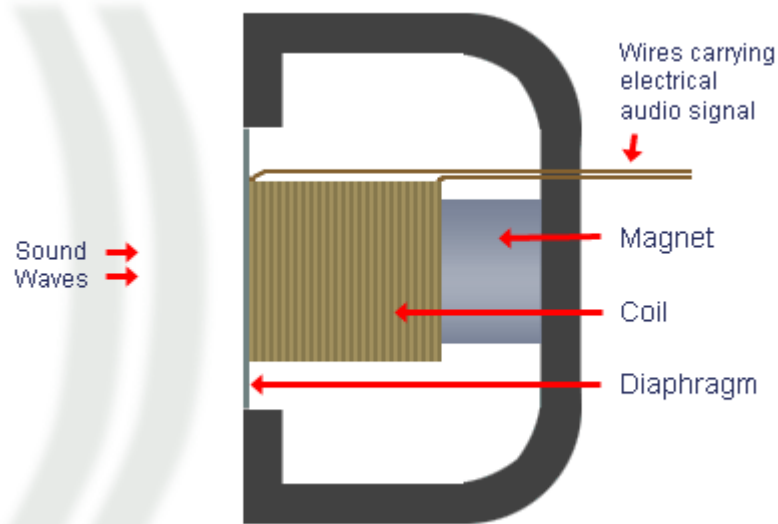


First invented in 1877 when Emile Berliner constructed a telephone voice transmitter.



## *Dynamic Microphone*

- Essentially a loud speaker in reverse
- Principal: when a magnet is moved near a coil of wire, a current is generated in the coil.
- Diaphragm connected to the coil, which moves along the magnet:



Dynamic microphones are...

- versatile and ideal for general-purpose use
- simple in design with few moving parts
- sturdy and resilient
- better suited to handling high volume levels
- no internal amplifier or external power

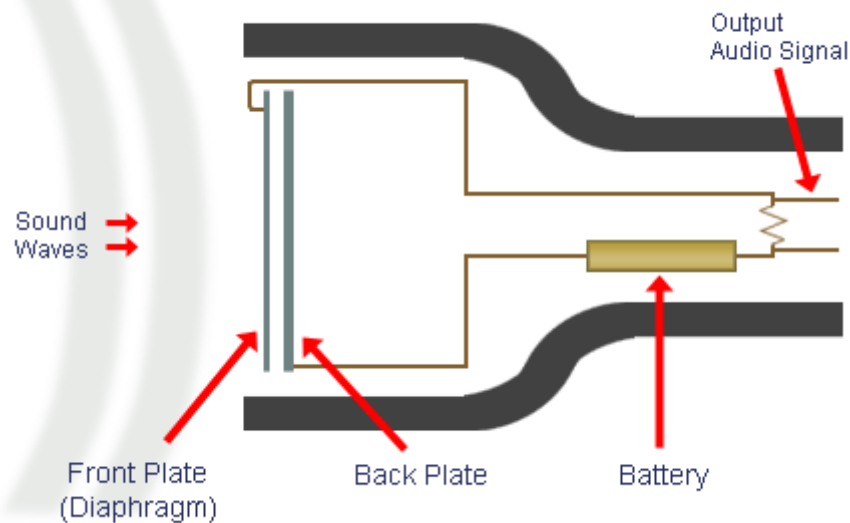


## Condenser Microphones

- Principal: a condenser (more usually known as a capacitor) stores energy in an electric field between two plates.
- One plate acts as the diaphragm. When it is struck by sound waves the distance between the two plates changes:

### Condenser microphones...

- require power
- create a stronger signal than a dynamic mic
- are more sensitive
- are not ideal for high-volume work



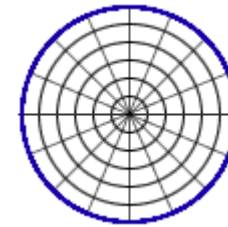
- A voltage is required across the two plates, hence these mics need a battery or *phantom power*.



## *Microphone Directionality*

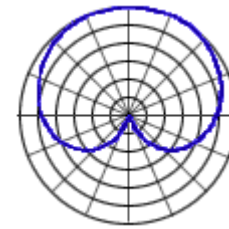
### 1. Omnidirectional

- Captures sound equally from all directions
- Good if mic must remain in place while sound moves
- Good if sound is coming from everywhere
- Picks up ambient noise



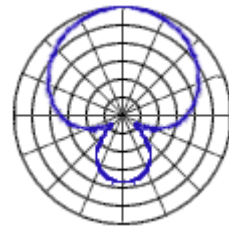
### 2. Cardioid

- Mostly front, but with some sensitivity at the sides



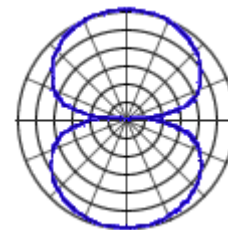
### 3. Hypercardioid

- Very focused
- Good for picking up a sound at a distance
- "Shotgun" mics



### 4. Bidirectional

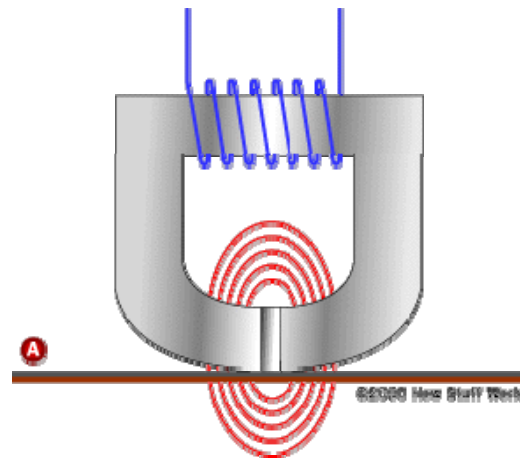
- Not very common
- Useful for interviews, perhaps?





## Tape Recorders

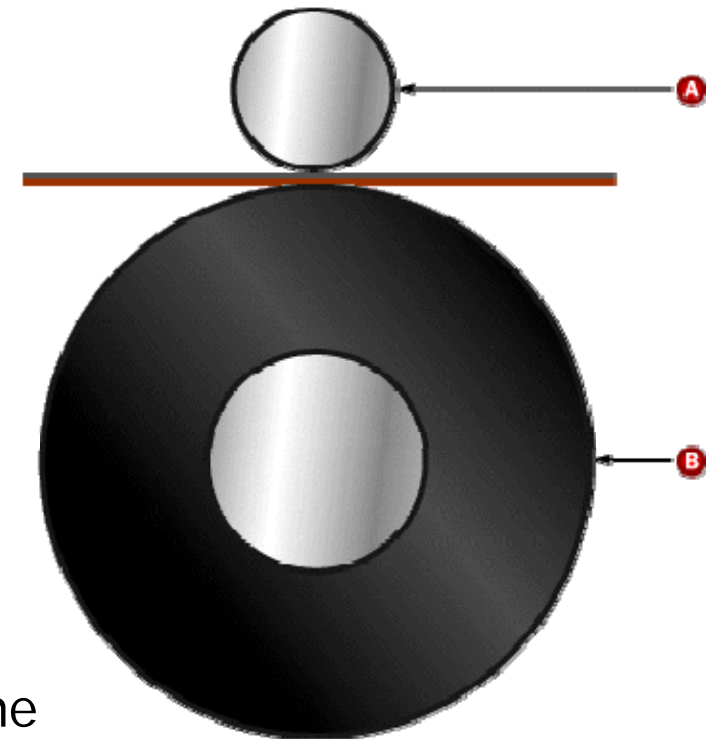
- an electromagnet applies a magnetic *flux* to the oxide on the tape
- the oxide “remembers” the flux it sees



- During recording, the audio signal is sent through the coil of wire to create a magnetic field in the core.
- During playback, the motion of the tape creates a varying magnetic field in the core and therefore a signal in the coil. This signal is amplified to drive the speakers.



- The capstan (B) revolves at a very precise rate to pull the tape across the head at exactly the right speed.
- The standard speed is 1.875 inches per second (4.76 cm per second).
- The Pinch Roller (A) simply applies pressure so that the tape is tight against the capstan.



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