

Radio 1

# Radio

Turn off all electronic devices

Radio 2

## Observations about Radio

It can transmit sound long distances wirelessly  
It involve antennas  
It apparently involves electricity and magnetism  
Its reception depends on antenna positioning  
Its reception weakens with distance  
There are two classic styles of radio: AM and FM

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## 3 Questions about Radio

1. How can a radio wave exist?
2. How is a radio wave emitted and received?
3. How can a radio wave represent sound?

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## Question 1

Q: How can a radio wave exist?

A: Electric and magnetic fields create one another.

Radio waves are electromagnetic waves:

- structures made only of electric and magnetic fields
- they are emitted or received by charge or pole
- they are self-sustaining while traveling, even in vacuum
- their electric and magnetic fields recreate one another

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## Electromagnetism (Version 3)

Magnetic fields are produced by

- magnetic poles and subatomic particles,
- moving electric charges,
- and changing electric fields.

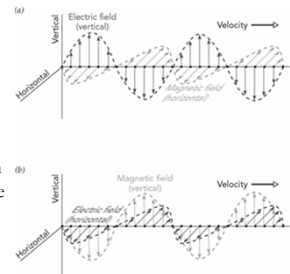
Electric fields are produced by

- electric charges and subatomic particles,
- moving magnetic poles,
- and changing magnetic fields.

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## Structure of a Radio Wave

- A radio wave's electric field is perpendicular to its magnetic field
- Its changing electric field creates its magnetic field
- Its changing magnetic field creates its electric field
- This self-reproducing wave travels at the speed of light
- It moves perpendicular to both fields, obeying a right-hand rule
- The wave's polarization is associated with its electric field



## Question 2

Q: How is a radio wave emitted and received?

A: Accelerating charge  $\leftrightarrow$  electromagnetic wave

Accelerating charge causes electromagnetic wave

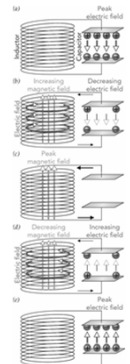
- It makes an electric field that changes with time
- It makes a magnetic field that changes with time
- and the two fields can form an electromagnetic wave

Electromagnetic wave causes accelerating charge

- Its electric field pushes on the charge

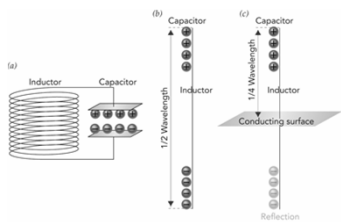
## A Tank Circuit

- For a bigger wave, allow charge to “slosh” in a tank
- Tank circuit is an electric harmonic oscillator
  - It consists of a capacitor and an inductor
  - Charge cycles through the circuit rhythmically
- Tank’s energy alternates between
  - magnetic field in its inductor
  - electric field in its capacitor
- Tank circuit can accumulate energy gradually
- Tanks’ frequency set by its capacitor & inductor



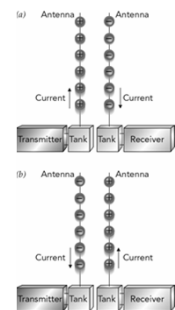
## An Antenna is a Tank Circuit

- An antenna is a straightened tank circuit!
- Antenna’s frequency is set by its length
- Full antenna is resonant when it is  $\frac{1}{2}$  radio wavelength long
- A conducting surface can act as half the antenna
- Above a conducting surface, an antenna is resonant when it is  $\frac{1}{4}$  wavelength long



## Emitting and Receiving Waves

- A transmitter uses a tank circuit to slosh charge up and down its antenna, which acts as a second tank.
- A receiver uses a tank circuit to detect charge sloshing on its tank-circuit antenna.
- Transmitter antenna charge affects receiver antenna charge
- Antenna orientations matter!



## Question 3

Q: How can a radio wave represent sound?

A: Vary the wave to send sound information.

AM or “Amplitude modulation”

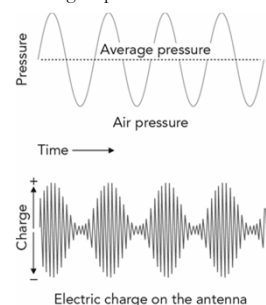
- Fluctuating amplitude conveys sound information

FM or “Frequency modulation”

- Fluctuating frequency conveys sound information

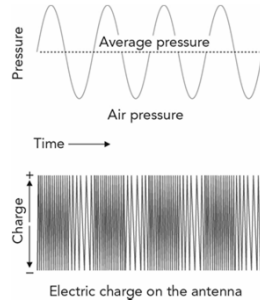
## AM Modulation

- Information can be encoded as a fluctuating amplitude of the radio wave
- The air pressure variations that are sound cause changes in the amount of charge moving on the antenna and thus the intensity of the wave
- The receiver detects these changes in radio wave intensity.



## FM Modulation

- Information can be encoded as a fluctuating frequency of the radio wave
- The air pressure variations that are sound cause slight shifts in the frequency of charge motion on the antenna and the frequency of the wave
- The receiver detects these changes in radio wave frequency.



## Summary about Radio

Accelerating charges cause electromagnetic waves

Electromagnetic waves cause accelerating charges

Those waves are only electric and magnetic fields

- Accelerating charge on a transmitting antenna
- produces a radio wave
- that causes charge to accelerate on a receiving antenna

Radio waves can represent sound information