

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

Radio 3

## 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.

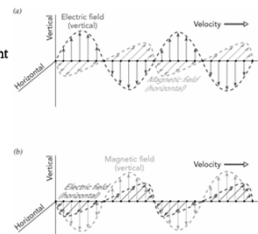
Electric fields are produced by

- ◊ 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 ↔ electromagnetic wave

Accelerating charge causes electromagnetic wave

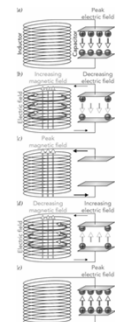
- ◆ It makes an electric field that changes with time
- ◆ It makes a magnetic field that changes with time
- ◆ and the two fields can form an electromagnetic wave

Electromagnetic wave causes accelerating charge

- ◆ Its electric field pushes on the charge

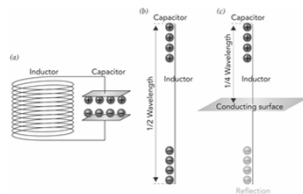
### A Tank Circuit

- ◆ 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



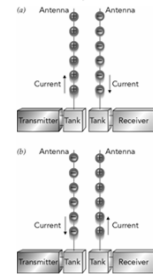
### An Antenna is a Tank Circuit

- ◆ An antenna is a straightened tank circuit!
- ◆ Antenna's frequency is set by its length
- ◆ Full antenna is resonant when it is 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 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"

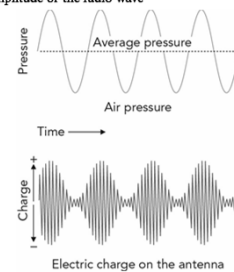
- ◆ Fluctuating amplitude conveys sound information

FM or "Frequency modulation"

- ◆ Fluctuating frequency conveys sound information

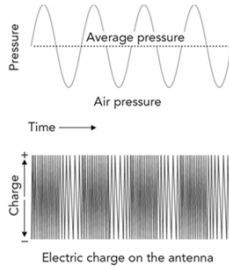
### AM Modulation

- ◆ 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