Grade 12 General / physics
Trimester 2 / Academic Year 2019-2020

I ♥ Physics

Electromagnetism part 2

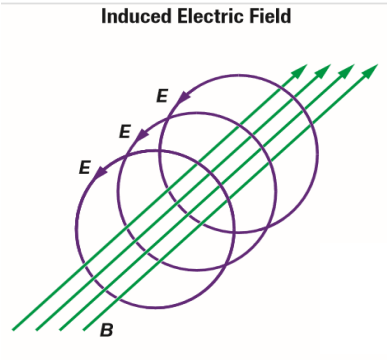
What are electromagnetic waves?

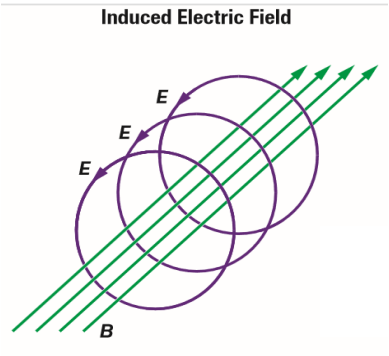
1- Define electromagnetic waves.

Waves are composed of oscillating magnetic and electric fields that can transfer through the space and matter.

2- How to create an electromagnetic wave?

By changing a magnetic field an electric field will produce or by changing an electric field a magnetic field will produce.

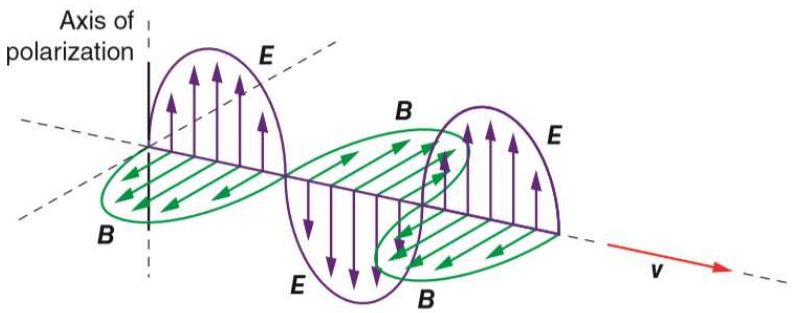




Electromagnetic wave properties

1- What are the properties of the electromagnetic waves?

- The magnetic field oscillates at right angles to the electric field.
- Both the electric field and the magnetic field are at right angles to the wave propagation direction.



- Electromagnetic waves are transverse waves and can travel through the vacuum and the matter.
- The speed of the electromagnetic field in the vacuum is equal to the speed of light $c = 3 \times 10^8 \text{m/s}$, this value change in another mediums.
- Each electromagnetic wave has a wavelength λ that inversely proportional to the frequency of the wave.

In the vacuum $\lambda = \frac{c}{f}$ $\lambda = \frac{v}{f}$ **In the matter**

The physics quantity		The unit
λ	The wavelength	m
c	The speed of light	m/s
f	The wave frequency	Hz

Applications

1- What is the wavelength of green light that has a frequency of 5.70×10^{14} Hz?

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2- What is the frequency of an electromagnetic wave that has a wavelength of 2.2×10^{-2} m?

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3- If an electromagnetic wave is propagating to the right and the electric field is in and out of the page, in what direction is the magnetic field?

……
……

4- Describe the change in the wavelength in the following cases.

The case	The change in the wavelength
The frequency of the wave is doubled	
The frequency of the wave is halved	
The frequency of the wave is quadrupled	

Types of electromagnetic waves

1- Define the electromagnetic spectrum.

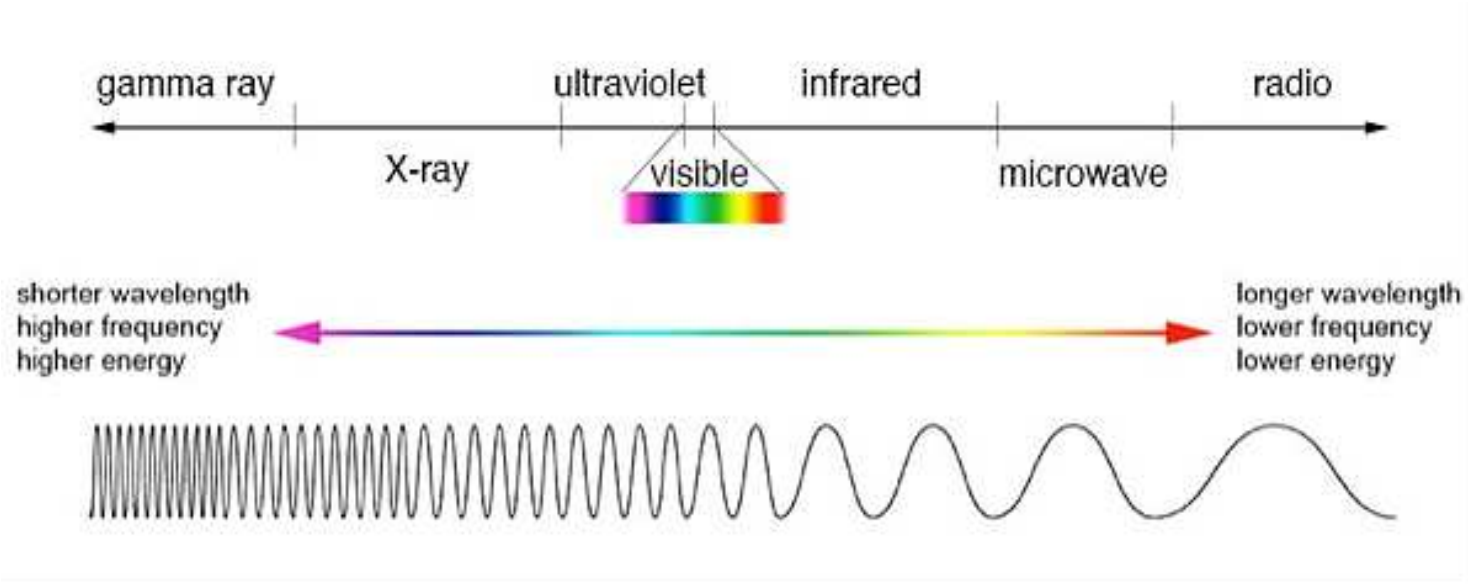
The range of frequencies that make up the continuum of electromagnetic waves.

2- Define the electromagnetic radiation.

The energy that is carried, or radiated, by an electromagnetic wave.

- **Note:** The energy carried by an electromagnetic wave is proportional to the square of the amplitude of the electric field and the area the wave crosses.

3- What are the types of electromagnetic waves?



4- What are the uses of electromagnetic waves?

Low frequency electromagnetic waves		
N	The waves	The uses
1	Radio waves	Communication over long distances (Radio) - Broadcast television
2	Microwaves	Radar – GPS - Cell phones - Cooking
3	Infrared	Night vision - Security cameras - Remote controls- worm buildings.
4	Ultra- violet	Sterilize instruments - Semiconductor industry - Patterns on silicon wafers in integrated circuits.

High frequency electromagnetic waves		
N	The waves	The uses
1	X-rays	Detect bone breaks and tooth problems - Kill cancerous cells
2	Gamma-rays	Detect dangerous substances in shipping containers - Treat cancer by destroying cells.

Transmitting Electromagnetic Waves

5- How are the radio waves and the information they carry broadcast?

By using a transmitter devise.

6- How does transmitter work?

A. Converts voice, music, pictures, or data to electronic signals
B. Amplifies the signal
C. Sends the signals to an antenna in a shape of oscillating potential difference that generates an oscillating electric field.
D. The oscillating electric field generates oscillating magnetic field.

3:53 min to 5:47 min
https://www.youtube.com/watch?v=FWCN_uI5ygY

Propagation through matter

- **Note1:** Air, glass, and water are dielectrics materials (poor conductor of electric current)
- **Note2:** Air, glass, and water are dielectrics materials (poor conductor of electric current)
- **Note3:** The velocity of an electromagnetic wave in a dielectric is always less than the wave's speed in a vacuum.

1- How we can calculate the velocity of a wave through any dielectric?

By using this equation. $$v = \frac{c}{\sqrt{k}} = \frac{c}{n}$$

k: is the dielectric coefficient
n: is the index of refraction

- **Note4:** $k = n^2$, both of n, k are dimensionless quantity.

Applications

1- What is the speed of an electromagnetic wave traveling through air? (k= 1.0005)

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2- Water has a dielectric constant of 1.77. What is the speed of light in water?

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3- The speed of light traveling through a material is 2.43×10^8 m/s. What is the dielectric constant of the material?

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Chapter 7 – Electromagnetism

Transmitting Electromagnetic Waves

1- Define the carrier wave.

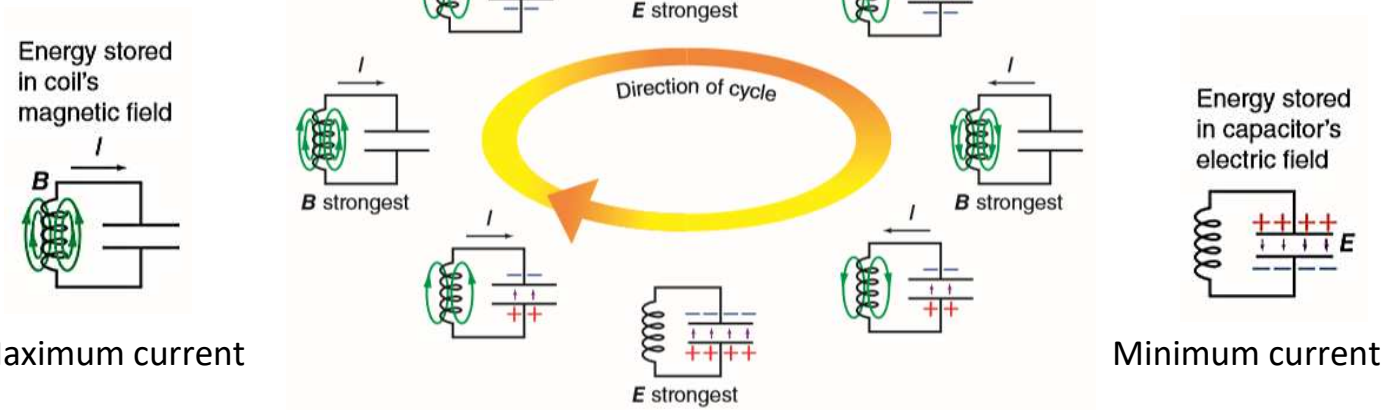
It is a certain radio wavelength specified for each radio station.

2- What are the parts of transmitter?

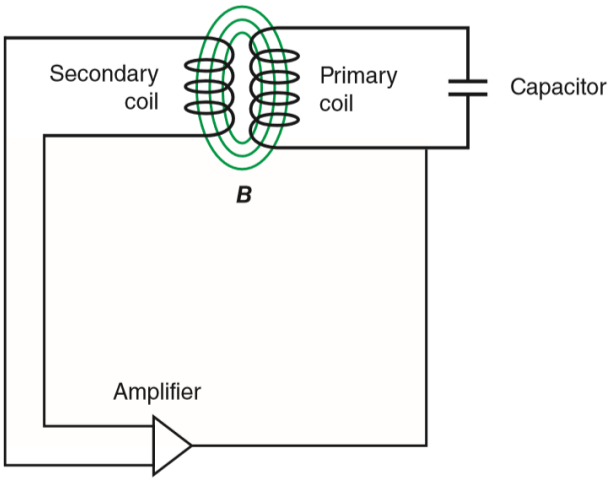
- ✓ The oscillator.
- ✓ The modulator.
- ✓ The amplifier.

3- How we can set the oscillation frequency?

In the oscillator we use an electric circuit contains a coil and a capacitor connected in parallel: https://www.youtube.com/watch?v=2_y_3_3V-so



- ➢ **Note:** As you see in the video the oscillations in a coil and capacitor die out over time. To avoid that we use another coil, forming a transformer, this enables the circuit to maintain its oscillations.



4- Define the resonant cavity.

The resonant cavity is a rectangular metal box that acts both as a coil and as a capacitor, used to increase the frequency of the produced wave.

- **Note**: The size of the box determines the frequency of oscillation

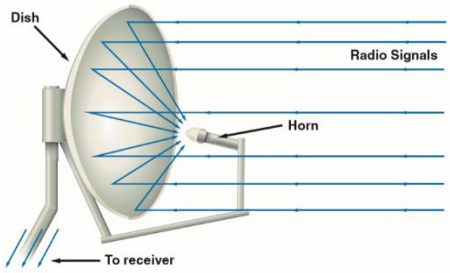
5- Define piezoelectricity.

It is a way to produce a continues oscillating potential difference by applying a potential difference on some materials like the quartz crystal.

- **Note**: The thinner the crystal, the higher is the vibration frequency.

https://www.youtube.com/watch?v=3jfgQF3jX7A

Receiving Electromagnetic Waves

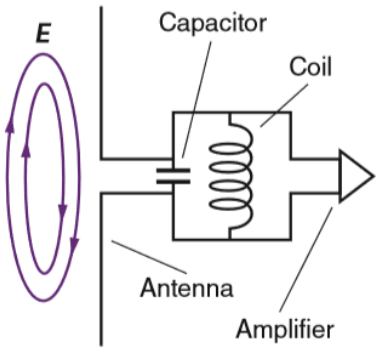


1- How we can receive the electromagnetic waves?

By using receiver device with antenna which has many different shapes (Wire – Dish …ets)

2- How does receiver device work?

A. The wave's electric field accelerates electrons in the metal of an antenna.
B. A potential difference across the antenna's terminals oscillates at the frequency of the wave.
C. The oscillating potential difference send to the receiver circuit that convert the electric signals into voice, music, pictures or data.



- **Important note**: The length of the antenna should be half of the wavelength to receive clear signals if the antenna connected to the receiver from the middle, but the length of the antenna should be quarter of the wavelength to receive clear signals if the antenna connected to the receiver from the end (like the cell phone receiver)

3- How you can select waves of a particular frequency and reject the others?

By using a **tuner** that control the amplitude of the receiver circuit until it makes the oscillation frequency of the receiver circuit equals the frequency of the desired wave.

4- Compare between FM and AM signals

FM signals / Frequency Modulation	AM signals /Amplitude Modulation
have less noise	Have more noise
Short wavelength and high frequency	long wavelength and low frequency

Applications

1- Why are AM antennas longer than FM antennas?

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2- Would an FM antenna designed to be most sensitive to stations near 88 MHz be shorter or longer than one designed to receive stations near 108 MHz?

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3- The wavelengths of radio waves reflected by a parabolic dish are 2.0 cm long. What is the length of the antenna that detects them?

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4- A receiving antenna is 4.8 m long. What frequency signal could it best detect?

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5- What is the optimum length of an antenna designed to receive a 101.3-MHz FM radio signal?

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6- At what frequency does a cell phone with an 8.3-cm-long antenna send and receive signals? The ideal length of a single-ended antenna in a cell phone is one-fourth the wavelength of the wave it broadcasts.

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The end