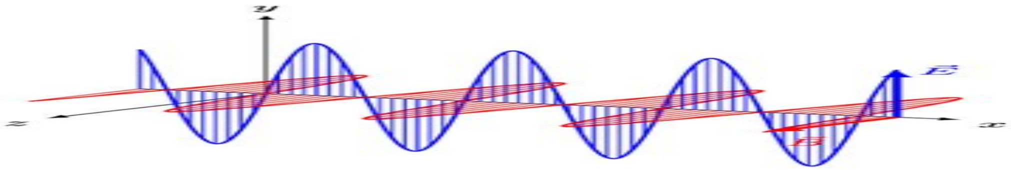

Unmute (m)

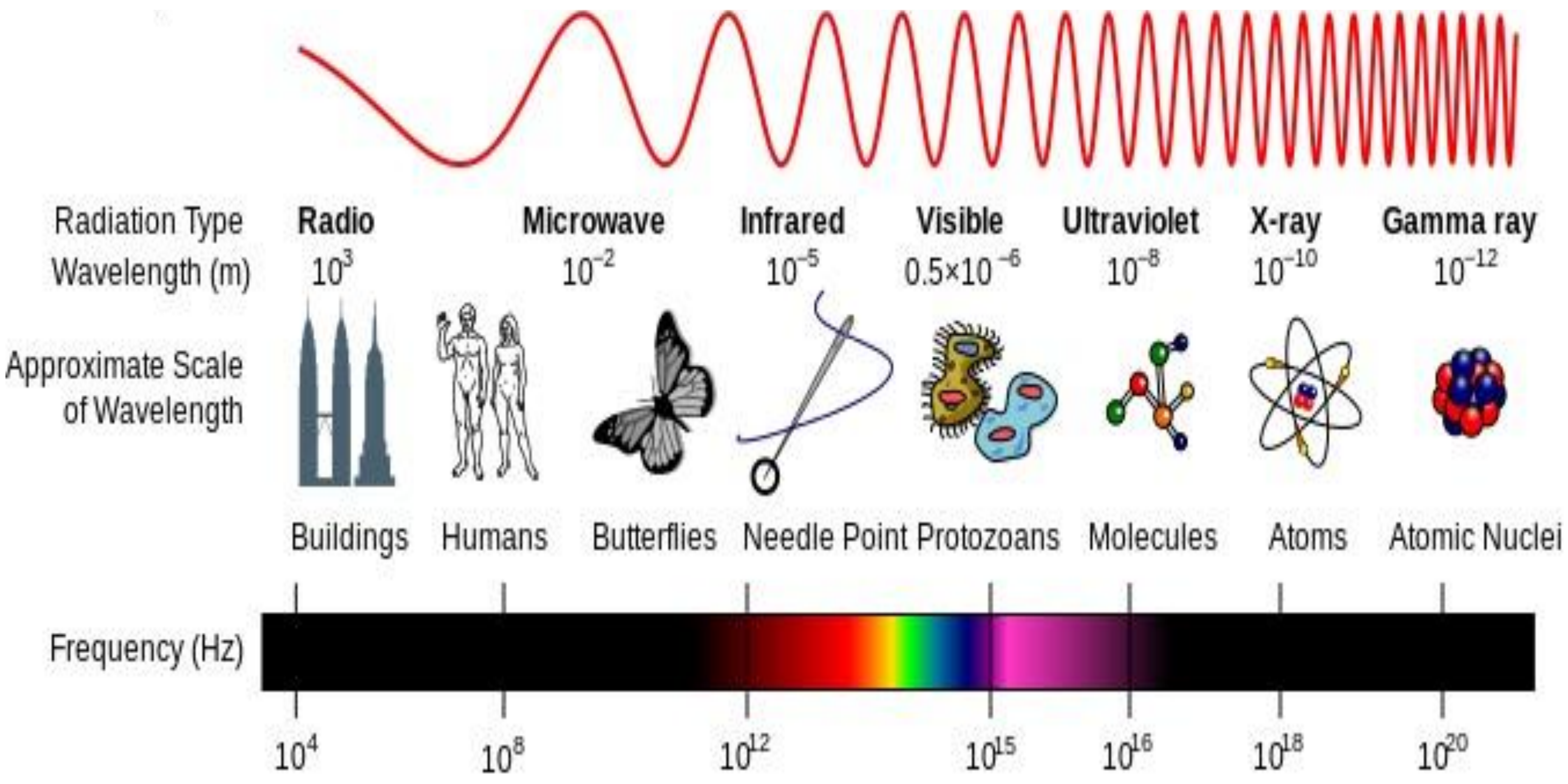
Electromagnetic Waves Scale
Uses of the Electromagnetic Waves



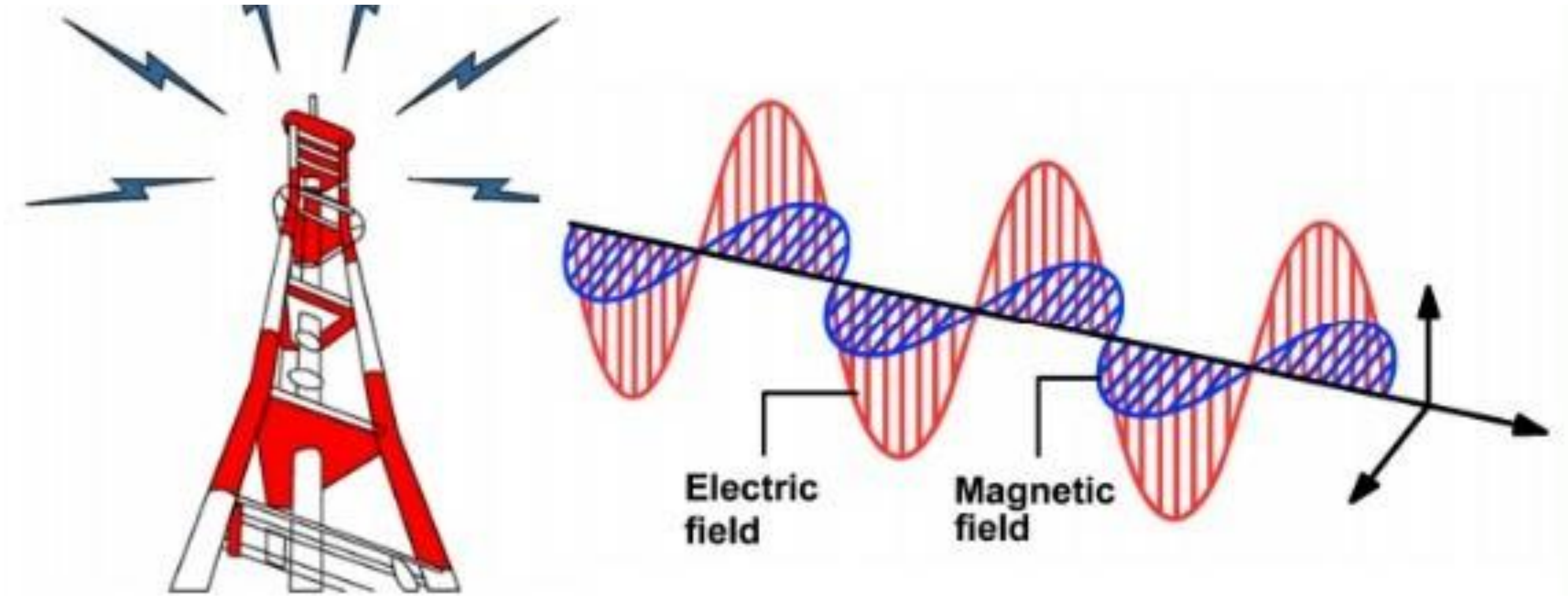
Learning objectives:

1. Understand the conditions for the appearance and properties of electromagnetic oscillations.
2. Know the types and characteristics of electromagnetic oscillations in accordance with the scale of electromagnetic oscillations.
3. Give examples of the use of electromagnetic oscillations.

THE ELECTROMAGNETIC WAVES



HOW ARE ELECTROMAGNETIC WAVES GENERATED/PRODUCED???

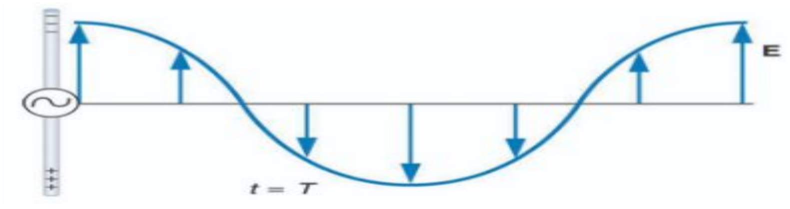


Generation of oscillation in the transmitter/ antenna

HOW ARE ELECTROMAGNETIC WAVES GENERATED/PRODUCED???

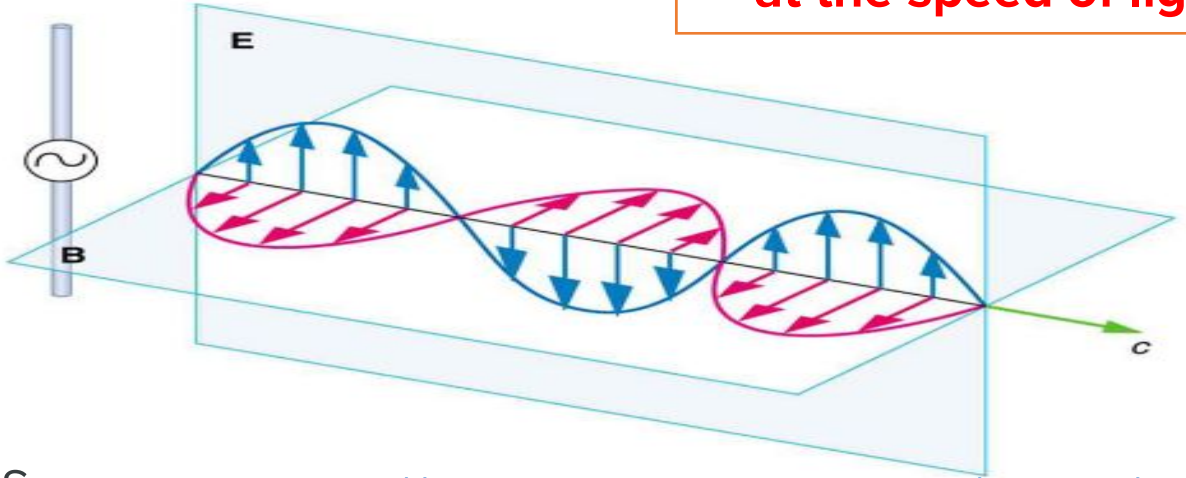
Generation of oscillation in the transmitter/ antenna

A long straight gray wire with an AC generator at its center, a broadcast antenna for electromagnetic waves.



- The charges in the antenna produces the electric field.
- The electric field (E) propagates away from the antenna at the speed of light.

- The current in the antenna produces the magnetic field.
- The magnetic field (B) propagates away from the antenna at the speed of light.

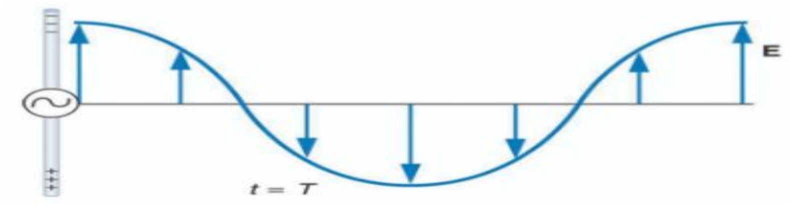


- The electric and magnetic fields (E and B) are in phase, vibrates at the same frequency (the frequency of the wave) and they are perpendicular to one another.

Source: https://courses.lumenlearning.com/physics/chapter/24-2-production-of-electromagnetic-waves/

Questions

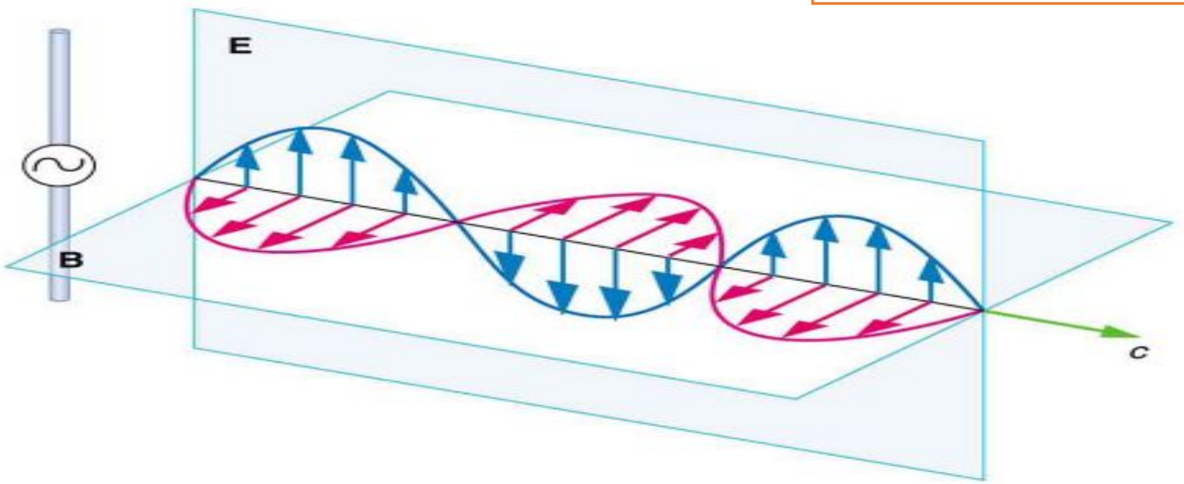
1. How does electric field E and magnetic field B propagate?



Answers: The electric and magnetic fields (E and B) are in phase, vibrates at the same frequency (the frequency of the wave) and they are perpendicular to one another.

2. If the speed of the EM waves in a vaccuum is independent of frequency of the waves, what is the value of its speed?

Answer: $c = 3\times10^{8}$ m/s.



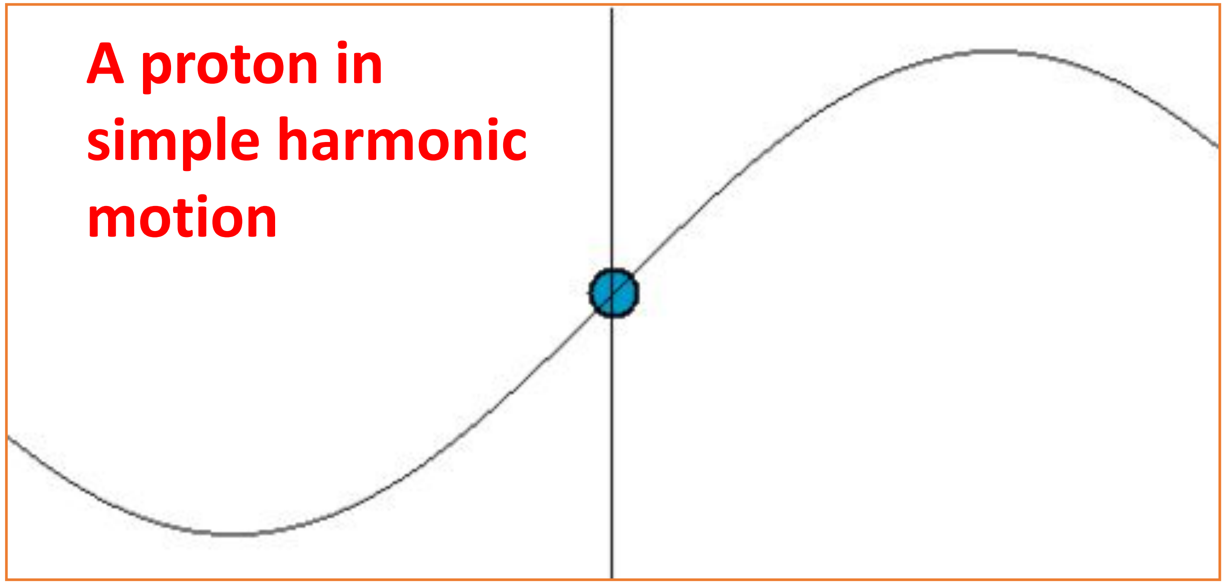
3. EM waves are transverse waves, what is meant by transverse?

Answers: It means at right angles or 90 degrees.

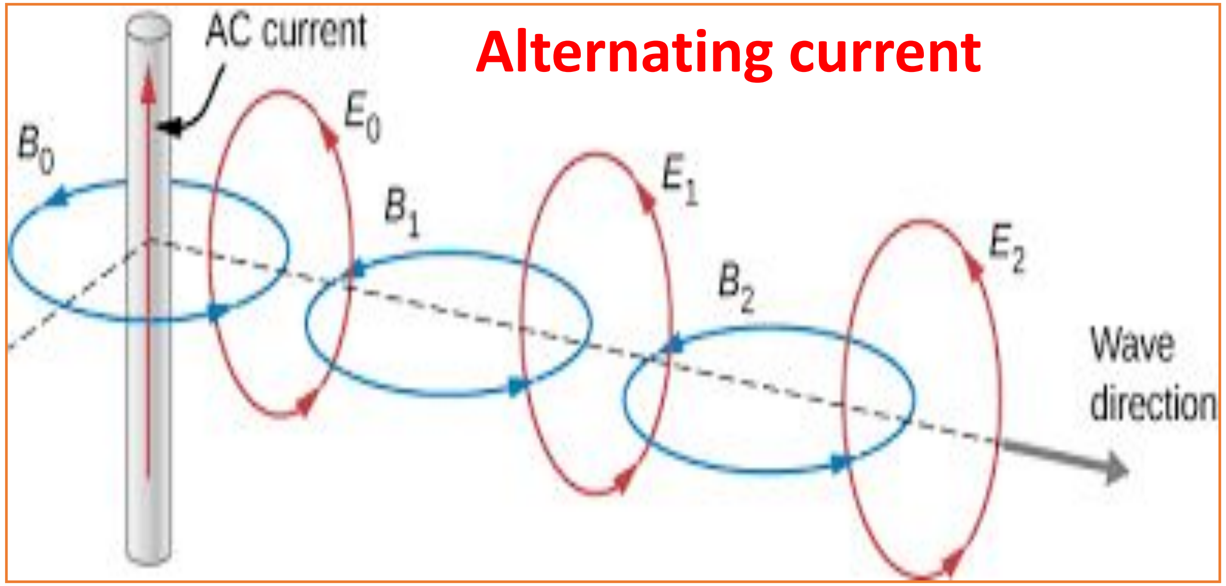
Source: https://courses.lumenlearning.com/physics/chapter/24-2-production-of-electromagnetic-waves/

HOW ARE ELECTROMAGNETIC WAVES GENERATED/PRODUCED???

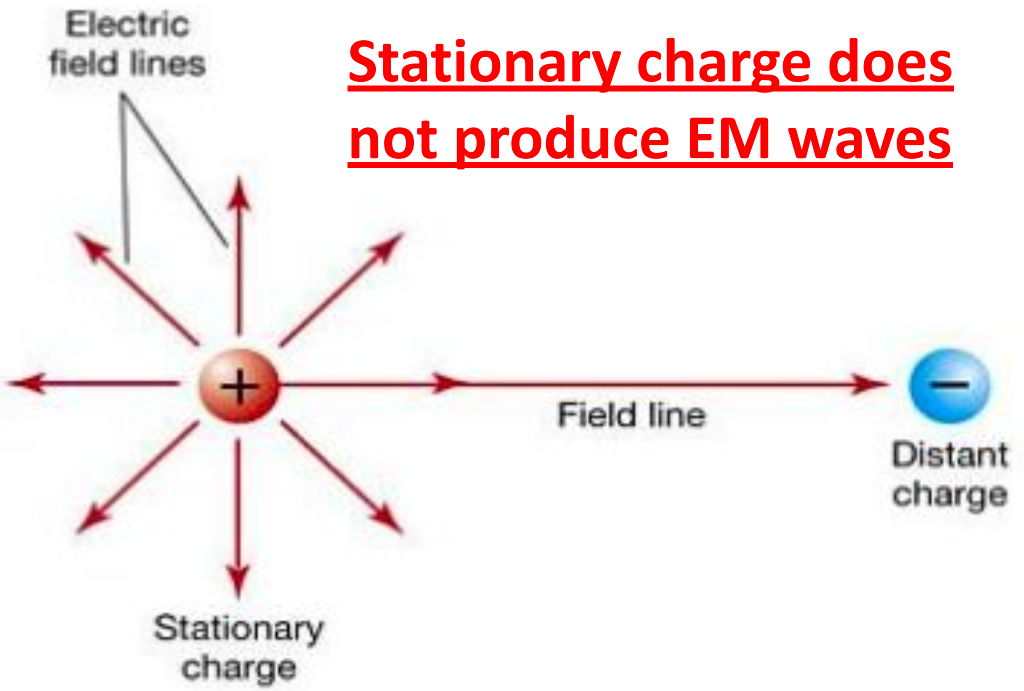
A proton in simple harmonic motion



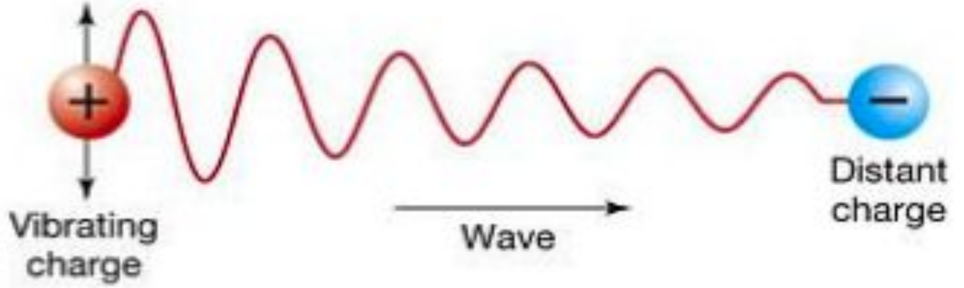
Alternating current



<u>Stationary charge does not produce EM waves</u>

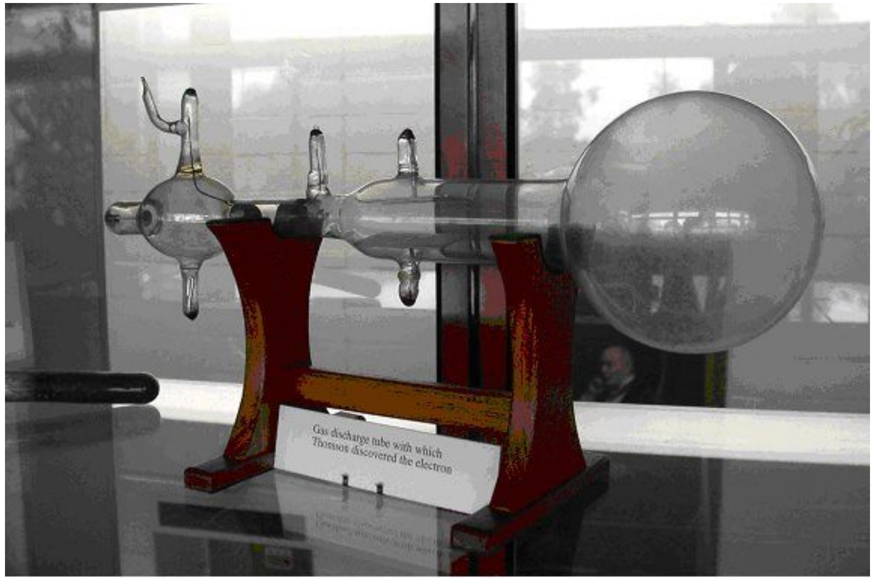


An accelerating electron or proton (charge)



HOW ARE ELECTROMAGNETIC WAVES GENERATED/PRODUCED???

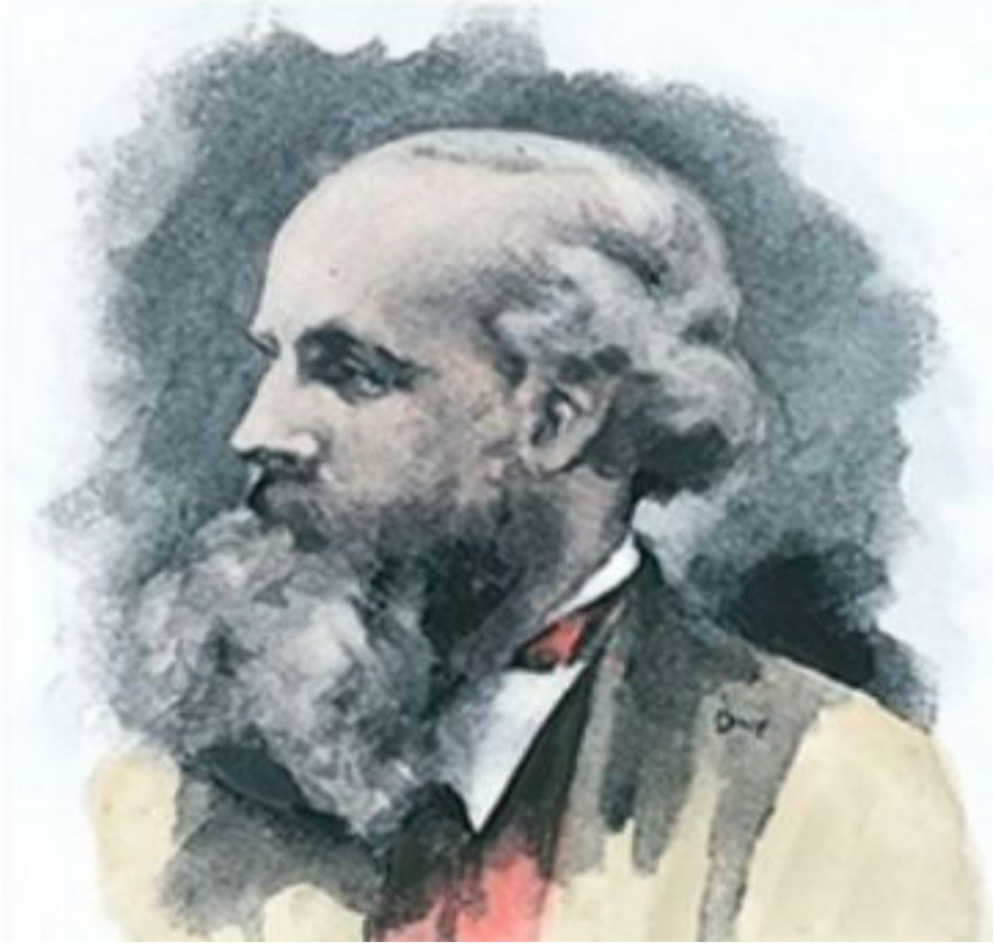
Charged particles traveling in a circular path in a mass spectrometer



https://slideplayer.com/slide/6878882/

James Clerk Maxwell

- 1831 – 1879
- Scottish physicist
- Provided a mathematical theory that showed a close relationship between all electric and magnetic phenomena
- His equations predict the existence of electromagnetic waves that propagate through space



Maxwell showed that, theoretically, the speed of these waves is given by

$$v = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

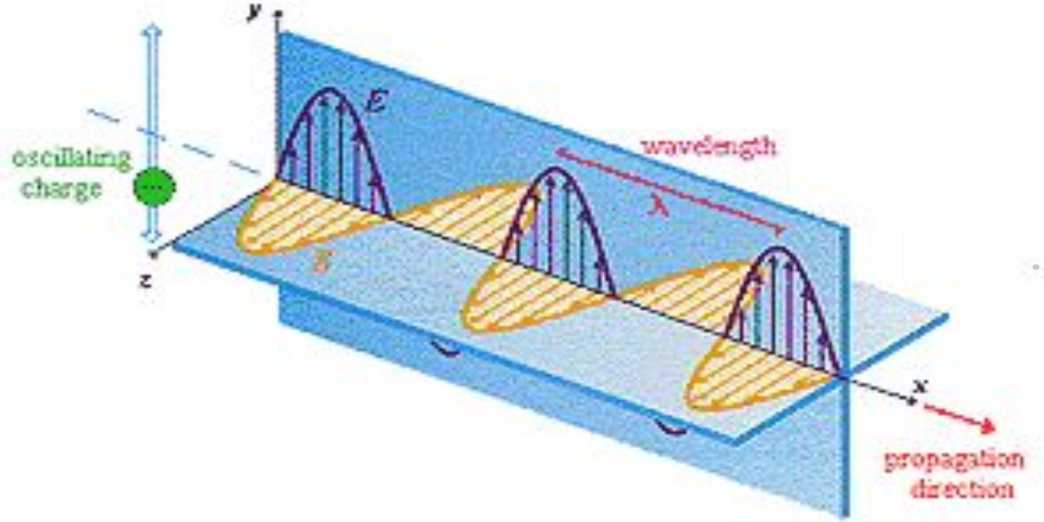
where ε_0 is the permittivity of free space and μ_0 is the permeability of free space. Placing the numeric values in the formula gives

$$v = \frac{1}{\sqrt{(8.85 \times 10^{-12}\ \text{F/m}) \cdot (4\pi \times 10^{-7}\ \text{Tm/A})}} \cong 3 \times 10^{8}\ \text{m/s}$$

The theoretically obtained value for the speed of electromagnetic waves was equal to the measured speed of light. Thus Maxwell concluded that light is an electromagnetic wave. The speed of EM waves in vacuum is denoted by the letter "c".

$$c = 299\,792\,458\ \text{m/s} \cong 3 \times 10^{8}\ \text{m/s}$$

The Nature of Electromagnetic (EM) Waves



- EM waves are produced by accelerating electric charges.

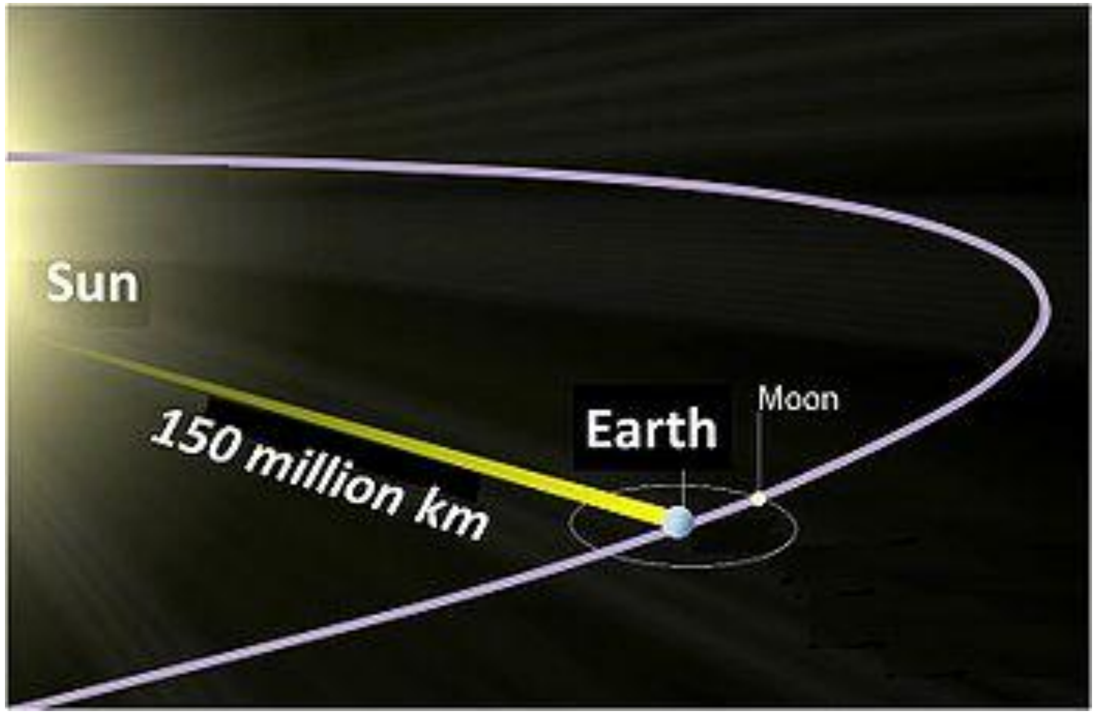
- do not require a material medium.
- transfer energy through space.

This is how astronauts on spacewalks use radios to communicate. Radio waves are a type of electromagnetic wave.

The Nature of Electromagnetic (EM) Waves

- can propagate through a material substance.
- All EM waves travel at the same speed in vacuum, $c = 3\times10^8$ m/s.

$$c = \lambda f$$



Exercises

1. Calculate the frequency in MHz of a radio wave of wavelength 250 m.

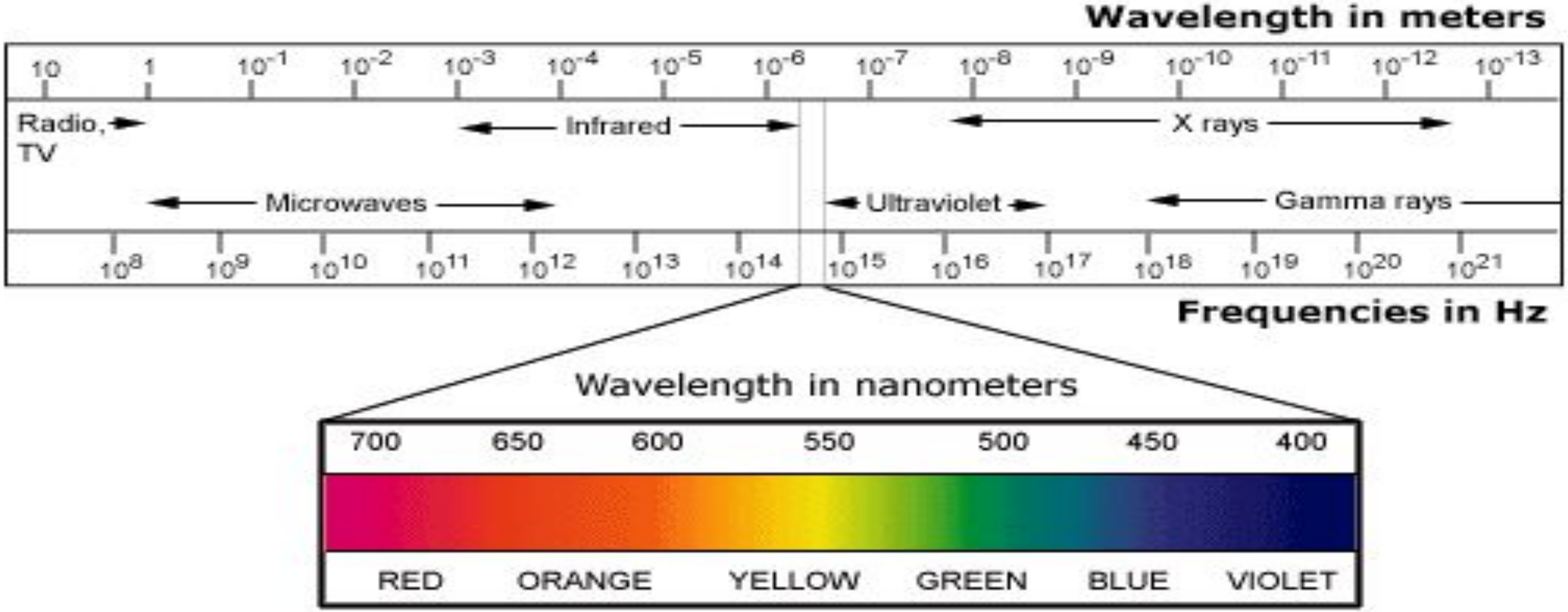
1.2 MHz

2. Calculate the wavelength in nm of an X-ray wave of 2.0×10^{18} Hz.

0.15 nm

Electromagnetic Spectrum

- The electromagnetic spectrum shows the range of frequencies of electromagnetic radiation



Exercises and Problems
CAMBIDGE EXAM CIE PAST PAPERS

For Examiner's Use

5 **(a)** State one property of electromagnetic waves that is **not** common to other transverse waves.

travel through a vacuum / free space

.... [1]

(b) The seven regions of the electromagnetic spectrum are represented by blocks labelled A to G in Fig. 5.1.

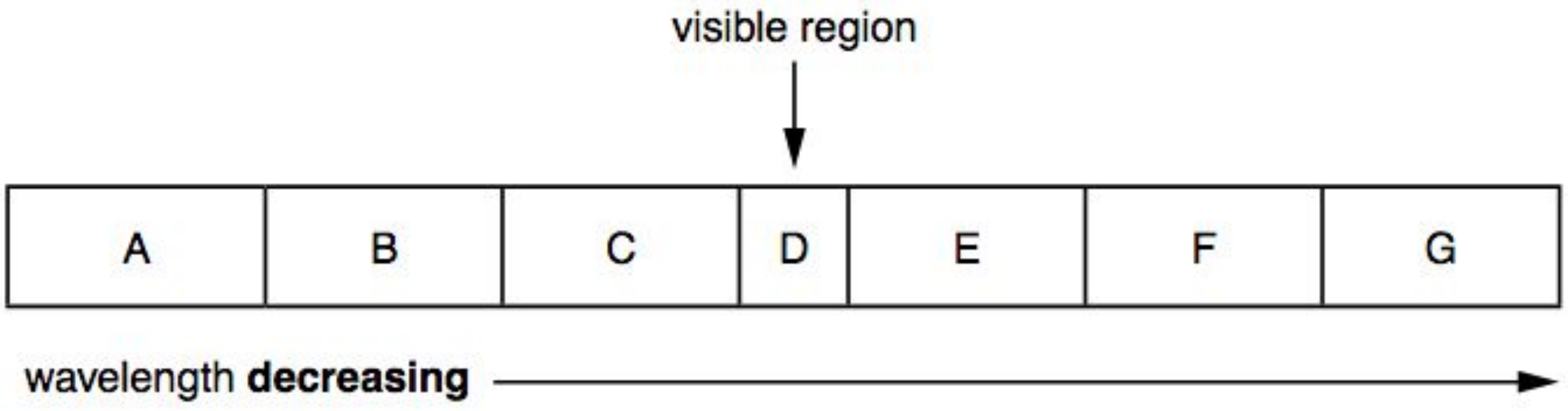


Fig. 5.1

A typical wavelength for the visible region D is 500 nm.

(i) Name the principal radiations and give a typical wavelength for each of the regions B, E and F.

B: name: .... **microwaves** wavelength: 10^{-4} to 10^{-1} m

E: name: .... **ultra-violet / UV** wavelength: 10^{-7} to 10^{-9} m

F: name: .... **X –rays** wavelength: 10^{-9} to 10^{-12} m

[3]

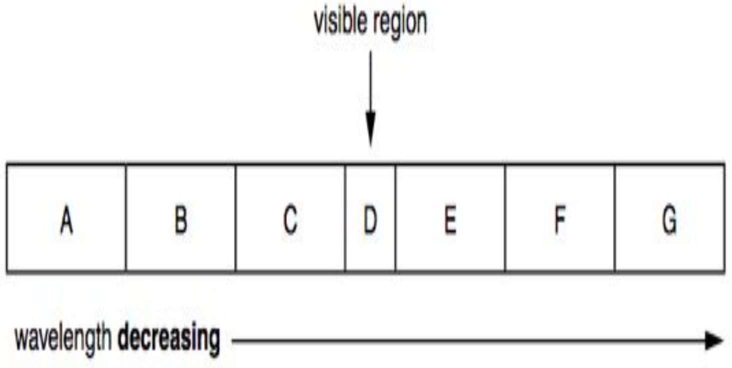


Fig. 5.1

(ii) Calculate the frequency corresponding to a wavelength of 500 nm.

$$f = \frac{3 \times 10^{8}}{500 \times 10^{-9}}$$

$$f = 6(.0) \times 10^{14} \text{ Hz}$$

frequency = ... Hz [2]

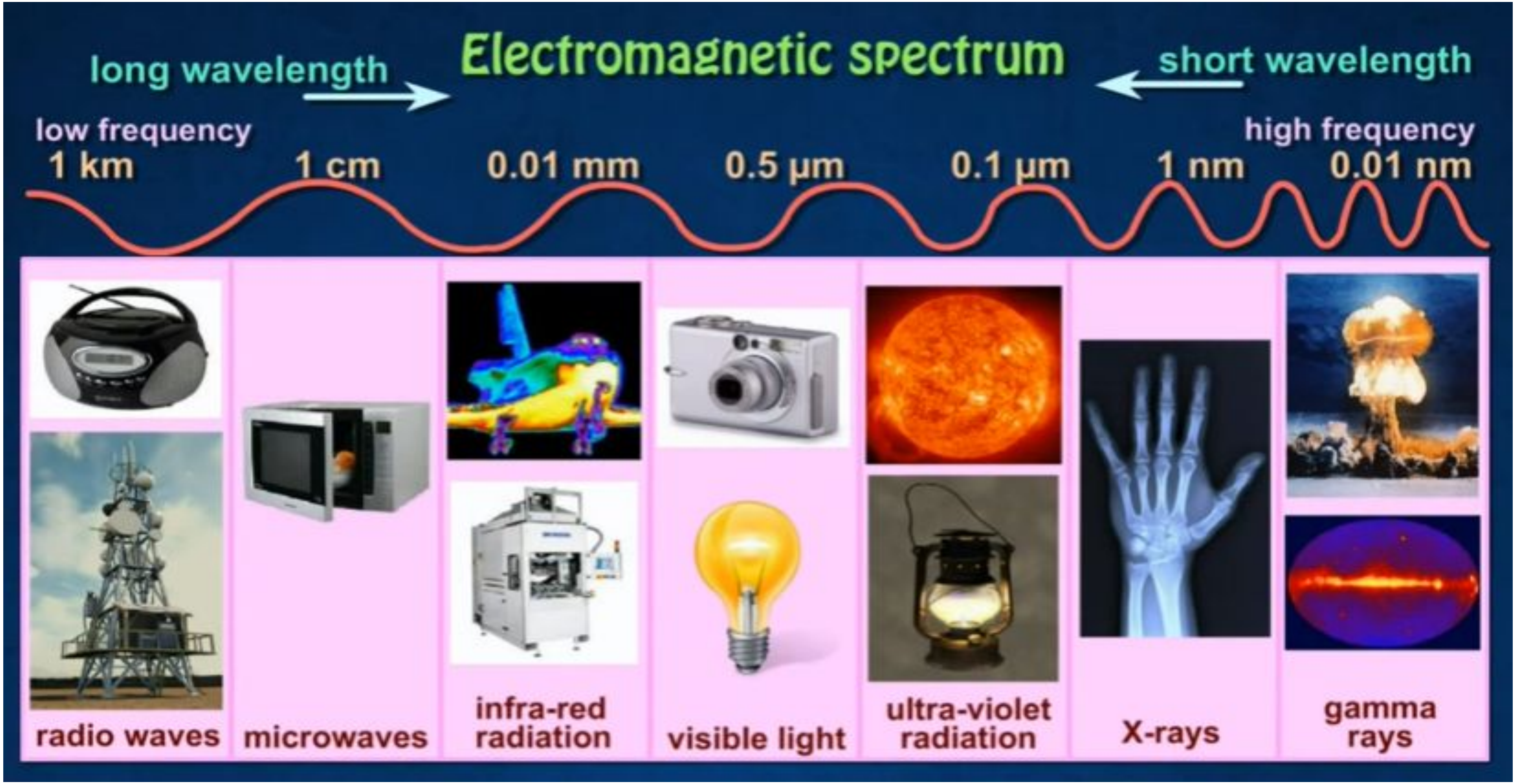
(c) All the waves in the spectrum shown in Fig. 5.1 can be polarised. Explain the meaning of the term *polarised*.

restrict the vibrations of (a transverse wave, especially light) wholly or partially to one direction.

[2]

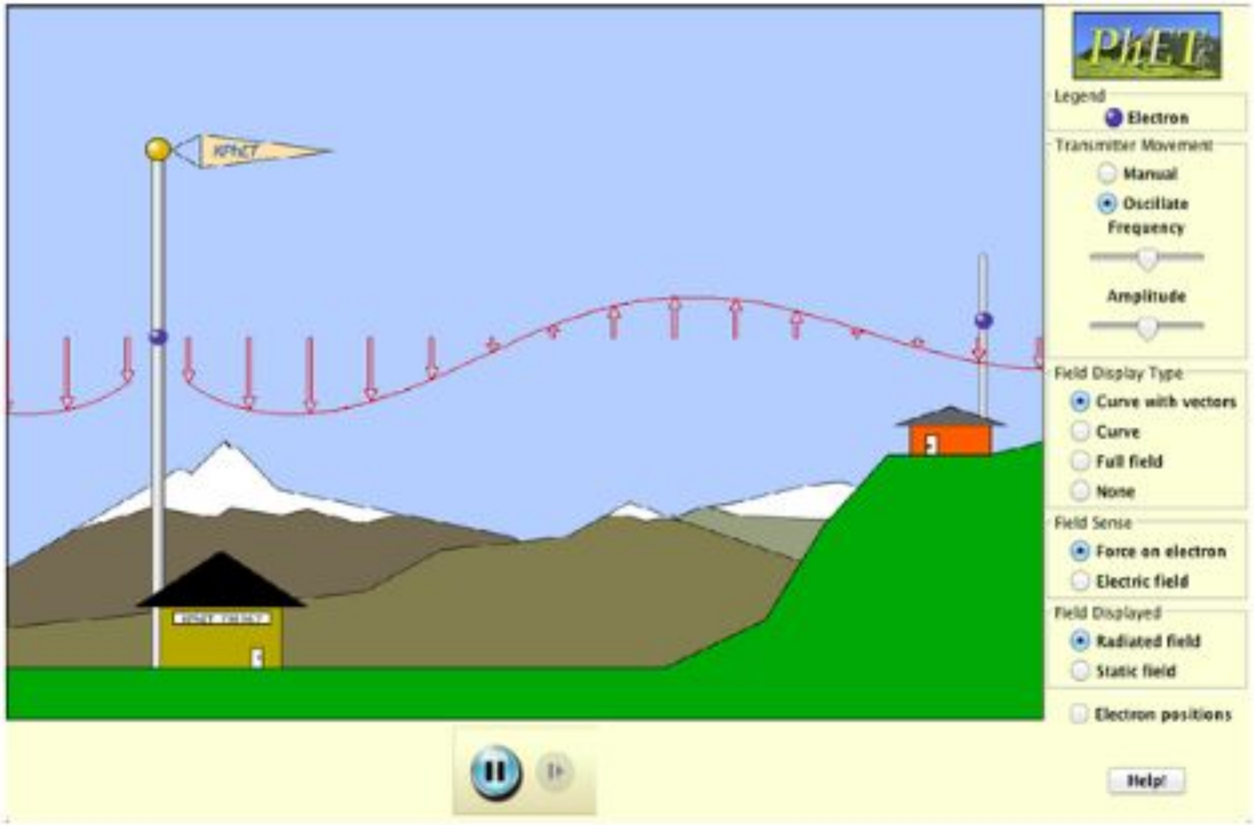
Electromagnetic Radiation

- Some uses of EM radiation



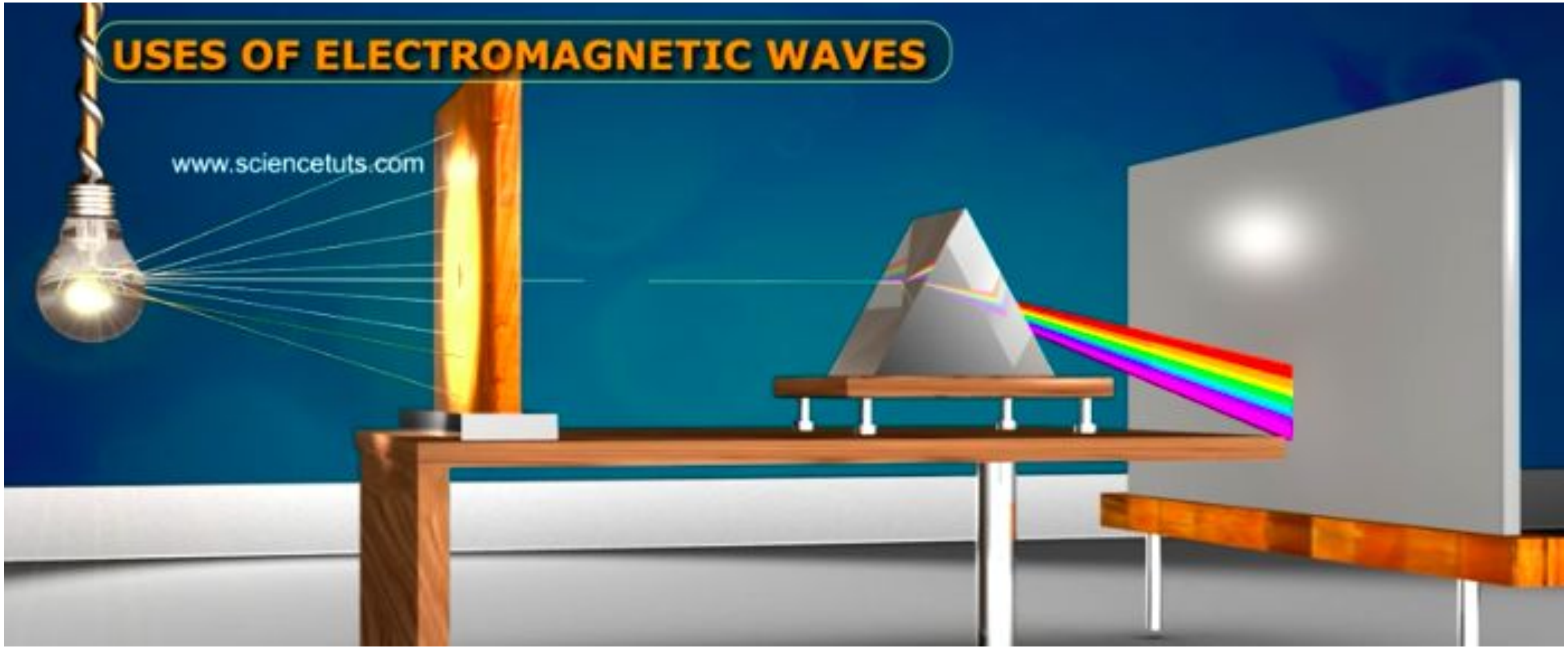
PhET Explorations: Radio Waves and Electromagnetic Fields

https://phet.colorado.edu/sims/cheerpj/radio-waves/latest/radio-waves.html?simulation=radio-waves



Watch: USES OF ELECTROMAGNETIC WAVES

https://www.youtube.com/watch?v=zht4R-qsr1c



Давайте поиграем в "Найди того, кто"... А теперь встаньте, студенты, и найдите кого-нибудь, кто... (не подходите к своим соседям по парте, идите к другим своим одноклассникам!!!)

Now, stand up students and find someone who… (don’t come to your seatmates, go to your other classmates!!!)

1. Find someone who can tell you the EM waves with longest wavelength…

2. Find someone who can tell you the EM waves with shortest wavelength…

3. Find someone who can tell you what is the use of microwaves…

4. Find someone who can tell you what is the use of infrared rays…

5. Find someone who can tell you what is the use of ultraviolet light…

"Найди того, кто"

Find someone who… (don't come to your seatmates, go to your other classmates!!!)

6. Find someone who can tell you what is the use of X-rays…

7. Find someone who can tell you what is the use of gamma rays…

8. Find someone who can tell you how much of electromagnetic spectrum are visible…

9. Find someone who can tell you what are some sources of electromagnetic radiation that we use every day…

Match words and pictures

Visible light

Infrared

Radio waves

Microwave

X-rays

Ultraviolet

Gamma rays

ANSWERS

Electromagnetic radiation	Uses	
Radio waves	Broadcasting and communications – their longer wavelength means they travel further in the Earth's atmosphere, reflecting off hills and the upper atmosphere.	
Microwaves	Cooking food – microwaves are absorbed by water molecules causing them to vibrate (heat up). Satellite transmissions – their wavelength penetrates our atmosphere.	
Infrared	Heater and night vision equipment – all objects, including people, give out infrared rays which can be detected even at night. It's also used for television remote controls.	
Visible light	Human vision, photography and optical fibres – it's the only part of the spectrum we can see.	
Ultraviolet	Fluorescent lamps – they have chemicals inside them which absorb ultraviolet rays and convert the energy to visible light.	
X-rays	Medical equipment – they enable us to see the internal structure of objects and materials by passing through some substances (eg body tissue) but being absorbed by others (eg bone).	
Gamma rays	Sterilising food and medical equipment – they are highly penetrative and can kill.