What Are Electromagnetic Waves?

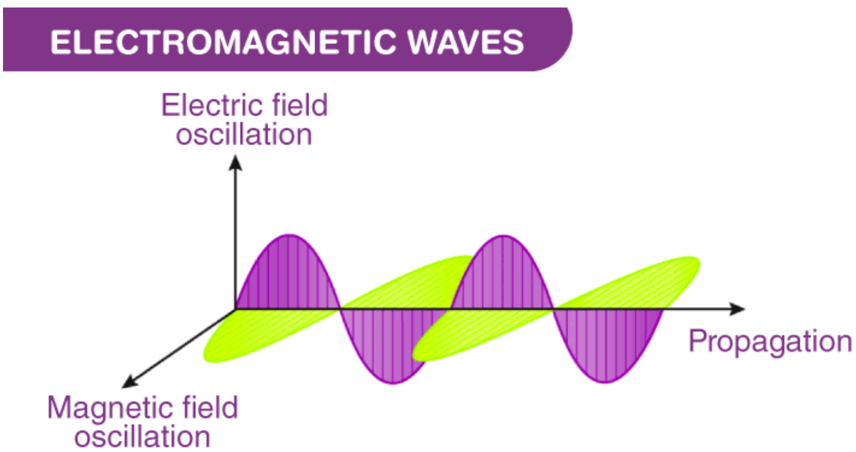
Electromagnetic waves are also known as EM waves. Electromagnetic radiations are composed of electromagnetic waves that are produced when an electric field encounters the magnetic field. It can also be said that electromagnetic waves are the composition of oscillating electric and magnetic fields. Electromagnetic waves are solutions of Maxwell's equations, which are the fundamental equations of electrodynamics.

How Are Electromagnetic Waves Formed?

Generally, an electric field is produced by a charged particle. A force is exerted by this electric field on other charged particles. Positive charges accelerate in the direction of the field and negative charges accelerate in a direction opposite to the direction of the field.

The Magnetic field is produced by a moving charged particle. A force is exerted by this magnetic field on other moving particles. The force on these charges is always perpendicular to the direction of their velocity and therefore only changes the direction of the velocity, not the speed.

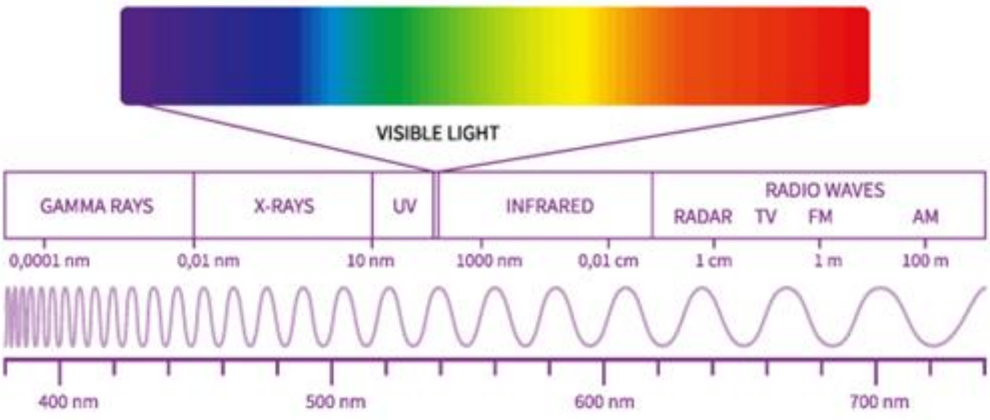
So, the electromagnetic field is produced by an accelerating charged particle. Electromagnetic waves are nothing but electric and magnetic fields travelling through free space with the speed of light c. An accelerating charged particle is when the charged particle oscillates about an equilibrium position. If the frequency of oscillation of the charged particle is f, then it produces an electromagnetic wave with frequency f. The wavelength λ of this wave is given by $\lambda = c/f$. Electromagnetic waves transfer energy through space.



Graphical Representation of Electromagnetic Waves

The highest point of the wave is known as the crest while the lowest point is known as a trough. In vacuum, the waves travel at a constant velocity of 3 x 10^8 $m.s^{-1}$.

Electromagnetic Spectrum



Electromagnetic waves are classified according to their frequency f or according to their wavelength

$\lambda = cf$.

The wavelength ranges of different lights are as follows,

For visible light – approx. 400 nm to approx. 700 nm

For violet light – approx. 400 nm

For red light – approx. 700 nm

Applications of Electromagnetic Waves

Following are a few applications of electromagnetic waves:

- Electromagnetic radiations can transmit energy in a vacuum or using no medium at all.
- Electromagnetic waves play an important role in communication technology.
- Electromagnetic waves are used in RADARS.
- UV rays are used to detect forged bank notes. Real banknotes don't turn fluorescent under UV light.
- Infrared radiation is used for night vision and is used in security cameras.

Frequently Asked Questions

Q1 : Name the property of an electromagnetic wave which is dependent on the medium in which it is travelling.

Velocity of an electromagnetic wave is a property which is dependent on the medium in which it is travelling. Other properties such as frequency, time period, and wavelength are dependent on the source that is producing the wave.

Q2: What is the wavelength of the photon of infrared light with the frequency 2.5 x 10^{14} Hz?

Since infrared light is a part of electromagnetic spectrum, the relation between the wavelength, frequency, and velocity is given by the formula:
$c = f\lambda$
Consider c = 3 x 10^{8} $m.s^{-1}$.
Substituting the values, we get wavelength = 1.2 x 10^{-6}m.

Q3: State if the given statement is true or false: Radio waves and X-rays both are on the electromagnetic spectrum and can travel at the same speed.

The given statement is true. Any wave from the electromagnetic spectrum travels at a constant speed of light. Other properties such as frequency, energy, and wavelength vary depending on the type of wave and the source producing them. But the velocity remains constant.
Q4

Q4: What is the reason behind photons travelling at a speed of light while the other particles cannot?

Photons can travel at a speed of light while other particles cannot because they do not have mass.

Light travels much faster than sound

Light travels at a speed of 299,792,458 m/s (that's nearly 300,000 km/s!). The distance around the Earth is 40,000 km, so in 1 second, light could travel seven and a half times around the world.

Sound only travels at about 330 m/s through the air, so light is nearly a million times faster than sound.

If lightning flashes 1 kilometer away from you, the light reaches you in 3 millionths of a second, which is almost instantly. The sound of the thunder takes 3 seconds to travel 1 kilometer

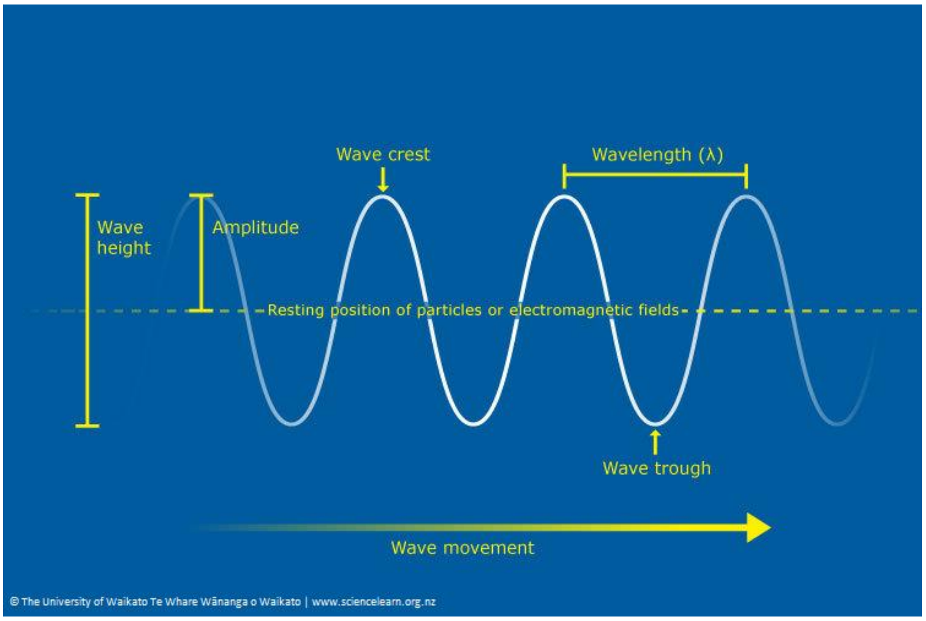
Light takes about 8 minutes and 20 seconds to reach the Earth from the Sun. When we see the Sun, we are seeing what it looked like over 8 minutes ago.

Light can travel through empty space

Unlike sound, which needs a medium (like air or water) to travel through, light can travel in the vacuum of space.

Light travels in straight lines

Once light has been produced, it will keep travelling in a straight line until it hits something else.

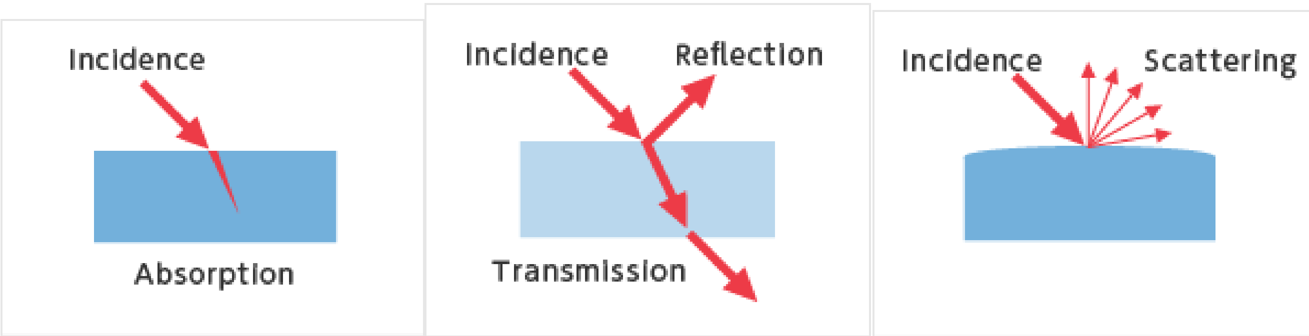


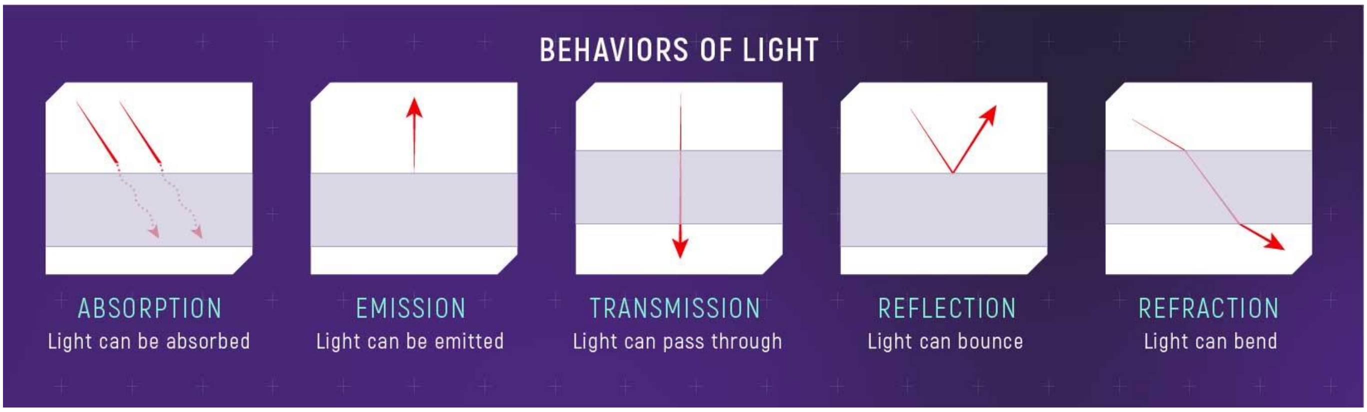
Interaction of light with matter

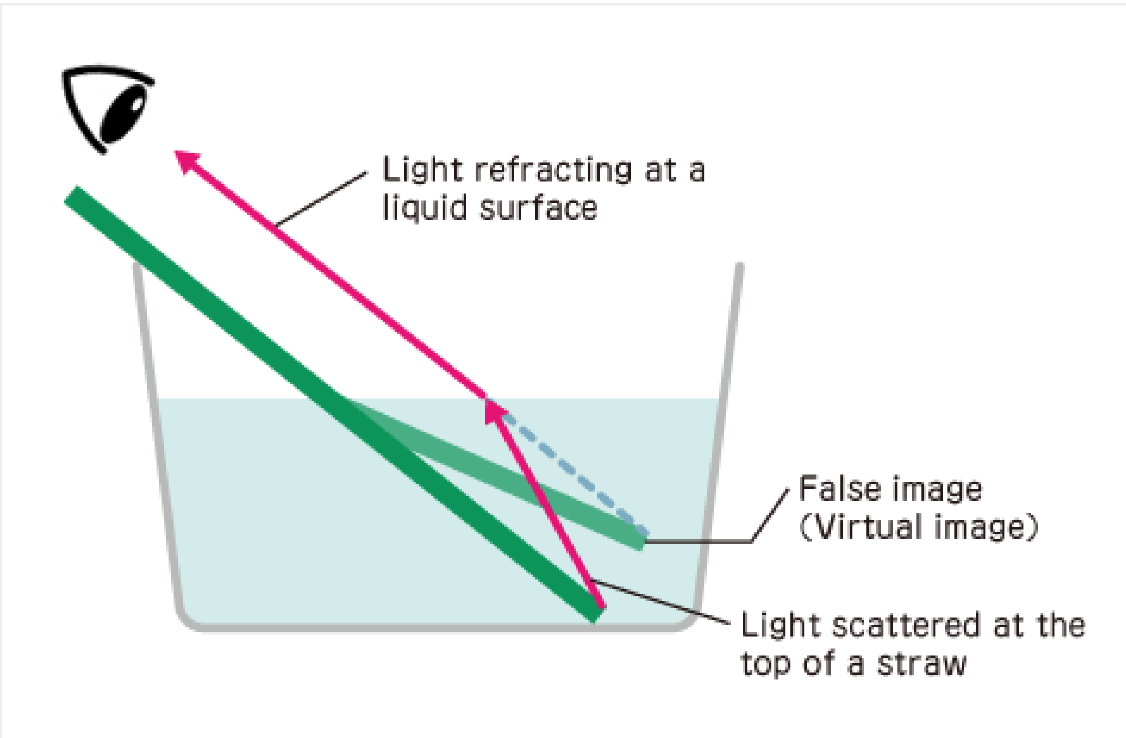
Light behaves in many different ways when it comes in contact with something. When in a vacuum such as outer space where no matter is present, light travels straightforward.

However, light behaves in a variety of ways when it comes in contact with water, air, and other matters – it is "absorbed", "transmitted through", "reflected", and "scattered". When light strikes matter, a part of that light is absorbed into the matter (a) and is transformed into heat energy.

If the matter that the light strikes is a transparent material, the light component that was not absorbed within the material is “transmitted” through (b) and exits to the outer side of the material. If the surface of the material is smooth (a mirror for example), “reflection” occurs (b), but if the surface is irregular having pits and protrusions, the light “scatters”.

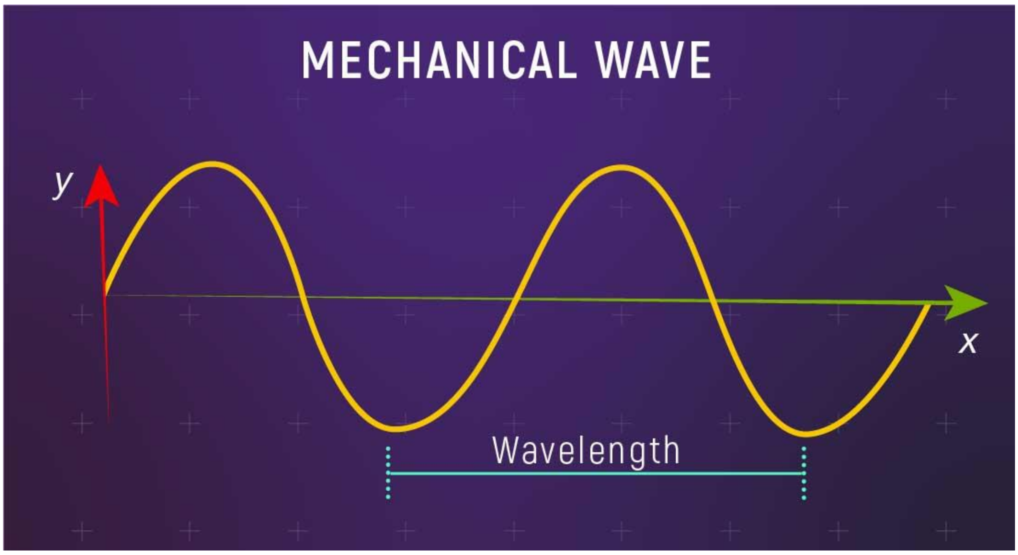





Light refracting at a liquid surface
False image (Virtual image)
Light scattered at the top of a straw

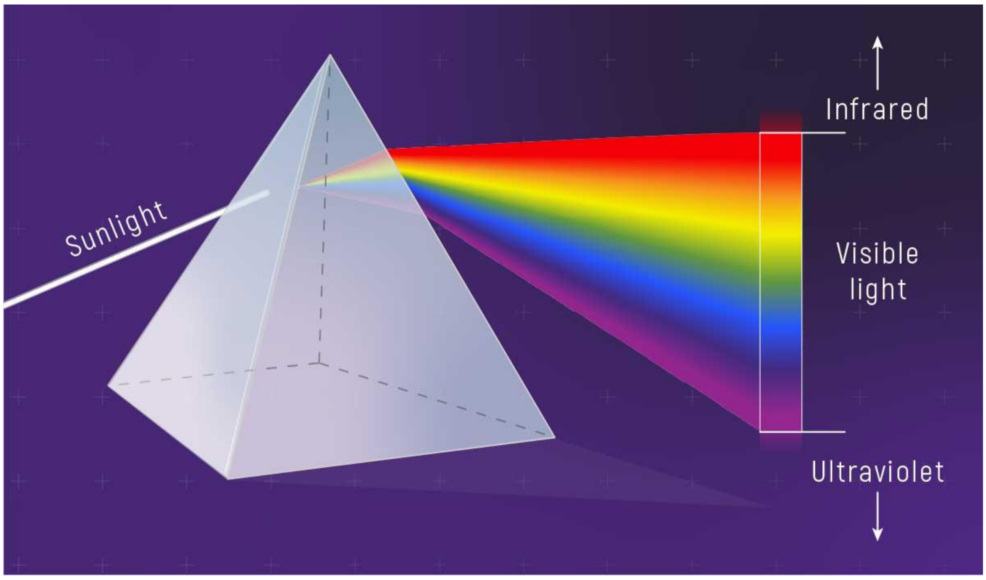
What Is Wavelength?

The wavelength of light is defined as **“The distance between the two successive crests or troughs of the light wave”.** It is denoted by the Greek letter lambda (λ). Therefore, the distance between either one crest or trough of one wave and the next wave is known as wavelength.

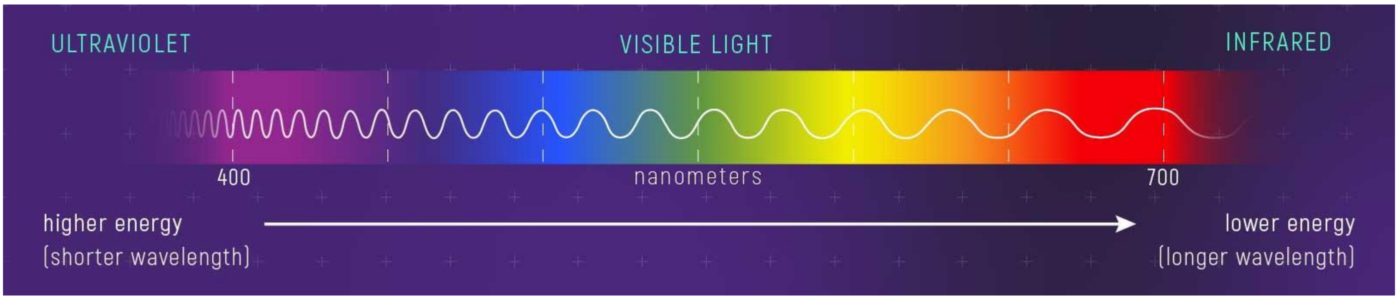


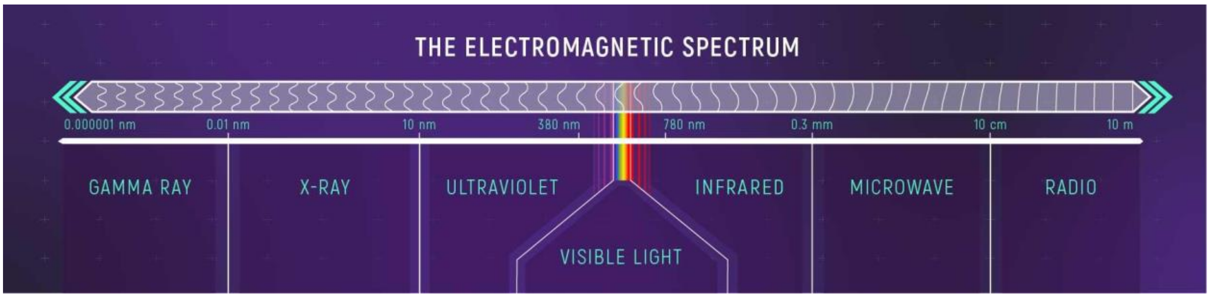
What is Visible Spectrum?

The visible spectrum is nothing but the observable region of the electromagnetic wave which is visible to human eyes. In the electromagnetic spectrum, the visible spectrum ranges from the infrared region to the UV region. The visible light lies in between the infrared and ultraviolet range of wavelengths. The human eye can detect the light spectrum ranging from 400 nanometers (violet) to about 700 nanometers (red). Other electromagnetic radiations are either too small or too large to capture for the human eye and are out of biological limitations.



When the visible light travels through a prism, the visible light gets separated into a spectrum of colors. Red color has the longest wavelength of 700 nm, and violet has the shortest wavelength of 380 nm. These colors arrange themselves according to the wavelength as the spectrum of rainbow colors.





How is the Wavelength of Light Calculated?

As light has the properties of a wave and a particle, it can be expressed in two equations:

$v=\lambda f$

$E=hf$

Where,

- v is the velocity of the light.
- λ is the wavelength of the light.
- f is the frequency of the light.
- E is the energy of the light wave.
- h is the Planck's Constant (6.64×10^{-34} joule. Second)

Color	Wavelength	Frequency
Violet	380-450 nm	668-789 THz
Blue	450-495 nm	606-668 THz
Green	495-570 nm	526-606 THz
Yellow	570-590 nm	508-526 THz
Orange	590-620 nm	484-508 THz
Red	620-750 nm	400-484 THz