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Dep. Medical physics



Medical physics
Third Stage

Lec 1

Properties of Light
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Properties of Light

- Travels in straight lines in a homogeneous medium
- Interaction with matter
- Absorption
- Reflection, refraction and scattering
- Polarization and diffraction

Electromagnetic wave (EM Wave)

- EM waves are generated by vibrating electrons
- Composed of two perpendicular oscillating fields
- Can be characterized by its frequency, which is inversely related to wavelength

$$(f = c / \lambda)$$

- Shares with sound the properties of spreading loss, attenuation, reflection, refraction, and diffraction, **but** can travel in vacuum

Light is defined as an electromagnetic wave with a wavelength in the visible part of the electromagnetic spectrum (380 to 700 nanometres). That is, light is any electromagnetic wave that we can see with our eyes.

Absorption vs propagation of light

- If light wave frequency = molecules resonant frequency
 - Light is absorbed (propagation is stopped)
 - Medium is opaque
- If light wave frequency \neq molecules resonant frequency
 - Light is reradiated and propagated forward through medium
 - Medium is transparent
- In a solid or liquid, propagation is in straight line
- In a gas, propagation is less organized and scatter increases

speed of light

All travelling waves can essentially be thought of as energy-carrying oscillations in motion. This means that light waves should be no different, and if light is in motion, it must have a speed. It turns out that light not only has a speed but that its speed is the fastest in the universe.

The **speed of light** in free space, **c** , is **300 million metres per second** (3.00×10^8 m/s), which is a constant and is essentially the speed limit of the universe that cannot be exceeded by any other object.

Speed of light depends on media

<u>Medium</u>	<u>Speed (m/s)</u>	<u>Refractive index</u>
Vacuum	3×10^8	1
Air	2.99×10^8	1.00028
Water	2.25×10^8	1.33
Glass	1.99×10^8	1.5
Diamond	1.25×10^8	2.4

Speed of light is slower in water than in air (opposite to sound)

Light waves can have different wavelengths, which determine the colour of visible light that is observed. This means that every time you view a beautiful red rose on a sunny day, your eyes perceive a **reflection** of red light from the rose, which has a wavelength of about 650 nm.

Example:

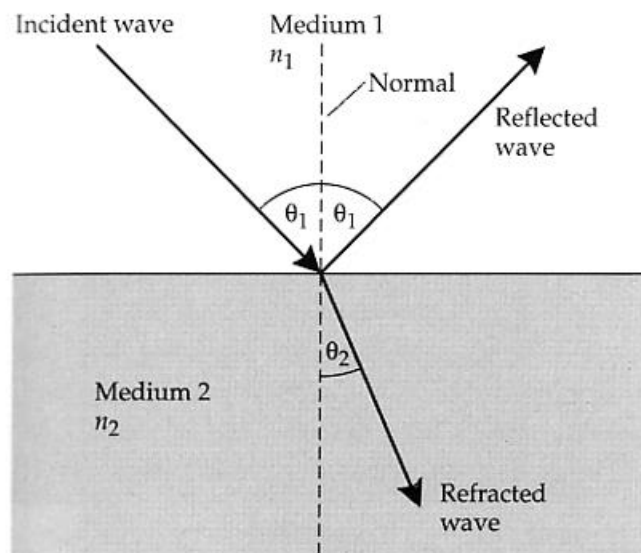
What is the wavelength of the red light that is emitted from a 4.6×10^{14} Hz laser ?

We know the frequency of the laser light and that the speed of light is 3.00×10^8 m/s so we can apply the wave equation:

$$\begin{aligned}\lambda &= c / f \\ &= \frac{3 \times 10^8}{4.6 \times 10^{14}} \\ &= 6.5 \times 10^{-7} \text{ m} = 650 \text{ nm}\end{aligned}$$

This wavelength corresponds to the colour red .

Light reflects and refracts



When 2nd medium has slower speed, light refracts towards normal

When 2nd medium has faster speed, light refracts away from the normal

Reflection and **Refraction** These are two of the more important properties of light, which can be used to make observations of distant objects in the universe.

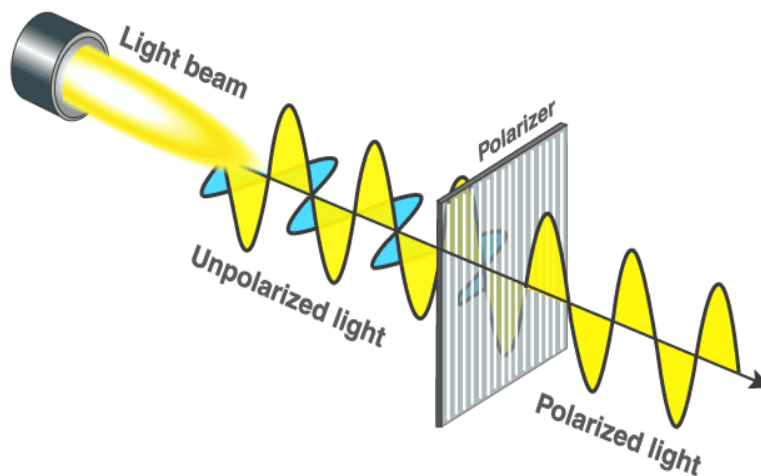
Reflection occurs when light that is travelling through a certain medium is incident onto a boundary between two media, and the light 'bounces' off the boundary or changes direction upon striking this boundary and moves on in the original medium. For an illustration of this, see the diagram above.

Refraction is another property of wave motion that is displayed by visible light. It occurs when light rays move from one medium to another and, upon doing so, change direction and speed. This is illustrated by the arrow in the diagram above .

Polarisation of light

Polarized light is a transverse wave whose electric field vibrates in one direction perpendicular to its line of propagation.

Polarisation of light is a property shown by transverse waves. The light waves which travel only in a single plane are known as polarized light waves. The process of transforming unpolarized light waves to polarized light waves is called the polarisation of light .



Discussion

Q/ 1

What is the definition of light ?

- A) An electromagnetic wave with a wavelength in the ultraviolet part of the electromagnetic spectrum
- B) An electromagnetic wave with a wavelength in the visible part of the electromagnetic spectrum
- C) An electromagnetic wave with a wavelength in the infrared part of the electromagnetic spectrum
- D) An electromagnetic wave with a wavelength in the X-ray part of the electromagnetic spectrum
- E) None of the above

Q/ 2

What happens when the frequency of a light wave is equal to the resonant frequency of a molecule?

- A) The light wave is absorbed
- B) The light wave is refracted
- C) The light wave is reflected
- D) The light wave is scattered
- E) None of the above

Q/ 3

What is the speed of light in free space?

- A) 200 million meters per second
- B) 300 million meters per second
- C) 400 million meters per second
- D) 500 million meters per second
- E) None of the above

Q/ 4

What determines the color of visible light that is observed ?

- A) The frequency of the light wave
- B) The wavelength of the light wave
- C) The speed of the light wave
- D) The amplitude of the light wave
- E) None of the above

Q/ 5

What happens to light when it moves from a medium with a slower speed to a medium with a faster speed?

- A) It refracts towards the normal
- B) It refracts away from the normal
- C) It is absorbed
- D) It is reflected
- E) None of the above

Q/ 6

What is the process of transforming unpolarized light waves to polarized light waves called?

- A) Polarization of light
- B) Refraction of light
- C) Reflection of light
- D) Absorption of light
- E) None of the above

Q/ 7

What is the speed of light in water?

- A) 2.25×10^8 m/s
- B) 2.99×10^8 m/s
- C) 1.25×10^8 m/s
- D) 3.00×10^8 m/s
- E) None of the above

Q/ 8

What is the wavelength of the red light that is emitted from a 4.6×10^{14} Hz laser?

- A) 500 nm
- B) 650 nm
- C) 700 nm
- D) 800 nm
- E) None of the above

Q/ 9

What happens to light when it hits a boundary between two media ?

- A) It is absorbed
- B) It is refracted
- C) It is reflected
- D) It is scattered
- E) None of the above

Q/ 10

What type of wave is polarized light?

- A) Longitudinal wave
- B) Transverse wave
- C) Electromagnetic wave
- D) Mechanical wave
- E) None of the above