

Focus 3''

Spectrum

Medium

Speed

Refraction

Absorption

Scattering

Reflection

Wavelength

Frequency

Energy

Dispersion

Colour

Monochromatic

Coherence

Polarization

Atoms

Transparent/Opaque/Translucent

Oscilloscope/Signal generator

Laser

Light boxes

Microwave RX TX

Hertz experiment

Glass bending/Optic fibre

## **Light**

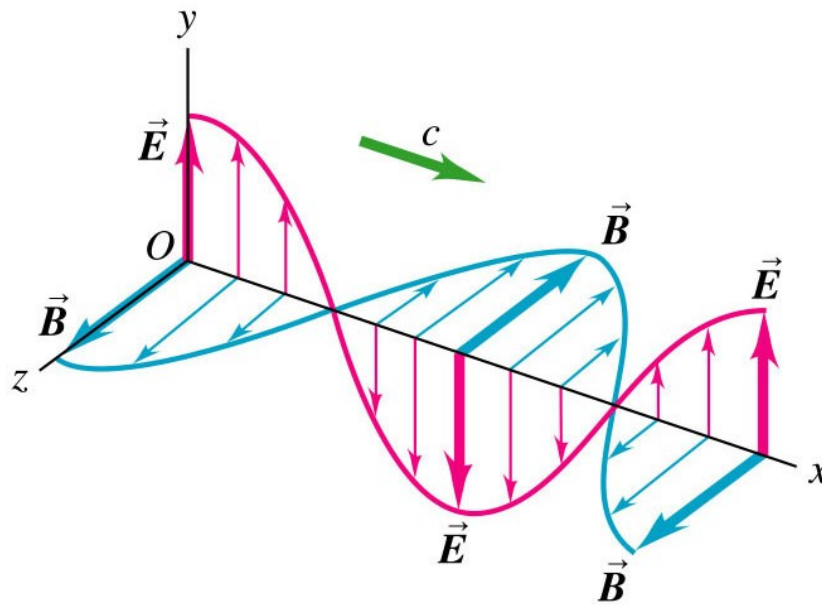
Light is a moving electromagnetic wave. It doesn't require a medium to wave about in and moves at 300,000 km/s in a vacuum. It travels slower in a denser medium; such as glass or water.

## **Colour**

Since it is a wave it has a wavelength, and the wavelength determines the colour of the light. A short wavelength is blue light and a long wavelength is red light. Our eyes are sensitive to the visible light spectrum, but there are so many other wavelengths. From short gamma rays to long radio waves.

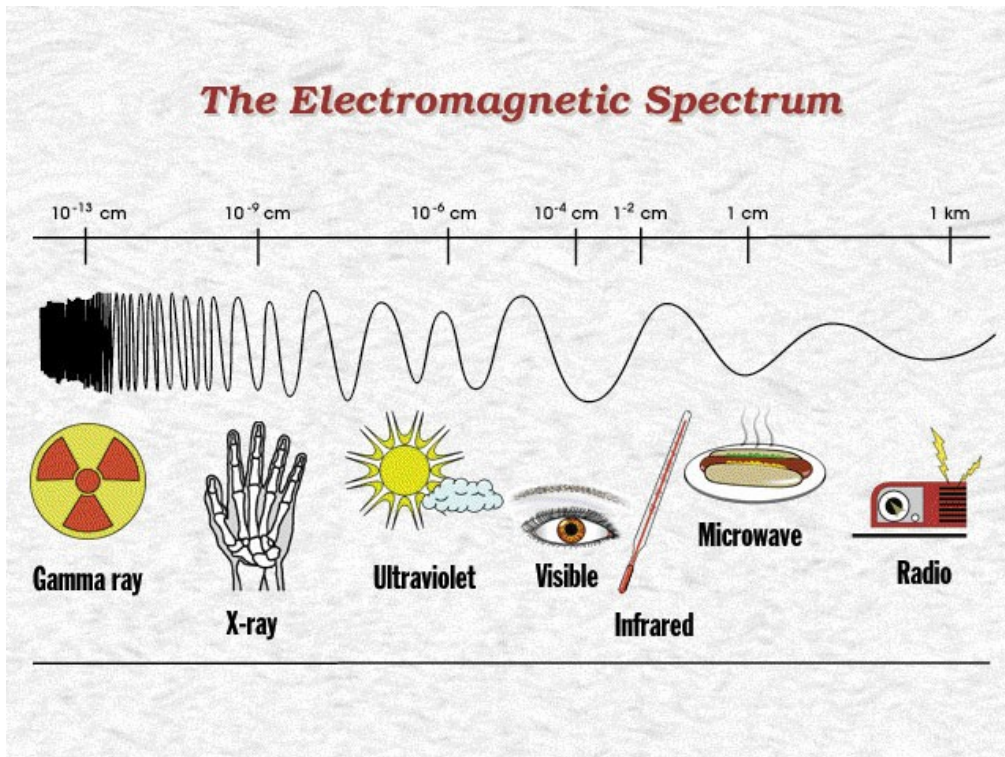
## **Energy**

Light carries energy; the shorter the wavelength the higher energy. But the energy can't be just any size, it comes in small packets of a certain size. These small packets are called photons. The energy in a beam of light is always some multiple of the single photons energy. You will never see half a photon.



$\vec{E}$ : y-component only  
 $\vec{B}$ : z-component only

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## Refraction

Light will slow down when it travels from a less dense to a more dense medium, and speed up when it travels from a more dense to a less dense medium. Whenever light changes speed, it will change direction. When light slows down it will move towards the normal, and when it speeds up it will move away from the normal. This change of direction is called refraction.

Boundary	Speed	Direction
Less dense → More dense	Slows down	Towards the normal
More dense → Less dense	Speeds up	Away from the normal

### REFRACTION DIAGRAM

## Lenses

Lenses are curved pieces of glass which spread out or concentrate light to a point called the focus. They do this by refracting the light. The distance of the focus from the lens is called the focal length. A thicker lens has a shorter focal length. There are two types of lenses; concave which curve in, and convex which curve out.

### CONCAVE AND CONVEX LENSES DIAGRAMS

## Reflection

When light hits a surface three things happen. Some of the light is absorbed by the surface material, some of the light transmitted through to the other side, and some of the light is reflected back. The amount of light absorbed, transmitted, and reflected depends on what material the surface is made of and the wavelength of the light.

### **SURFACE DIAGRAM**

Which way does the light go:

- The reflected light bounces back at the same angle as the incident light.
- The transmitted light is refracted to an angle depending on the density of the materials.
- The absorbed light makes the material's atoms vibrate.

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**REFLECTION DIAGRAM****Questions**

1. Where does the energy of the light go if it is absorbed by the surface?
2. Do you think sound behaves the same way at surfaces too?
3. How do sunglasses work?
4. Estimate what fraction of visible light is absorbed, transmitted, and reflected for these materials:

<b>Surface Material</b>	<b>Reflected</b>	<b>Absorbed</b>	<b>Transmitted</b>
Glass			
Silver (mirror)			
Brick			

## Total Internal Reflection

Imagine light travelling through a material till it hits a surface with less dense material on the other side. If the light hits the surface straight-on then almost all of it will be transmitted to the other side. If it hits the surface on a slight angle then some light will be reflected but most will still go through. If we keep increasing the light's angle of incidence (towards the surface, away from the normal) more and more will be reflected and less and less will be transmitted. Till we come to a special angle where **all** of the light is reflected and **none** is transmitted; this angle is called the **critical angle**. And just like everything about light there is a different critical angle for different materials and wavelengths of light. Critical angle for yellow light in glass is  $41^\circ$ .

### CRITICAL ANGLE DIAGRAM

Light can become trapped inside a material if it bounces off the surfaces at angles larger than the material's critical angle. This is called **total internal reflection**. It's actually responsible for sunsets and the colourful patterns you see on detergent bubbles and oil slicks.

### TOTAL INTERNAL REFLECTION DIAGRAM

#### Questions

1. How is total internal reflection used in optic fibres?
2. What is an endoscope and what are **two** things it is are used for?
3. How does total internal reflection cause sunsets?



## **Colours**

### **Dispersion**

White light may be split into the colours of the rainbow. This effect is known as dispersion, and the colours of light produced are called the visible spectrum. A triangular prism will disperse light, and so will a raindrop. The spectrum is made from an infinite number of merged colours but Newton liked the idea of seven main colours—red, orange, yellow, green, blue, indigo and violet.

### **Colour Addition**

Two colours of light that mix to make white light are called complementary colours. Red and cyan are complementary colours, as are green and magenta. Blue and yellow form another pair.

### **Colour Subtraction**

One way of removing colours from a beam of light is to use a filter. A filter is really just a coloured slide of plastic that allows only light of a certain colour to pass through it. For example, a red filter allows only red light to pass through it—all other colours are absorbed by the chemical dye.

### **Seeing Colours**

Colour subtraction also occurs when we look at coloured objects. When we see a red T-shirt, it's because white light hits it and reflects red light to our eyes. The red T-shirt absorbs all other colours except for red.