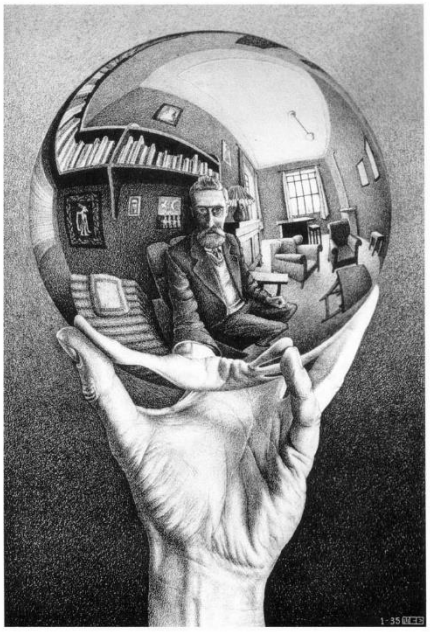
ScE8.2 : Optics



ScE8.2.1: Light - **ANSWERS**

1. Early Theories of Light (p.132 et 135)
2. The Speed of Light (p.135-136)
3. Optical Technologies (p.133-134)
4. Properties of Light :
    a. Rectilinear propagation (p.175)
    b. Propagation through vacuum
    c. Propagation through substances (p.173-174)
    d. Reflection (diffuse and specular) p.176-177
    e. Refraction (p.149, 1179)
    f. Dispersion (p.149)
5. Waves and the Wave Model of Light (p.138-140)
6. The Electromagnetic Spectrum (p.156-160)

Terms

1. **Rectilinear propagation** : a property of light that says it travels in a straight line
2. **Transparent:** see-through; lets light travel clearly through it
3. **Translucid:** cloudy; lets light through but not clearly.
4. **Opaque:** doesn't let light travel through it at all.
5. **Reflection** : when light bounces off a surface
6. **Specular reflection :** when light bounces off a glossy surface and forms an image of the surroundings
7. **Diffuse reflection :** when light bounces off a rough surface and does NOT form an image of the surroundings.
8. **refraction** : when light makes a bend as it passes from one substance into another.
9. **dispersion** : when the different colours of white light are separated into a rainbow
10. **frequency** : the number of waves per second
11. **wavelength** : the distance between two crests or two troughs of a wave.
12. **amplitude** : the height of the crest or the depth of the trough of a wave
13. **crest** : the highest point of a wave.
14. **trough** : the lowest point of a wave.
15. The electromagnetic **spectrum** : the series of electromagnetic waves ranging from the longest wavelength (low energy) to the shortest (high energy)

The First Theories of Light

1. Describe two theories first proposed by the early Greeks to explain light and how our eyes can see. Which theory do scientists still use?

   Some early Greek thinkers like Pythagoras thought that light was made up of particles produced by light sources, such as the sun, that bounce off objects and into our eyes, and that is how we see things. We still use this theory today, called the Particle Theory of Light.

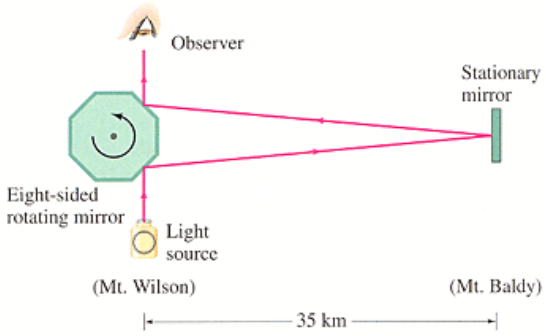
   Others thought that light was like fibers produced by our eyes that go out to the objects that we see. Today we know that's wrong.

2. How did Galileo first attempt to measure the speed of light? Why was this method not successful?

   Galileo used an assistant and lanterns placed on two hilltops, and tried to measure the time for light to travel between the two using human reflexes. This couldn't work because light is so much faster than human reflexes.

3. How did Michelson eventually succeed in measuring the speed of light?

   Michelson used an expriment with a rotating mirror that allowed him to measure a much shorter amount of time than human reflexes.



4. What is the speed of light? **300,000 km/h!!!**

5. In a thunderstorm, why do we see the lightning before we hear the thunderclap? How can you tell how far away was the lightning based on the length of the delay between the two?

   We see the lightning first because light travels so much faster than sound. Each 3 second delay between the two means the source if the lighning is 1 km away.

6. Give 5 examples of optical technologies.

   - **Mirrors**
   - **Glasses**
   - **Cameras**
   - **Microscopes**
   - **Telescopes**

The Properties of Light

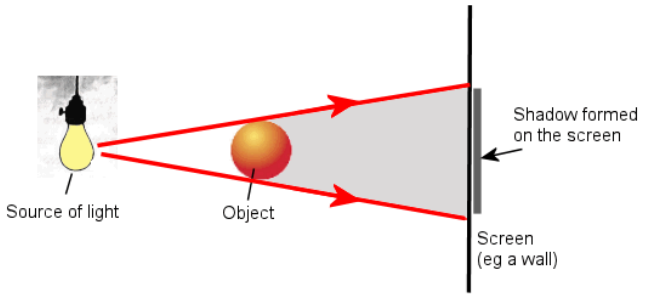
List the 6 properties of light

1. Rectilinear propagation
2. Propagation through a vacuum
3. Propagation through substances
4. Reflection
5. Refraction
6. Dispersion

1. Rectilinear propagation

What is rectilinear propagation?
It means that light travels in a straight line, without going around objects

What effect does it cause? Use a diagram to explain.
This causes shadows. Shadows are places where the light is blocked by an object in its path.



2. Propagation through a vacuum

What is a vacuum?
A vacuum is space where there is nothing, no substance not even air.

Give two examples of light travelling through a vacuum.
Light from the sun and from stars travels through the vacuum of space to reach the Earth.

Why is it interesting that light can travel through a vacuum?

- **Because without light from the sun there would be no life on Earth.**
- **Because light is a wave, but most waves need a substance to carry them. But light waves don't need a substance.**

3. Propagation through substances

Complete the following table to compare transparent, translucent, and opaque substances.

	Definition	Examples
Transparent	**see-through; lets light travel clearly through it**	**Air, water, glass**
Translucent	**cloudy; lets light through but not clearly**	**Frosted glass, translucent plastics**
Opaque	**doesn't let light travel through it at all**	**Wood, metal**

4. Reflection

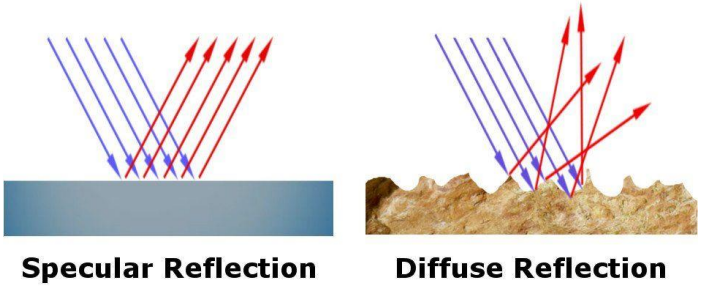
What is reflection? Give an example.

Reflection is when light bounces off a surface, such as when you see a reflection in a mirror, or when you see any object around you that isn't a light source.

What is the difference between specular and diffuse reflection?

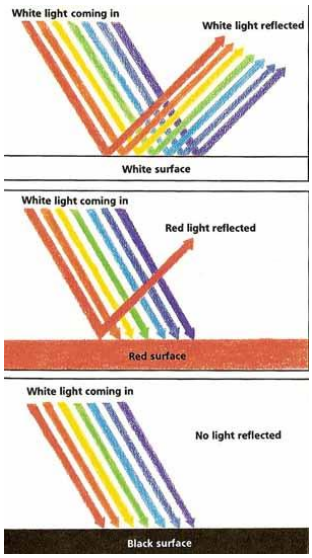
In specular reflection, the light hits a smooth glossy surface such as a mirror or the surface of a very still lake. Light rays all bounce off the surface at the same angle and we see a reflection of the surroundings, called an image.

In diffuse reflection, the surface is bumpy. Each light ray bounces off in a different direction so we just see the object itself, with no image of the surroundings.



Specular Reflection **Diffuse Reflection**

How does diffuse reflection allow us to see the colour of something?



When we say that an object is a certain colour, it means that only light of that colour reaches our eyes from the object. All the other colours are absorbed by the surface of the object and only the light of that one colour is reflected into our eyes.

Example: when you see a red apple, all the colours except red are absorbed by the skin of the apple, but red is reflected back so that is the colour you see.

5. Refraction

What is refraction? Give an example.

Refraction is when light bends when it passes from one substance into another.
Example: when a straw in a glass of water looks like it has a break

Figure 3

6. Dispersion

What is dispersion? Give an example.

Dispersion is when white light is separated into the colours of the rainbow because of refraction.
Example: rainbows!

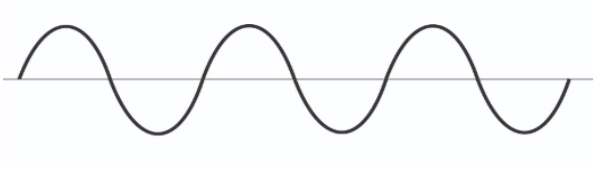
Application

Identify which property of light is represented in each situation.

Situation	Property of light
Light from stars can be seen from the earth	**Propagation through a vacuum**
Light travels through air.	**Propagation through a substance**
You see that an apple is red.	**Diffuse reflection**
You see a rainbow in the sky after a rain.	**Dispersion**
On a sunny day, you cast a shadow on the ground.	**Rectilinear propagation**
You see shiny reflections in the glossy paint of a car.	**Specular reflection**
You see sheet of paper, with no reflections in it.	**Diffuse reflection**
You see yourself in a mirror.	**Specular reflection**

Properties of a Wave

On this diagram of a wave, label the crest, the trough, the amplitude, and the wavelength. Using a ruler, measure and label the wavelength and the amplitude of the wave.



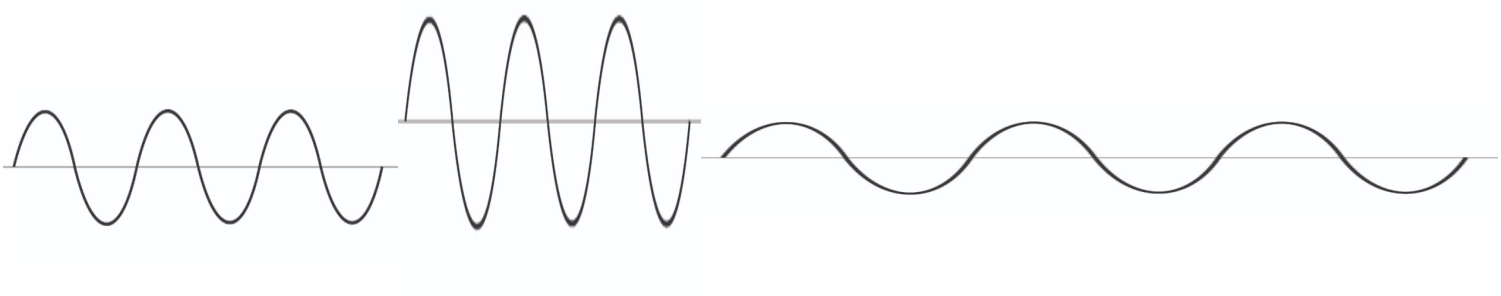
What is the frequency of a wave?

The frequency is the number of vibrations per second.

What is the relationship between the wavelength, the frequency, and the energy of a wave?

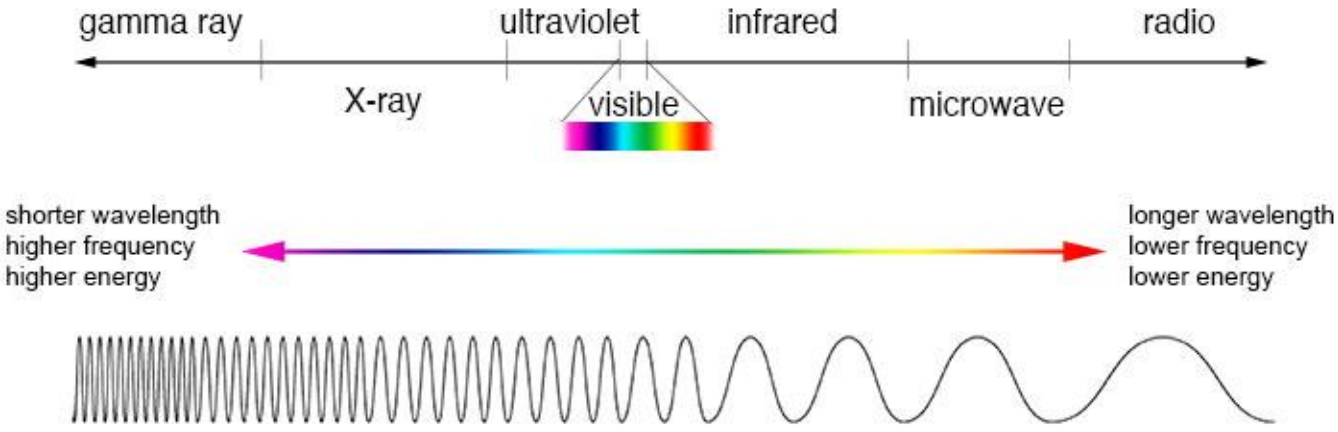
The higher the frequency, the shorter the wavelength and the higher the energy.

Practice activity: Measure the wavelength and the amplitude of each of the following waves. Which one has the least amount of energy? Which one has the highest frequency?



The Electromagnetic Spectrum

Sketch a diagram of the electromagnetic spectrum.



The Different Wavelengths of Radiation in the Electromagnetic Spectrum

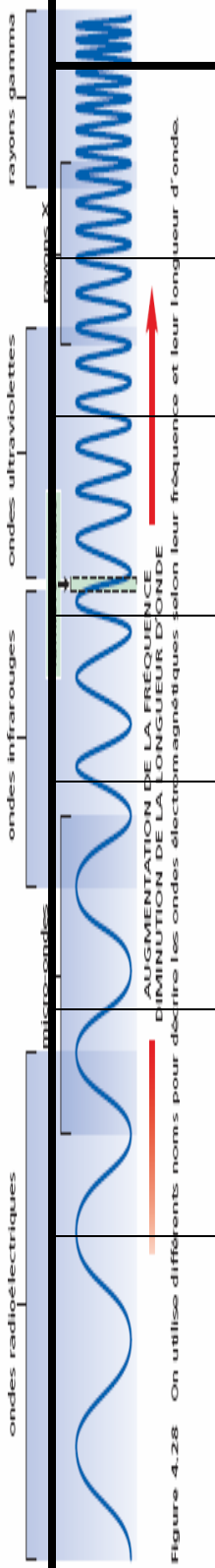


Figure 4.28 On utilise différents noms pour décrire les ondes électromagnétiques selon leur fréquence et leur longueur d'onde.

Type of radiation	Uses	Danger (if applicable)
Gamma rays	• **Radiation therapy for cancer**	• **High exposure causes radiation sickness** • **Lower exposure causes cancer and birth defects**
X rays	• **Medical imaging to see if you have broken bones**	• **Too much exposure over time can cause cancer**
Ultraviolet rays	• **Tanning** • **Skin makes vitamin D**	• **Sunburn** • **Skin cancer**
Visible light	• **For seeing!!!!** • **Art**	
Infrared light	• **For warming things** • **Infrared cameras for night pictures** • **Infrared thermometers**	
Microwaves	• **For warming food** • **Communication satellites** • **Radar**	
Radio waves	• **Radio and TV broadcasting (airwaves)** • **MRI**	