SNC2D PHYSICS

LIGHT & GEOMETRIC OPTICS

- What Is Light? (P.380-391)

What Is Light?

For centuries, scientists have tried to understand the nature of light and its properties. Some of these properties are easily observable. For example, light travels at a very high speed. When you turn on the light switch in a room, the room immediately fills with light.

What Is Light?

NOTE!

Light travels so fast that something travelling at the speed of light could circle Earth's equator about 7.5 times in just one second.

What Is Light?

Light also travels in straight lines. When you turn on a flashlight in a dark room with dust in the air, you can see a beam of light travelling in a straight line. Sharp shadows around objects such as trees or railings are also evidence of the straight-line nature of light. In fact, that is why you can see Earth's shadow on the Moon during a lunar eclipse.

Light Energy

The Sun emits large amount of energy in all directions. A fraction of this solar energy reaches Earth and heats Earth's surface. Some solar energy is in the form of light. Plants convert the energy in light into chemical energy during photosynthesis. The plants use this chemical energy as food.

Light Energy

Light is a form of energy. We use light energy to light our homes and schools. We build solar cells to capture light energy and convert it into electrical energy. We then use the electrical energy to power our businesses, homes, and appliances. Another technology captures light energy and converts it to thermal energy to heat water for our homes.

Figure 2 Solar cells collect light energy and convert it into electrical energy.

Light Energy

*Light is one of the many forms of energy that reaches us from the Sun. Energy from the Sun is sometimes called solar radiation. To reach us, this **radiation** has to pass through space, which is a vacuum. (There is no matter in a vacuum; not even air.)*

RADIATION

- transfer of energy through matter or space (i.e. a vacuum)

Light Energy

*Energy travels through space (a vacuum) as electromagnetic waves. An **electromagnetic wave (em)** is a wave of energy associated with electric and magnetic fields. Electromagnetic waves can pass through space or through a medium, such as glass or water. In the vacuum of space, where there are very few particles, em waves travels at almost 300,000 km/s.*

Light Energy

ELECTROMAGNETIC (EM) WAVE

- wave of energy associated with electric and magnetic fields
- can pass through space (vacuum) or a medium such as glass or water
- travel at the speed of light (c)

NOTE!

c = 3.00 x 10^8 m/s or 300,000 km/s

Visible Light and Colours

*The light we see when we look at a candle, a glowing light bulb, or the Sun is called **visible light**. Visible light from the Sun and most light bulbs appears to be white.*

VISIBLE LIGHT

- form of energy that we can see
- travels in a straight line

Visible Light and Colours

Over 300 years ago, an English scientist named Isaac Newton was the first scientist to separate white visible light into its component colours. Newton shone a beam of white light from the Sun through a triangular piece of glass, called a prism.

Visible Light and Colours

When he did this, he noticed that the beam of light that appeared on the opposite side of the prism was not white at all. Instead, Newton saw red, orange, yellow, green, blue, indigo, and violet light on the other side of the prism.

NOTE!

*Some people use the name "**Roy G. Biv**" to help them remember these colours. These are also the colours that we see in a rainbow.*

Visible Light and Colours

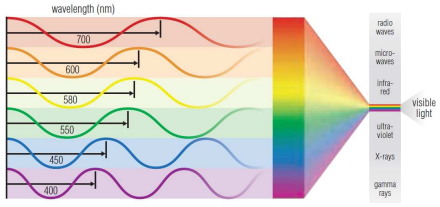
PRACTICE

1. When white light enters one side of a prism, why does a multi-coloured band of light come out the other side?

   white light is made up of a mixture of colours of light – the prism simply separates these colours

The Visible Spectrum

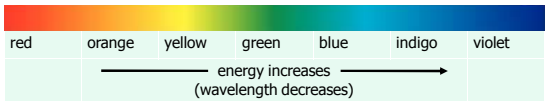
*The continuous sequence of colours that together form visible white light is called the **visible spectrum**. Scientists have learned that the different colours of light in the visible spectrum have different amounts of energy. Red light (with the longest wavelength) has the least energy and violet light (with the shortest wavelength) has the most energy.*



The Visible Spectrum

VISIBLE SPECTRUM

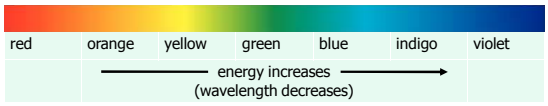
- continuous sequence of colours that form white light (ROY G. BIV)
- different colours = different wavelengths = different energies
- red = longest wavelength & least energy
- violet = shortest wavelength & most energy



The Visible Spectrum

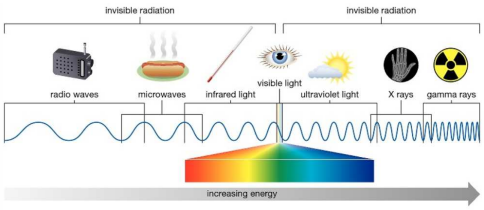
PRACTICE

2. Compare red light with blue light.
   (a) Which has the longer wavelength? red
   (b) Which has more energy? violet



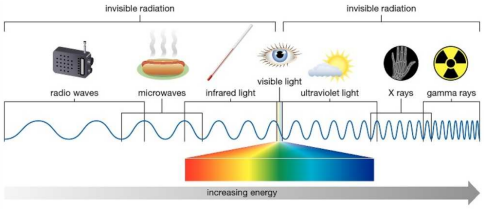
The Electromagnetic Spectrum

Visible light is just one type of energy that travels in the form of electromagnetic waves. There are also invisible electromagnetic waves, such as radio waves, microwaves, and X-rays. Solar radiation includes visible light and these invisible types of electromagnetic waves.



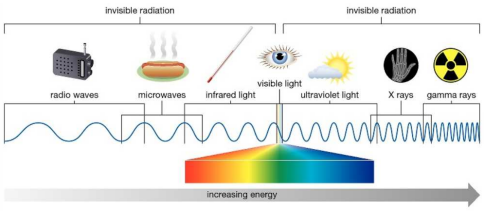
The Electromagnetic Spectrum

Each type of electromagnetic wave has a different amount of energy associated with it. For example, X-rays have much more energy than radio waves. The arrangement of all electromagnetic waves (including visible light) according to energy is called the ***electromagnetic spectrum****.*



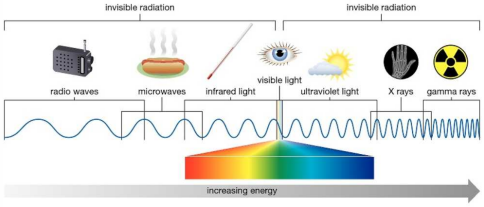
The Electromagnetic Spectrum

There are seven types of electromagnetic waves in the electromagnetic spectrum: radio waves, microwaves, infrared light, visible light, ultraviolet light, X-rays, and gamma rays. The Sun emits all of these forms of radiation. Humans have developed technologies to produce them also.



The Electromagnetic Spectrum

For example, radio stations produce radio waves to broadcast music over long distances. Hospital X-ray machines produce X-rays to help diagnose injuries. UV light (black light) produces special effects for stage shows. Microwave ovens convert electricity into microwaves to heat food.



The Electromagnetic Spectrum

NOTE!

Black lights cause materials to fluoresce or glow. The lamps have a dim purple or violet glow due to the small amount of visible light that passes through the dark blue filtering material contained in the bulb. Black lights are low power and so are not a concern. However, powerful ultraviolet sources, such as those used in water purifiers, present a hazard to eyes and skin and as a result require the use of personal protective equipment.

The Electromagnetic Spectrum

THE ELECTROMAGNETIC (EM) SPECTRUM

- arrangement of all em waves according to energy

radio waves	micro-waves	infrared light	visible light	ultraviolet light	X rays	gamma rays
	energy increases → (wavelength decreases)					

The Electromagnetic Spectrum

PRACTICE

3. (a) What are two ways that radio waves and X-rays are similar?
   (b) What are two ways that radio waves and X-rays are different?

   (a) both travel at the speed of light & are invisible
   (b) radio waves have a longer wavelength & less energy than X-rays

The Electromagnetic Spectrum

PRACTICE

4. Which poses more of a danger to human health, very long wavelength radiation or very short wavelength radiation? Why?

   shorter wavelengths are more dangerous since they have more energy (i.e. infrared light, which has a long wavelength, warms the skin while ultraviolet light, which has a shorter wavelength, burns the skin)

✔ Check Your Learning

1. How does light energy move from one place to another?

   it travels in a straight line as a form of energy (radiation)

✔ Check Your Learning

2. How could you demonstrate that visible light is composed of many different colours?

   direct white light through a prism

✔ Check Your Learning

3. What does ROY G. BIV stand for?

   red – orange – yellow – green – blue – indigo – violet

✔ Check Your Learning

4. Write these em waves in order from lowest energy to highest energy: infrared waves, X-rays, visible light, gamma rays, microwaves.

   microwaves, infrared waves, visible light, X-rays, gamma rays

✔ Check Your Learning

5. List some devices that you have used that involve em waves. State the type of em wave used in each device.

   radio – radio waves
   microwave ovens – microwaves
   heat lamps – infrared light

✔ Check Your Learning

6. A huge problem facing aid workers in tropical disaster areas is providing safe drinking water. Scientists are testing a simple idea: fill a clear plastic bottle with water, put on the cap, and let it sit in the direct sunlight for a day.
   (a) Explain why this idea might work.

   (a) the sun would heat (boil) the water and kill any microorganisms in the water

✔ Check Your Learning

6. A huge problem facing aid workers in tropical disaster areas is providing safe drinking water. Scientists are testing a simple idea: fill a clear plastic bottle with water, put on the cap, and let it sit in the direct sunlight for a day.
   (b) Discuss the advantages and disadvantages of this method over boiling water or adding chemicals.

   (b) answers will vary

✔ Check Your Learning

TEXTBOOK
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