Topic 4.1
What is light and how is it produced?

Specific Expectations

- **E2.1** use appropriate terminology related to light and optics, including, but not limited to: *angle of incidence*, *angle of reflection*, *angle of refraction*, *centre of curvature*, *focal length*, *luminescence*, *magnification*, *principal axis*, *radius of curvature*, and *vertex*
- **E3.1** describe various types of light emissions and how they produce light
- **E3.2** identify and label the visible and invisible regions of the electromagnetic spectrum, and identify the colours that make up visible white light

Skills

- formulate scientific questions
- analyze and interpret qualitative data
- communicate using a variety of formats

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see pages TR-50 to TR-52 for a summary of the materials required in this topic.

Overview

In this topic, students will develop an understanding of what light is and how it is produced. They will represent light as waves and learn that different colours of light have different wavelengths. And they will have the opportunity to make connections with students like themselves who have investigated and developed applications for properties of light.

Common Misconceptions

- **Students may confuse the shape of a light wave with the path of light.** Although light is known to exhibit wave-like properties, it can and should be represented with straight lines.
- **Since the Sun also produces heat, students may think that light requires heat.** Light can be produced by a variety of methods, many of which do not involve heating objects. Remind students about the difference between standard incandescent bulbs, which emit a large amount of heat, and compact fluorescent bulbs, which do not emit much heat.
- **Students may think that light is unique in its wave properties.** As they will see in this topic, light is just one form of electromagnetic radiation. Consider demonstrating other forms such as radio waves, or microwaves.

Background Knowledge

Light is unique in that it demonstrates properties of particles and of waves simultaneously. Technically, light exists as tiny photons that travel at almost 300 000 000 m/s, carrying energy and interacting with matter in predictable ways. Light travels in straight lines. This property is called the rectilinear propagation of light. Many rays of light make up a beam of light. White light is made up of different colours, or wavelengths, of light. For example, blue light has a wavelength of 450 nm to 495 nm. Red light has a longer wavelength, typically greater than 620 nm. All wavelengths of light are smaller than the cells that make up our bodies. Generally speaking the smaller the wavelength, the greater the energy carried by photons of light.

Literacy Strategies

Before Reading

- ELL Before engaging English language learners in reading activities, it is important to introduce key concepts using visuals like drawings and demonstrations. These activities provide background knowledge that may be new to some students and an opportunity to build vocabulary. Introduce the key question, ensuring that it is understood, and elicit some answers. Record the answers on a concept map.
- Review the key terms with students and link the terms to the key concepts.
- Ask students to answer the topic question in their own words and save this to reflect on during and after reading. You could create a concept map together to record answers to this question, and build on it during and after reading.

During Reading

- As students read this topic, ask them to use sticky notes to highlight sections that they do not understand. They can discuss these questions with a classmate, then ask the whole group about any words, phrases, or ideas they still do not understand.
- ELL English language learners are often tripped up by such idioms as a "*blink of an eye*" or "*on the other hand*", which they may take literally. They can also miss antecedents. For example, when it is stated that four things happen when light interacts with matter, they may not realize that those four things follow the statement. Partner such learners with students who have strong language skills and are sensitive to their needs.
- As students read through this topic, ask them to make connections between items in the margins (key terms, diagrams, captions) and the main text. Ask how several text features are connected or related to each other.

After Reading

- Ask students to summarize two things they learned in this topic and one thing they still do not understand.
- Ask students to collaborate to consider how the topic connects to their daily life. This could be a think-pair-share activity. Invite English language learners to use their first language or sketches in the thinking stage of this activity.
- Use an exit card strategy. Distribute small pieces of paper and have students draw or write their answers to the question "What is light?". They can hand their answers to you as they leave the classroom. Make sure English language learners understand what is expected.

Assessment FOR Learning

Tool	Evidence of Learning	Supporting Learners
Learning Check, page 279	Students describe examples of converting various forms of energy to light energy.	• In addition to the examples in the student textbook, introduce other examples such as the lights in the classroom, a watch that glows, or a Bunsen burner. In a darkened room, strike the flint to produce an interesting incandescence.
Activity 4.1, page 281 Learning Check, page 283	Students explain how waves can transfer energy, and describe light as a wave.	• Ask these questions to guide students. "When you look at light, what do you see? What do you think about when you think of light?" • Have students work with a classmate to create a Venn diagram that compares the ways light behaves like a wave with the ways light behaves like a particle. Students could use **BLM G-49 Venn Diagram**.

Topic 4.1 (Student textbook pages 276–285)

Using the Topic Opener

- Ask students for examples of how they have seen light used to communicate ideas, feelings, and information.
- Many students will not understand that light waves and radio waves are different examples of the same phenomena. Explicitly draw their attention to this. Point out that radio waves are longer than light waves, but carry energy and behave in the same way. The pictures we see on television can be carried by radio waves.
- One method of using light to communicate is Morse code. Ask students to explain how they could use light to send an SOS signal (three short pulses, three long pulses, three short pulses).

Starting Point Activity (Student textbook page 277)

Pedagogical Purpose

The starting point activity introduces students to strategies of messaging and communication that do not involve light or sound energy. In the absence of these elements, communication is very difficult.

Planning	
Materials	paper, writing implements, mirrors, and other materials as required (optional)
Time	10 min in class

Activity Notes and Troubleshooting

- A large room would be ideal for this activity so that pairs can spread out. Book the gymnasium if possible, or take the class outside.
- Ask students to share their three word messages with the class and have them look for similarities.
- Encourage originality in thinking by offering a reward such as a snack or privilege for creative and successful communication.
- Students will benefit from developing their own ideas, but also from seeing the different ways other pairs develop to communicate at a distance. Have a few pairs describe or demonstrate their techniques for the class.

Additional Support

- ELL If possible, allow English language learners with the same first language to work together. Demonstrate what to do, and allow them to work in their first language for this activity.
- Pair students randomly then adjust groupings based on gender. Ask students if they think female and male students had different approaches to communication.
- Pair students with strong interpersonal skills with students who require support in this area.
- Enrichment—Ask students to describe ways people communicate messages without using light. They will describe voice and radio technologies, and may mention Braille. Have a sample of Braille available for students to examine.

Starting Point Activity Answers

Answers may vary. Students should gain an understanding of the difficulty of communicating without using sound or technology.

Instructional Strategies for Topic 4.1

Student textbook pages 278–279

- Set up the room with many different sources of light, including incandescent lamps, fluorescent lamps, candles (if safe), light sticks—whatever you have to set the stage for learning about this topic.
- ELL To support English language learners, label each source and introduce a t-chart explaining incandescence and luminescence, focusing on the meaning, and giving one or two examples. English language learners may not be familiar with objects like glow sticks or tubular fluorescent lighting.
- Focus students' attention on the filament of the lamp shown in Figure 4.2. Explain that this is the part that heats up and releases energy in the form of light.
- Use text features to reinforce understanding. Guide students to make connections between the features in the margins and the main part of the text.
- Ask students to create a diagram with arrows to represent the energy conversions involved in luminescence and incandescence.

Student textbook pages 280–283

- The essential learning for students is that light is a form of radiation. Like radio waves, it cannot be seen but it has effects that can be experienced when this radiation interacts with matter. Students have a chance to experience waves transferring energy in Activity 4.1. You could also demonstrate water waves, as in Figure 4.3, and radio waves and microwaves, as in Figure 4.5. Use these demonstrations to build English language learners' vocabulary and to link their observations to sections of the text that further explain the concepts discussed.
- Draw students' attention to the size comparisons in Figure 4.5.

Learning Check Answers (Student textbook page 279)

1.

Types of Light Production	How Light is Produced	Technologies
Incandescence	Objects are heated to the point where they give off light.	candles, torches, incandescent light bulbs
Luminescence	Chemiluminescence: chemical energy converted to light energy.	light sticks
	Electric discharge: electrons collide with gas particles and release light.	street lights
	Fluorescence: electrons collide with gas particles which produce UV-light that interacts with phosphor on inner surface of bulb.	standard and compact fluorescent bulbs

2. Bioluminescence is created by a chemical reaction in the firefly.

3. The sun is an incandescent light source because light is produced from heated gases.

4. Incandescent bulbs convert electrical energy to light but release a large amount of heat in addition to light, so they are not very energy efficient. Compact fluorescent bulbs convert most of the electrical energy they consume to light rather than heat, so they are more energy efficient.

Activity 4.1 Transferring Energy (Student textbook page 281)

Pedagogical Purpose

Students will investigate and experience the transfer of energy across a distance by a wave and relate their experience to the transmission of light.

Planning	
Materials	Per group: rope (about 2 m long) small, light bell
Time	10 min in class

Skills Focus

- make inferences
- work cooperatively

Activity Notes and Troubleshooting

- Have students work in pairs.
- This activity could easily be done as a teacher demonstration but it is more effective if students do the activity to experience the transfer of mechanical energy into sound energy first hand.
- Focus students' attention on the direction of motion of any single point on the rope, at right angles to the direction of the wave produced.
- Use a small bell that can be heard but will not disturb other classes.

Additional Support

- Pair English language learners with students with strong English language skills to help with understanding, and with the wording for descriptive answers.
- DI Bodily-kinesthetic, spatial, and logical-mathematical thinking is involved in completing this activity. Ensure groups include students with a variety of strengths, or pairs of groups work together on the What Did You Find Out? questions. Groups should be made responsible for ensuring that every member understands the questions and their answers.

Activity 1.1 Answers

What Did You Find Out?

1. The motion of the rope is vertical, but this motion moves horizontally along the rope.
2. The motion of the bell is also vertical.
3. Mechanical energy resulting from the movement of your hands caused the bell to ring.
4. The wave of up and down motion is carried along the length of the rope.
5. Light is a wave that travels as a wave from its source until it interacts with matter just as the up and down motion of your hand is carried to the bell through the rope.
6. Answers may vary. Students should describe their idea and how the energy was transferred from its source, through the rope, to the bell.

Learning Check Answers (Student textbook page 283)

1. X rays, ultraviolet, purple, green, yellow, red, infrared, microwaves

2. X rays have the shortest wavelength and infrared light has the longest wavelengths. Diagram C has the shortest wavelength so it is most like X rays. Diagram B has the longest wavelengths, so it is most like infrared light. Diagram A is most similar to visible light.

3. a) Radio waves have a wavelength about the size of a house.

b) Visible light has a wavelength about the size of a bacterium.

c) X rays with wavelengths about the size of a water molecule are used in medical diagnosis and treatment.

Using Making a Difference (Student textbook page 284)

Literacy Support

Before Reading

- Have students look at the pictures of the students beside each section of text. Ask them how these images of people's faces got to their textbook's pages. Lead them to recognize that light was captured by a camera that was used to make the picture.
- Focus students' attention on the number of paragraphs in each profile and what each paragraph could be used for. For example: to introduce the topic, to convey information, to summarize, and so on.
- ELL English language learners may benefit from a brief introduction to the key vocabulary related to the problem and the solution.

During Reading

- Read the first portion of text aloud to students. Have students write one question about what they heard that they would like answered.
- Students could use a 5W approach (who, what, when, where, why) to take notes while they read.
- Encourage students to identify all the ways light is involved in each invention.

After Reading

- Ask pairs of students to discuss whether they believe Charlie, Penélope, and Maude deserve the awards they have won. Have students justify their opinions with evidence from the text.
- Answer the questions posed under each section of text as a class discussion. Ensure that English language learners understand the questions. They may not understand that the phrase "In what other ways" refers to the profile they have just read.

Instructional Strategies

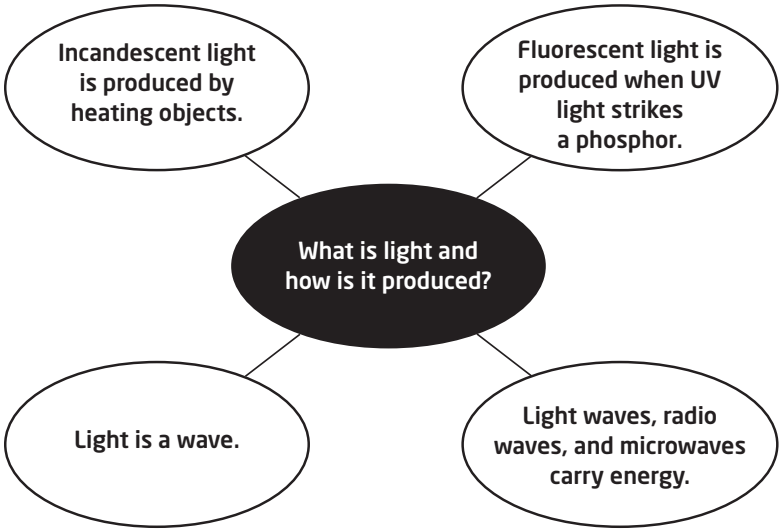
- Have students read together as a class or read the passage to students.
- After each profile, invite students to highlight key points or phrases.

Topic 4.1 Review (Student textbook page 285)

Please see also **BLM 4-4 Topic 4.1 Review (Alternative Format).**

Answers

1. Answers may vary. For example:



2. Using the rope to ring a bell in Activity 4.1 and the sound and energy of water waves are proof that waves carry energy.

3. The wavelength of electromagnetic waves determines the colour of light.

4. Sketches should resemble Figure 4.5 on page 282. The invisible region is larger than the visible region.

5. Venn diagrams should include the following points.
Incandescence: light produced by heating objects
Luminescence: light produced without heat
Both: electrical energy is converted to light energy

6. electrical energy → electrons meet resistance in filament → filament heats up → energy is released as light

7. Electric discharge technology can be found in street lights and in the lights at sporting events and television stations.

8. Herschel discovered that there is significant energy coming from the sun that is not part of the visible spectrum. This is known as infrared radiation and is part of the invisible electromagnetic spectrum.