Topic 4.2
How does light interact with objects to give them colour?

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*
- **E2.6** predict the effect of shining a coloured light on objects of different colours, and test their predictions through inquiry
- **E3.7** explain how the colour of an object is determined by reflection, absorption, and transmission of colour

Skills

- conduct inquiries, using standard equipment and materials safely
- gather data from experiments
- analyze and interpret data to support or refute a hypothesis
- draw ray diagrams

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 examine how light interacts with objects to give them colour. Students will learn that light can be reflected, absorbed, or transmitted by objects. Students will have the opportunity to investigate how objects can absorb some colours and reflect or transmit others.

Common Misconceptions

- **Students may believe that light is some how changed when encountering an object so that new colours are produced by the object.** Show students how to use a prism to separate the colours in white light. Encourage students to use a prism to separate the colours in white light on their own to help them realize that white light is composed of all colours and that any visible phenomena occur because colours are subtracted from white light. You can also use a diffraction grating to produce many vivid colours. Borrow one from the senior physics teacher.
- **Students may believe that light transmitted by an object, such as a filter, originated in the object.** In fact, any light that is transmitted or reflected by an object was present in the light before it reached the object. Objects such as apples, books, and filters are not sources of light. Have students imagine an object in a room with no source of light. The object will not be visible because it is not creating its own light. Remind students that white light contains all colours. Some objects transmit many colours, such as clear, colourless glass, while some objects may transmit only a narrow range of colours, such as colour filters.

Background Knowledge

The retina in the human eye responds to light in different ways, depending on the type of light. Rod cells respond particularly well in very low light situations but do not respond to different colours. Cone cells, on the other hand, come in three different types, each responding well to one of the three additive primary colours: red, blue, and green. Since most light is a mixture of many different wavelengths, our eyes are adapted to respond well to many colours. However, our eyes are not as sensitive as those of birds, which have four types of colour receptors.

Light interacts with matter in predictable ways. It can be transmitted, absorbed, or reflected by objects. Light that is transmitted by objects encounters little change and passes through transparent materials. This light can be seen on the other side of the object. Light that is absorbed by objects is removed from incident rays and is not detected by our eyes. Reflected light encounters an object and interacts in such a way as to be observable to the human eye. Many situations occur that enable transmission, absorption, and reflection of light simultaneously. A good example of this occurs when you see your reflection in a store window and can also see the objects on display behind the glass. Daylight reflects off you and strikes the windowpane at such an angle that some light is absorbed, some is transmitted through the glass to the objects and then reflected back to you, and some reflects off the glass back to your eyes.

Literacy Strategies

Before Reading

- Students could work in pairs to discuss and record the meaning of each key term and contribute one or more terms to a class word wall. Ask students to find the key terms in the text and identify items that appear in the margins of the page. They should look for connections between the margin notes and the use of the term in the main text.
- Students could work together to create a concept map to show how the key terms relate to one another, and to the main topic.
- Encourage students to preview text features, including diagrams and photographs with captions, and predict what they will learn about in this topic.

During Reading

- Encourage students to use context to find meaning in the text. For example, cellophane is mentioned in Figure 4.11, on p. 23, but many students may not know what cellophane is. Have students describe the properties of cellophane, based on the way it is described in the caption and shown in the illustrations. Ask students to think of a similar substance that is flexible but transmits light (plastic wrap).
- If you are asking student to make notes during reading, model explicitly what you want students to record. For example, date, title, point form or full sentences, main point and supporting details for each spread, and so on.

After Reading

- Use the Learning Check questions to guide a class discussion on a topic that may not be well understood. Invite students to draw or revise diagrams at the chalkboard or whiteboard to illustrate the answer to each question.
- Review the key concepts of this topic by working with students to revise and complete the concept map they began before reading the topic.

Assessment FOR Learning		
Tool	**Evidence of Learning**	**Supporting Learners**
Learning Check, page 289	Students accurately use the words *transparent*, *translucent*, and *opaque*; and illustrate transmission, reflection, and absorption of light.	• Provide several different types of materials, and have students use the terms *transparent*, *translucent*, *opaque*, *transmit*, *reflect*, and *absorb* to classify them. • Review Science Skill Toolkit 5, Scientific Drawing, on pages 382 to 383. Students can also use **BLM G-14 Making Simple Scientific Drawings**.
Activity 4.2, page 291 Learning Check, page 291	Students use words and/or drawings to show what happens when coloured light hits objects of a different colour.	• Allow students to work in pairs to interpret and analyze their observations in Activity 4.2. • Bring in a red light and a green pepper and allow students to verify their predictions to Learning Check question 2.

Topic 4.2 (Student textbook pages 286–293)

Using the Topic Opener

- Have students look at the photograph in the opener. Ask students why the glass in the window makes the light coming through it so colourful. Encourage many theories. It is subtractive colour theory that explains why stained glass looks so attractively coloured, as students will learn in this topic. The glass absorbs certain wavelengths of light and lets others through.
- Work as a class to brainstorm other examples in students' lives where light interacts with objects to give them colour. These can include examples of transmission as well as reflection.
- Some students will not have an underlying assumption about the colours present in light and may not be engaged by the topic. Encourage students to think of why their clothes have the colours they do, and whether they would look the same in all types of lighting.

Starting Point Activity (Student textbook page 287)

Pedagogical Purpose

Students will challenge their pre-existing ideas of colour and coloured light, and investigate the influence of absorption and reflection on the colour of objects.

Planning	
Materials	Per group: flashlight red filter blue filter tape bright coloured, shiny objects (red, blue, and white)
Time	15 min in class 10 min preparation
Safety	Remind students not to shine flashlights in their eyes or their classmates' eyes.

Activity Notes and Troubleshooting

- You could tape red filters to half the flashlights and blue filters to the other half. If you do so, have students view the objects in one colour of light, then switch flashlights with another group to view the objects using the other colour.
- Brightly coloured, shiny objects are better able to reflect light than dull objects. Use objects with shiny surfaces and bright colours.
- Most colour filters allow more colours of light through than simply red or blue. Theatre gel filters are better than most at transmitting only red and blue light. See **www.scienceontario.ca** for availability.
- Challenge students to examine their thinking about what makes up light before they begin this activity and then revisit their thinking after they complete the activity. They could use a think-pair-share strategy to do this.
- This activity could be conducted as a demonstration using a high intensity flashlight or a floodlight.

Additional Support

- ELL Pair English language learners with students who have strong English language skills to help with understanding, and with vocabulary to describe observations.
- Enrichment—Allow students to identify other objects in the classroom or school and view them using each filter. Ask students how they could create a dark environment in which to view the objects. Have them describe their procedure and observations to the class.

Starting Point Activity Answer

Results may vary depending on the filters used. The source of light, and the source of the colours, is the flashlight. Objects reflect the light that strikes them. A red object will appear red in red light and black in blue light. Conversely, a blue object will appear blue in blue light and black in red light. A white object will appear red in red light and blue in blue light.

Students should support their points of view and review their opinions after completing the topic.

Instructional Strategies for Topic 4.2

Student textbook pages 288-289

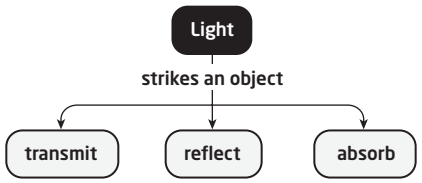
- Read the first paragraph aloud to students and have them look at the ray models of light in Figure 4.6 and Figure 4.7. Use straight lines to draw a ray diagram. Explain to students that rays travel in straight lines until they encounter an object. Insist that students use a ruler when drawing ray diagrams.
- Demonstrate reflection, absorption, and transmission using concrete materials and ray diagrams. Ask students to describe or draw other links between the verbs *transmit*, *absorb*, and *reflect* and the adjectives *opaque*, *transparent*, *translucent*. More than one link is possible for each.

Student textbook pages 290-291

- Examine Figures 4.9 and 4.10 with students. Ask students to explain how the results shown here are similar to the their own observations in the Starting Point Activity.
- Demonstrate the observations in Figure 4.11 using different colours of cellophane. For each colour, ask students to explain what is happening to the white light from the classroom light as it is transmitted or reflected by the cellophane.

Learning Check Answers (Student textbook page 289)

1.



2. Rays represent light well because they travel in straight lines and then either pass through the object (transmission), bounce off the object (reflection), or end at the object (absorption).

3. a) The book would look similar to the way it looks when it is not behind anything. Clear plastic wrap is transparent.

b) The main shape or colour of the book would be visible but not much else. Waxed paper is translucent.

c) You would not see the book at all. Aluminum foil is opaque.

Activity 4.2 Shining the Spotlight on Colour (Student textbook page 291)

Pedagogical Purpose

Students will investigate the influence of the colour of light shining on a coloured object to compare reflected and absorbed light. Students will see that the colour of light reflected is the same as the colour of the object.

Planning	
Materials	Per group: blue marking pen white paper flashlight with a blue filter
Time	15 min in class 5 min preparation
Safety	Remind students not to shine flashlights into their eyes or their classmates' eyes.

Skills Focus

- make predictions
- analyze and interpret data to determine whether it supports a prediction

Activity Notes and Troubleshooting

- Ensure that students use very white paper and bright blue marking pens.
- Most colour filters allow more colours of light through than simply red or blue. Theatre gel filters are better than most at transmitting only red and blue light. See **www.scienceontario.ca** for availability.
- Challenge students to examine their thinking about what makes up light before the activity, and then revisit their thinking after the activity.
- This activity could be a conducted as a teacher demonstration using a high intensity flashlight or spotlight. Each student should write a prediction and share it with a classmate before you conduct the demonstration.

Additional Support

- ELL A quick demonstration before the activity will help English language learners understand what to do. Pair English language learners with students who have strong English language skills to help with explaining results.
- Students who are colour blind will not be able to complete this task. Watch for students, particularly males, experiencing difficulty, and pair them with a classmate to help with observations.

Activity 4.2 Answers

2. Students should give reasons their predictions.

3. The blue marker should appear blue under blue or white light because blue rays are reflected in both cases. Students may have predicted that the blue marker would appear black but that would happen only if the light were absorbed and not reflected.

Learning Check Answers (Student textbook page 29)

1. Diagrams should show all colours of light hitting the surface of the lemon and only the yellow rays being reflected.
2. Red light shining on a green pepper will be absorbed and will not reflect. In the absence of other light, the pepper will appear black. Diagrams should show red light hitting the surface of the green pepper and being absorbed.

Activity 4.3 Exploring the Properties of Light (Student textbook page 25)

Pedagogical Purpose

Students will explore the propagation of light along a straight path. Students will see that rays of light travel in a straight line and do not interfere with each other as they travel from their source to an object.

Planning	
Materials	Per group: cardboard tubing (4 cm to 8 cm in diameter and about 25 cm long) ruler utility knife translucent wax paper aluminum foil masking tape push pin
Time	30 min in class 10 min preparation
Safety	Demonstrate for students how to hold the utility knife with the blade pointing away from you. Ensure that students handle the knives and push pins safely.

Background

Rays of light travel in a straight line from their source without interference until they encounter matter. (This is only true for macroscopic events. Interference does occur at the subatomic level.) As a result, the rays investigated in this activity will cross at the pinhole of the pinhole camera, without interfering with one another. This is unlike water waves and sound waves, which interfere with each other to produce interesting effects like supercrests and supertroughs.

Skills Focus

- plan an investigation
- select appropriate materials
- conduct an investigation, using equipment and materials safely
- communicate ideas using a variety of formats

Activity Notes and Troubleshooting

- Students should work in pairs or groups of three or four. Many hands may be needed for Part 1.
- Have students present their design for Part 1 to you before they carry out their experiments. Ensure they have a manageable plan that will support or refute the hypothesis that light travels in a straight line.
- Ensure every student has an opportunity to use the pinhole camera to observe an image.
- Commercial pinhole cameras are available.

Additional Support

- ELL Pair English language learners with students who have strong English Language skills to help with understanding.
- DI You may wish to pair students with strong interpersonal skills with students weak in this area.
- DI You may wish to organize groups by asking students to self identify roles, such as builder, investigator, and data recorder.
- Have one or more pinhole cameras already built for students to refer to as they construct the pinhole camera in Part 2.

Activity 4.3 Answers

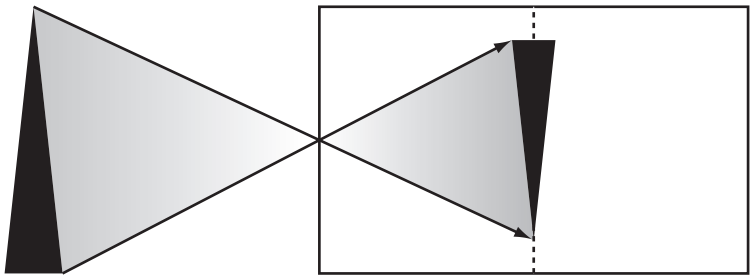
Part I

Experiments may vary. One possible experiment involves drawing spots on the sheet of cardboard, then pointing the flashlight at each spot, and holding the cardboard tube so that the light passes through the tube. The light should still shine on the spot it was aimed at. Another possible experiment involves shining the light parallel to the cardboard or paper, and tracing its path with a pencil. The path should be a straight line.

Part II

What Did You Find Out?

1. Light from higher points on the object would travel in a straight line through the pinhole, and end up low on the image. Light from lower points on the object would travel in a straight line through the pinhole and end up high on the image.

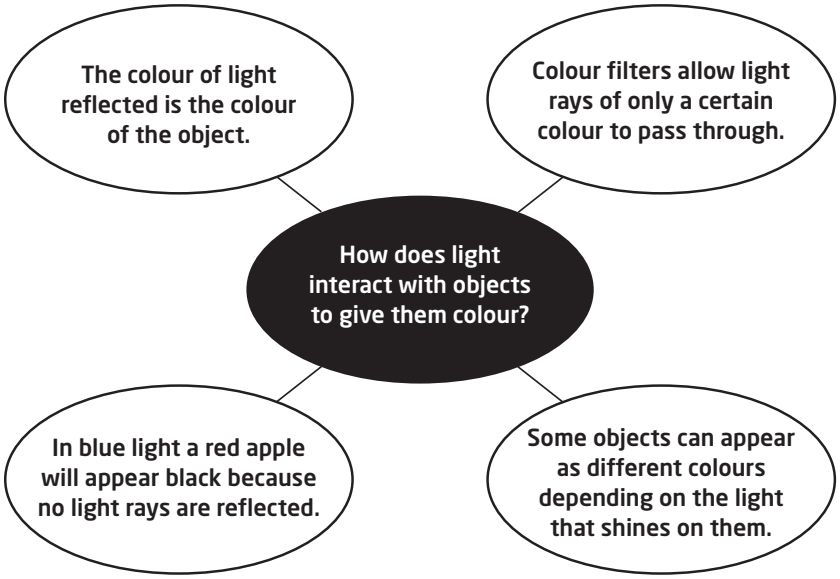


Topic 4.2 Review (Student textbook page 293)

Please see also **BLM 4-5 Topic 4.2 Review (Alternative Format)**.

Answers

1. Answers may vary. For example:



2. left: transmitted and reflected
centre: absorbed
right: transmitted, reflected, and absorbed

3. Light rays pass directly through transparent objects. Translucent objects allow some light rays to pass through, some to bounce off, and some to be absorbed. Diagrams should resemble Figure 4.8 on page 289.

4. Answers may vary. For example:

a) hockey puck, hockey stick

b) clear glass, coloured glass

c) shower curtain, frosted glass

5. An opaque object that absorbs all colours of light, reflecting none, will appear black.

6. Green light is reflected by plants, so it is not a good colour of lights for plants to grow in. Red and blue light are absorbed by most plants and used in photosynthesis.

7. The red wall lit by red light would continue to appear red, because that is the colour of light reflected. The yellow and blue walls would appear black, because these walls absorb all colours of light except yellow and blue, which are reflected.

8. Answers may vary. For example: stop signs, exit signs, and lights around airports are red. All of these examples use the colour red as a sign to increase awareness.