### Critical Learning
- The behavior of light depends on the materials with which it interacts.
- The fundamental concept of structure and function focuses on the relationship between the function of a human-made object and the form that the object takes.

### Guiding Questions
- How does light behave when it passes through a variety of media?
- How can a ray diagram be used to describe the characteristics of an image formed when light passes through a variety of media?
- What are some applications of lenses?

### Curriculum Expectations

#### Scientific Investigation Skills and Career Exploration

**A1.** Demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analyzing and interpreting, and communicating)

- **A1.5** conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively to collect observations and data
- **A1.6** gather data from laboratory and other sources, and organize and record the data using appropriate formats, including tables, flow charts, graphs, and/or diagrams
- **A1.8** analyze and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions
- **A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language in a variety of formats
- **A1.12** use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement

**E2.** Investigate, through inquiry, properties of light, and predict its behavior in mirrors and as it passes through different media

- **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 [C]
- **E2.3** use an inquiry process to investigate the refraction of light as it passes through a variety of media (e.g., angle of incidence and refraction as light passes through a clear acrylic block) [PR]
- **E2.4** predict the qualitative characteristics of images (e.g., location, orientation, size, type) formed by converging lenses, test their predictions through inquiry, and draw ray diagrams to record their observations [PR, AI, C]

**E3.** demonstrate an understanding of characteristics and properties of light, particularly with respect to reflection and refraction and the addition and subtraction of colour

- **E3.4** Describe qualitatively how visible light is refracted at the interface between two different media

#### Learning Goals

Students will be able to:
- explain the phenomenon of refraction and (by extension) total internal reflection
- use ray diagrams to illustrate observations using lenses
- predict and explain the characteristics of images formed by a converging lens using ray diagrams
- demonstrate inquiry skills of performing and recording, analyzing and interpreting, and communication

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**LITERACY GAINS** TRANSFORMING INSTRUCTIONAL PRACTICE SUPPORTS GRADE 10 SCIENCE
## Light Bends  Lesson 8

### Instructional Components and Context

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<th>Readiness</th>
<th>Terminology</th>
<th>Resources</th>
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<td>How light interacts with matter (Lesson 2)</td>
<td>Angle of incidence</td>
<td>Websites</td>
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<td>Collaborative norms and skills, e.g., taking roles, taking turns, disagreeing agreeably</td>
<td>Angle of refraction</td>
<td><strong>Optics Videos</strong></td>
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<tr>
<td>Drawing ray diagrams</td>
<td>Converging lens</td>
<td><strong>Gizmos</strong></td>
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<td></td>
<td>Diverging lens</td>
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<td>Focal point</td>
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<tr>
<td></td>
<td>Refraction</td>
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<td></td>
<td>Total internal reflection</td>
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</table>

### Terminology
- Angle of incidence
- Angle of refraction
- Converging lens
- Diverging lens
- Focal point
- Refraction
- Total internal reflection

### Resources
- **Websites**
- **Optics Videos**
- **Gizmos**

### Materials
- Optical devices (actual or images) and/or situations that involve refraction, e.g., camera, binoculars, refracting telescope, microscope, the eye, eyeglasses, contact lens, optical fibres, gemology, mirages
- Ray box, a rectangular prism, paper, pencil, ruler, converging and diverging lenses
- Optical bench with a converging lens
- Optical fibre or Lucite rod

### Monitoring Performance Checklist
- Interactive software, (e.g., Gizmo “Light rays with lenses”)
**Light Bends**  Lesson 8

**Minds On (Elicit, Engage)**

**Whole Class → Observing Refraction of Light**
Demonstrate a variety of examples of refraction, (e.g., Pencil appears “bent” in a glass of water). Students use their observations to respond to the questions: What do you see? How can we explain what we see? How does the path of light that passes through the medium or object differ from the path of light through air?

**Small Groups → Exploring Optical Devices that Use Lenses**
Form groups and distribute a placemat to each group. Students individually address the prompts on the outside, and then use this information to address the question in the middle of the placemat collaboratively (See sample placemat for template and questions). Students record their answers.

Debrief by posting the placemats. Use a think-aloud to draw some conclusions from the collection of placemats, (e.g., how a number of technologies benefit our lives). Extend the discussion by inviting students to draw additional conclusions.

**Action! (Explore, Explain)**

**Whole Class → Previewing Learning Goals**
Share the learning goals and guiding questions. Review any safety procedures pertinent to this lesson.

**Whole Class/Individual → Reading a Procedure**
Review drawing ray diagrams and the success criteria for quality of ray diagrams (from Lesson 3). Distribute procedures and material list. Students read procedure, and as they do, monitor their use of strategies to identify key words, sort out unfamiliar words and visualizing. Debrief by asking students if and how they used these comprehension strategies.

**Pairs/Small Groups/Whole Class → Investigating Using Lens**
Pairs complete the investigation by following the procedure.

Pairs combine to form small groups and compare their observations.

Debrief by prompting students to form a conclusion, (i.e., the amount that light bends or angle of refraction) as it passes through a medium depends on the angle at which it strikes the boundary (or angle of incidence) between the two media, within error limits).

Distribute procedures and material list 2. After students read the procedure, address any clarifying questions they have. Pairs complete the investigation by following the procedure.

Pairs combine to form small groups and compare their observations.

Debrief by prompting students to form a conclusion, (i.e., that a converging lens focuses the light at a point (the focal point) and that this location depends on the curvature of the surface of the lens, within error limits).

**Consolidation (Elaborate, Evaluate, Extend)**

**Pairs/Small Groups/Whole Class → Investigating Using a Simulation**
Pairs use interactive software, (e.g., Gizmo “Light rays with lenses”) to demonstrate how a ray diagram can be used to predict the characteristics of the image produced by a converging lens. Pairs combine to form small groups and compare observations. Repeat the appropriate steps in the simulation, if necessary.

One member of each group reports the group’s observations. Elicit answers to the following questions: Is the image produced by a converging lens virtual or real? How do you know this? Is the image produced identical to the object in size and in appearance? How do you know this?

**Pairs → Checking for Understanding**
Students locate the image of an object using a converging lens and label the focal point.

**Whole Class/Individual → Gathering Information for Culminating Task**
Review the anchor chart listing the various technologies (from Lesson 1). Add any additional technologies. Pose the questions: Which of these technologies use converging or diverging mirrors? How does it use it? Students jot notes and any questions for their assigned technology in their project log.
Placemat

Placemat is a strategy that encourages accountable talk. It also provides a structure for group note taking. A placemat is a sheet divided into sections, one for each member of the group and/or one for each prompt under consideration, and a central area in the center. One way to use the placemat is to have each member individually jot notes to a prompt on one of the sections. Then students use the central area to come to consensus, or address a related prompt which requires members to draw on each of the sections. The strategy can be used for a wide range of learning goals, for example, to encourage students to share ideas and come to a consensus about a concept/topic, to activate the sharing of prior knowledge among students, to help students share problem-solving techniques, and to facilitate peer review and coaching on a particular type of problem or skill.


See Think Literacy Cross-Curricular Approaches, Grades 7-12, pages 162-164.

Sample Placemat

Optical Device:

<table>
<thead>
<tr>
<th>What is the most common use of this device?</th>
<th>How does this device benefit the user?</th>
</tr>
</thead>
<tbody>
<tr>
<td>How would modern life be different without this device?</td>
<td></td>
</tr>
<tr>
<td>What function does the lens serve in the device?</td>
<td>Who benefits from this device?</td>
</tr>
</tbody>
</table>

Think-Aloud

A Think-Aloud is an instructional scaffold that models thinking processes, making the invisible visible. In a think-aloud, the teacher verbalizes how effective readers process the text, e.g., by monitoring comprehension and using strategies to construct meaning. While teachers can think aloud at any point in an instructional sequence, think-alouds are frequent during the modelling phase of the gradual release model and during read-alouds.

See Think Literacy Subject-Specific Examples: Language/English, Grades 7-9, Engaging in Reading: Reading Between the Lines/Inference, page 3.

A think-aloud is, therefore, a form of explicit instruction that requires teachers to be aware of their own thinking processes and that helps student think about their thinking. Developing metacognitive awareness is an important aspect of learning.

See Metacognition Guide.

Safety Procedures

Teachers must model safe practices at all times and communicate safety expectations to students in accordance with school board and Ministry of Education policies and Ministry of Labour regulations. Teachers are responsible for ensuring the safety of students during classroom activities and also for encouraging and motivating students to assume responsibility for their own safety and the safety of others. Teachers must also ensure that students have the knowledge and skills needed for safe participation in science activities.

To carry out their responsibilities with regard to safety, it is important for teachers to have:
- concern for their own safety and that of their students
- the knowledge necessary to use the materials, equipment, and procedures involved in science safely
- knowledge concerning the care of living things – plants and animals – that are brought into the classroom
- the skills needed to perform tasks efficiently and safely

Students demonstrate that they have the knowledge, skills, and habits of mind required for safe participation in science activities when they:
- maintain a well-organized and uncluttered work space
- follow established safety procedures
- identify possible safety concerns
- suggest and implement appropriate safety procedures
- carefully follow the instructions and example of the teacher
- consistently show care and concern for their own safety and that of others

Various kinds of health and safety issues can arise when learning involves field trips. Out of school field trips can provide an exciting and authentic dimension to students’ learning experiences. They also take the teacher and students out of the predictable classroom environment and into unfamiliar settings. Teachers must preview and plan these activities carefully to protect students’ health and safety.

Consolidation (Elaborate, Evaluate, Extend)

Anchor Chart

An anchor chart is a strategy for capturing students’ voices and thinking. Anchor charts are co-constructed. By making students’ thinking visible and public, they “anchor” or stabilize and scaffold classroom learning. Anchor charts should be developmentally appropriate and clearly focused, accessible, and organized.
Sample Procedures 1 and 2 Handout

Materials 1
• ray box
• a rectangular prism
• several sheets of plain paper
• a pencil and ruler

Sample Procedure 1
1. Using a single slit, aim a beam of light perpendicular to the long edge of the acrylic block. Sketch what you see.
2. Aim the light beam angled to the long edge of the prism. Sketch what you see. Label the incident ray, the transmitted ray (which has been bent or refracted at the boundary), and the reflected ray.
3. Using the same incident angle as in step 2, aim the light beam at a different location on the long edge of the prism. Sketch what you see on the same sheet of paper.
4. Repeat step 2 using a different angle. Sketch what you see on a different sheet of paper. Repeat this step two more times, each time using a different angle than before.
5. Join another group to compare observations. If necessary, repeat the inquiry.

Question Prompts:
1. Does the change in location along the long edge affect the angle of refraction?
2. What is the relationship between the angle of incidence and the angle of refraction?
3. What type of image do you think is produced by a converging lens?

Materials 2
• ray box
• diverging and converging lenses
• several sheets of plain paper
• optical bench with a converging lens
• a pencil and ruler

Sample Procedure 2
1. Predict how two types of lenses will bend light in the same way.
2. Using multiple slits, aim a beam of light, first at the converging lens, then at the diverging lens. Sketch what you see.
3. Using an optical bench, project the image formed with a converging lens onto a screen. Describe the appearance of this image (e.g., is it the same size? Is it upright?)
## Monitoring Performance Checklist Template

**Investigation** ________________________________  **Date** ________________________________

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Student Names</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Student 1</td>
</tr>
<tr>
<td>Applies proper procedures for the use and care of the equipment</td>
<td></td>
</tr>
<tr>
<td>A1.4[IP]</td>
<td></td>
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<tr>
<td>Follows instructions provided by teacher or developed by class or group</td>
<td></td>
</tr>
<tr>
<td>A1.5[PR]</td>
<td></td>
</tr>
<tr>
<td>Uses all required lab equipment safely</td>
<td></td>
</tr>
<tr>
<td>A1.5[PR]</td>
<td></td>
</tr>
<tr>
<td>Uses equipment accurately and effectively to ensure repeatable results</td>
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<tr>
<td>A1.5[PR]</td>
<td></td>
</tr>
<tr>
<td>Adheres to the rules of conduct in effect during inquiry activities</td>
<td></td>
</tr>
<tr>
<td>A1.5[PR]</td>
<td></td>
</tr>
<tr>
<td>Returns all equipment clean to the correct storage area or as instructed otherwise</td>
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</tr>
<tr>
<td>A1.5[PR]</td>
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</tr>
<tr>
<td>Creates tables or graphs that present the observation in a logical manner and include appropriate symbols and units</td>
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<tr>
<td>A1.6 [PR], A1.12[C]</td>
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