Level 4 Module 4

Light

Planning and Preparation Guide

In *PhD Science*™ Level 4, lessons are designed to fill 45 minutes of instructional time. Every lesson has a Launch, Learn, and Land section, and each section serves a specific purpose within the scope and sequence of the lesson. Teachers should always begin the lesson with a Launch to prepare students for the Learn portion of the lesson. The Land generally includes a debrief of the Learn so that students can reflect on their learning and build consensus before moving forward. Teachers who decide to spend more than one class day on a lesson should consider beginning the second day of the lesson with a summary of the previous day's learning.

The purpose of this Planning and Preparation Guide is to summarize the preparation requirements for each lesson. The calendar included in this guide contains the following sections to aid in planning and preparation.

Preparing to Teach: This section describes preparation teachers should complete before a lesson begins.

Materials: This section lists all materials necessary for the lesson. For more information, refer to the module-specific materials lists in the *PhD Science* Teacher Resource Pack.

Module Resources: This section lists all module resources necessary for the lesson.

Alternative Pacing: This section provides pacing suggestions for classrooms with less than 45 minutes of instructional time for science.

Advance Preparation: This section describes preparation teachers should complete a specified number of days before an upcoming lesson.

Instructional Routines

The following instructional routines are recommended for use in this module. For specific information about each routine, refer to the *PhD Science* Implementation Guide.

- Gallery Walk
- Graffiti Wall
- Inside–Outside Circles
- Mix and Mingle
- Quick Write
- Stop and Jot
- Think–Pair–Share

Module at a Glance

Anchor Phenomenon: Visibility of and Communication to Howland Island *Essential Question: Why didn't Amelia Earhart complete her journey?*
Concept 1: Sight *Focus Question: How does light affect what we see?*
Concept 2: Physical Properties of Objects *Focus Question: How do an object's physical properties affect how we see it?*
Application of Concepts: Engineering Challenge
Concept 3: Communication *Focus Question: How can we communicate effectively across a distance?*
Application of Concepts: Socratic Seminar and End-of-Module Assessment

Calendar

Concept 1: Sight (Lessons 1–6)

Focus Question: How does light affect what we see?

Lessons 1–2

Phenomenon Question: What makes an island difficult to see?

Lesson 1

Obtain and combine information to investigate Amelia Earhart's final flight.

Preparing to Teach

- ☐ Open *Baltimore News-Post* article "Navy Hunts Amelia Lost in Pacific Ocean" (1937): http://phdsci.link/1102.
- ☐ Cue "POV: Howland Island" video (Waitt Institute 2009): http://phdsci.link/1096.

Materials

- ☐ Science Logbook (Module Question Log)
- ☐ Science Logbook (Lesson 1 Activity Guide)
- ☐ *Amelia Lost: The Life and Disappearance of Amelia Earhart* by Candace Fleming (2011)

Alternative Pacing

Day 1: Launch through Notice and Wonder about Howland Island Video

Day 2: Introduce *Amelia Lost* through Land

Lesson 2 Develop a model to explain why Amelia Earhart could not find Howland Island.	**Preparing to Teach** None **Materials** ☐ Science Logbook (Module Question Log) ☐ Science Logbook (Lesson 2 Activity Guide) ☐ *Amelia Lost* **Module Resources** ▪ Lesson 2 Resource: Sky, Clouds, and Water Photograph **Alternative Pacing** Day 1: Launch through Develop Anchor Model Day 2: Build Driving Question Board through Land
Lessons 3–4 *Phenomenon Question: How do we see objects in the classroom?*	
Lesson 3 Gather evidence of light traveling as rays.	**Preparing to Teach** ☐ Prepare shaded lamp (with extension cord if needed) or large flashlight. ☐ Prepare the modified flashlights, and set up the materials for the reflection investigation for each group. **Materials** ☐ Science Logbook (Lesson 3 Activity Guides A and B) ☐ Reflection Investigation (per group): modified flashlight, square or rectangular mirror, 2 large binder clips, ruler, protractor, colored pencils or markers (3 colors), blank computer paper ☐ Lamp with shade or large flashlight ☐ Modified flashlight materials (per group): flashlight, 2 index cards, glue stick, scissors, pencil, masking tape, Reflection Investigation Setup Instructions (Lesson 3 Resource) **Module Resources** ▪ Lesson 3 Resource: Reflection Investigation Setup Instructions **Alternative Pacing** Day 1: Launch through Model Light Rays Day 2: Investigate Reflection through Land
Lesson 4 Gather evidence to support how light reflects off an object to the eye.	**Preparing to Teach** ☐ Prepare a shadow box for each group. ☐ Cue reflected light video (Surrey NanoSystems 2016): http://phdsci.link/1098. (optional)

	Materials ☐ Science Logbook (Lesson 3 Activity Guides A and B) ☐ Science Logbook (Module Question Log, Lesson 4 Activity Guide) ☐ Sight Exploration (per group): shadow box, flashlight ☐ Shadow box materials (per group): black photo box (4″ × 8″ × 12.25″), ruler, wooden pencil (triangular or hexagonal shape), modeling compound or clay, black construction paper, thumbtack, drill with $\frac{5}{32}$″ and $\frac{1}{2}$″ drill bits, tape, Shadow Box Setup Instructions (Lesson 4 Resource A) **Module Resources** ▪ Lesson 4 Resource A: Shadow Box Setup Instruction ▪ Lesson 4 Resource B: Eye Cross Section Diagram **Alternative Pacing** Day 1: Launch through Explore Sight Day 2: Explore the Eye through Land
Lessons 5–6 *Phenomenon Question: How do we see an object in a shadow?*	
Lesson 5 Observe objects in shadows to develop a model to explain indirect illumination.	**Preparing to Teach** ☐ Prepare shadow box with wall for each group. **Materials** ☐ Science Logbook (Lesson 5 Activity Guide) ☐ Classroom objects (1 per student) ☐ Shadow Exploration (per group): shadow box with wall, flashlight ☐ Launch demonstration: projector or another light source, object to cast a shadow ☐ Shadow box with wall materials (per group): shadow box from Lesson 4, small piece of cardboard, tape, Shadow Box with Wall Setup Instructions (Lesson 5 Resource) **Module Resources** ▪ Lesson 5 Resource: Shadow Box with Wall Setup Instructions **Alternative Pacing** Day 1: Launch through Explore Shadows Day 2: Develop a Model through Land

Lesson 6 Explain how direct and indirect illumination affect the ability to see objects.	**Preparing to Teach** ☐ Cue reflected light video (Surrey NanoSystems 2016): http://phdsci.link/1098. **Materials** ☐ Science Logbook (Lesson 6 Activity Guide) ☐ 2 flashlights (one modified (from Lesson 3) and one unmodified) **Module Resources** ▪ Lesson 6 Resource: Conceptual Checkpoint Photograph **Alternative Pacing** Day 1: Launch through Update Anchor Model Day 2: Conceptual Checkpoint through Land

Concept 2: Physical Properties of Objects (Lessons 7–13)

Focus Question: How do an object's physical properties affect how we see it?

Lessons 7–8

Phenomenon Question: Which physical properties affect how light reflects off objects?

Lesson 7 Investigate how the physical properties of an object affect its ability to reflect light.	**Preparing to Teach** ☐ Prepare student materials for the Reflectiveness Investigation (Lesson 7 Resource). **Materials** ☐ Science Logbook (Lesson 7 Activity Guide) ☐ Reflectiveness Investigation (per group): flashlight, ruler, protractor, 5–10 classroom objects of varying colors and textures (e.g., sheets of construction paper, crayons, plastic game pieces, wooden toys, metal keys) ☐ 3 identical flashlights, 3 classroom objects (2 objects with the same color and 2 objects with the same texture—for example, white ceramic mug, white paper cup, black ceramic mug) **Module Resources** ▪ Lesson 7 Resource: Reflectiveness Investigation Setup Instructions **Alternative Pacing** Day 1: Launch through Investigate Reflectiveness Day 2: Determine Patterns in Physical Properties of Objects through Land
Lesson 8 Investigate how the surface texture of an object affects its ability to reflect light.	**Preparing to Teach** ☐ Prepare student materials for the Surface Texture Investigation (Lesson 8 Resource).

	Materials ☐ Science Logbook (Lesson 8 Activity Guide) ☐ Surface Texture Investigation (per group): flashlight, shadow box (from Lessons 3–6), modeling compound or clay (from Lessons 3–6), stack of smooth plastic building blocks, stack of rough plastic building blocks ☐ Surface Texture Investigation (per group): 4 plastic building blocks of the same color and size, medium or fine grit sandpaper, Surface Texture Investigation Setup Instructions (Lesson 8 Resource) **Module Resources** ▪ Lesson 8 Resource: Surface Texture Investigation Setup Instructions **Alternative Pacing** Day 1: Launch through Investigate Surface Texture Day 2: Develop a Model of Light Reflection on Different Surfaces through Land
Lesson 9 *Phenomenon Question: How does color affect how we see objects?*	
Lesson 9 Demonstrate how the color of light and the color of an object affect what we see.	**Preparing to Teach** ☐ Prepare student materials for investigation (Lesson 9 Resource). ☐ Cue "POV: Howland Island" video (Waitt Institute 2009): http://phdsci.link/1096. **Materials** ☐ Science Logbook (Lesson 9 Activity Guide) ☐ Color Investigations (per group): set A cards, set B cards, color wheel card, flashlight, rubber band, piece of green plastic tablecloth or cellophane, piece of red plastic tablecloth or cellophane, piece of blue plastic tablecloth or cellophane ☐ Launch materials: white object (e.g., a cup), flashlight, piece of red plastic tablecloth or cellophane **Module Resources** ▪ Lesson 9 Resource: Color Investigations **Alternative Pacing** Day 1: Launch through Investigate Color Day 2: Discuss Investigation Results through Land

Lessons 10–13

Phenomenon Question: How do different conditions affect how we see an object?

Lesson 10

Explore how conditions can affect visibility, and gather information about Howland Island.

Preparing to Teach

- ☐ Open the *Townsville Daily Bulletin* article (Associated Press 1937): http://phdsci.link/1101.
- ☐ Open Howland Island satellite image (Google 2020): http://phdsci.link/1099.

Materials

- ☐ Science Logbook (Lesson 10 Activity Guides A and B)
- ☐ Chart paper (1 per group)

Module Resources

- Lesson 10 Resource: Rouen Cathedral Paintings

Alternative Pacing

Day 1: Launch through Introduce Flight Conditions Project

Day 2: Examine Howland Island through Land

Lesson 11

Evaluate and create a physical model of Howland Island.

Preparing to Teach

- ☐ Prepare the model components: ocean, cloud shadows, *Itasca* beacon, and viewfinders (Lesson 11 Resource A).
- ☐ Prepare materials and set up for students to construct Howland Island model (Lesson 11 Resource B), including printing a copy of Lesson 11 Resource B for each group.

Materials

- ☐ Science Logbook (Lesson 10 Activity Guides A and B)
- ☐ Science Logbook (Lesson 11 Activity Guide, Lessons 1–9 Activity Guides)
- ☐ Howland Island model (per group): flat paperboard (e.g., cereal box), sheet of green construction paper, 100 square centimeters of adhesive-backed sandpaper, ruler, scissors
- ☐ Ocean component: blue construction paper, clear or blue plastic wrap, black construction paper, scissors, clear tape, masking tape (optional)
- ☐ *Itasca* beacon component: electrical tape, small white light-emitting diode (LED), 3-volt watch battery (CR2025), blue construction paper, plastic wrap

Module Resources

- Lesson 11 Resource A: Flight Conditions Model Setup Instructions
- Lesson 11 Resource B: Howland Island Model Instructions

	Alternative Pacing Day 1: Launch through Create Howland Island Model **Day 2: Create Howland Island Model through Land**
Lesson 12 Explore how physical properties and different conditions affect the appearance of objects.	**Preparing to Teach** ☐ Prepare materials and set up for Modeling Flight Conditions before the lesson (Lesson 12 Resource). **Materials** ☐ Science Logbook (Lesson 12 Activity Guide) ☐ Ocean component from Lesson 11: blue construction paper, clear or blue plastic wrap, black construction paper, scissors, clear tape, masking tape (optional) ☐ *Itasca* beacon component from Lesson 11: electrical tape, small white LED, 3-volt watch battery (CR2025), blue construction paper, plastic wrap ☐ Other model materials: lamp, 3 viewfinders (paper towel tubes or construction paper and tape), 3 stopwatches, Modeling Flight Conditions (Lesson 12 Resource) ☐ Pencil **Module Resources** ▪ Lesson 12 Resource: Testing Flight Conditions **Alternative Pacing** Day 1: Launch through Model Possible Flight Conditions Day 2: Discuss Results through Land
Lesson 13 Apply new understanding about the ways physical properties and different conditions affect how objects are seen to the anchor model.	**Preparing to Teach** None **Materials** ☐ Science Logbook (Lesson 10 Activity Guides A and B) ☐ Science Logbook (Lesson 11 Activity Guide, Lessons 1–9 Activity Guides) ☐ Science Logbook (Lesson 13 Activity Guide) **Module Resources** ▪ Lesson 13 Resource: Conceptual Checkpoint Photographs **Alternative Pacing** Day 1: Launch through Revise Anchor Model Day 2: Conceptual Checkpoint through Land

Application of Concepts: Engineering Challenge (Lessons 14–17)

Lessons 14–17

Phenomenon Question: How can you make Howland Island and the runway easier to find?

Lesson 14

Apply the engineering design process to develop, build, and test a solution that makes Howland Island easier to find.

Preparing to Teach

- ☐ Open Howland Island satellite image: http://phdsci.link/1099.
- ☐ Open the *Townsville Daily Bulletin* article (Associated Press 1937): http://phdsci.link/1101.
- ☐ Arrange materials for the engineering challenge on a table so students can easily access them.

Materials

- ☐ Science Logbook (Lesson 14 Activity Guide)

Module Resources

- Lesson 14 Resource A: Current Airport Runway Photograph
- Lesson 14 Resource B: Engineering Design Process

Alternative Pacing

Day 1: Launch through Prepare for Engineering Challenge

Day 2: Imagine and Plan a Design Solution through Land

Lesson 15

Apply the engineering design process to develop, build, and test a solution that makes Howland Island easier to find.

Preparing to Teach

- ☐ Arrange materials for the engineering challenge on a table so students can easily access them.

Materials

- ☐ Science Logbook (Lesson 14 Activity Guide)
- ☐ Engineering Challenge (per group): Howland Island model from Lessons 10–13, aluminum foil, cotton balls, construction paper in various colors, colored markers, toothpicks, pony beads in various colors, craft sticks, modeling clay, chenille stems, 6 small LEDs in various colors, 3 3-volt watch batteries (CR2025), scissors, clear or masking tape, glue, electrical tape, measurement tools (optional)
- ☐ Small ocean model (per group): sheet of blue construction paper, plastic wrap
- ☐ Ocean model component from Lessons 10–13
- ☐ 3 viewfinders
- ☐ 3 stopwatches

Module Resources

- Lesson 12 Resource: Testing Flight Conditions

	Alternative Pacing Day 1: Launch through Create a Design Solution Day 2: Create a Design Solution through Land
Lesson 16 Apply the engineering design process to develop, build, and test a solution that makes Howland Island easier to find.	**Preparing to Teach** ☐ Arrange materials for the engineering challenge on a table so students can easily access them. **Materials** ☐ Science Logbook (Lesson 14 Activity Guide) ☐ Engineering Challenge from Lesson 15 (per group): Howland Island model from Lessons 10–13, aluminum foil, cotton balls, construction paper in various colors, colored markers, toothpicks, pony beads in various colors, craft sticks, modeling clay, chenille stems, 6 small LEDs in various colors, 3 3-volt watch batteries (CR2025), scissors, clear or masking tape, glue, electrical tape, measurement tools (optional) ☐ Small ocean model from Lesson 15 (per group): sheet of blue construction paper, plastic wrap ☐ Science Logbook (Lesson 16 Activity Guide) ☐ Ocean model component from Lessons 10–13 ☐ 3 viewfinders from Lesson 15 ☐ 3 stopwatches from Lesson 15 **Module Resources** ▪ Lesson 12 Resource: Testing Flight Conditions **Alternative Pacing** Day 1: Launch through Improve a Design Solution Day 2: Improve a Design Solution through Land
Lesson 17 Apply the engineering design process to develop, build, and test a solution that makes Howland Island easier to find.	**Preparing to Teach** ☐ Prepare 3 blank line plots for midnight, sunrise, and 8:45 a.m. (Lesson 17 Resource). **Materials** ☐ Science Logbook (Lesson 16 Activity Guide) ☐ *Amelia Lost* **Module Resources** ▪ Lesson 17 Resource: Class Line Plots **Alternative Pacing** Day 1: Launch through Share a Design Solution Day 2: Share a Design Solution through Land

Concept 3: Communication (Lessons 18–24)

Focus Question: How can we communicate effectively across a distance?

Lessons 18–21

Phenomenon Question: How do people use radios to communicate?

Lesson 18 Ask questions about radio communication.	**Preparing to Teach** None **Materials** ☐ Science Logbook (Lesson 18 Activity Guide) ☐ *Amelia Lost* (1 per group) ☐ Sticky notes (several per group) ☐ Handheld radio **Module Resources** ▪ Lesson 18 Resource: Radio Communication Event Timeline **Alternative Pacing** Day 1: Launch through Explore Radio Communication Events Day 2: Create Timeline of Radio Communication Events through Land
Lesson 19 Develop an initial model to explain radio communication.	**Preparing to Teach** ☐ Prepare materials to explore radio communication systems (Lesson 19 Resource). **Materials** ☐ Anonymous Quick Write responses from Lesson 18 (2 per group) ☐ Science Logbook (Lesson 19 Activity Guide) ☐ Radio communication materials: handheld radio (1 per group) ☐ Transmitter, computer ☐ Sight model from Lesson 4 **Module Resources** ▪ Lesson 19 Resource: Radio Communication Exploration **Alternative Pacing** Day 1: Launch through Explore Radio Communication Day 2: Develop Class Communication System Model through Land
Lesson 20 Conduct an investigation of breakdowns in a radio communication system.	**Preparing to Teach** ☐ Prepare materials to investigate blocking radio signals (Lesson 20 Resource).

	Materials ☐ Science Logbook (Lesson 20 Activity Guide) ☐ Blocking Radio Signals Investigation: variety of materials (e.g., aluminum foil, cardboard, construction paper, plastic bags, wax paper, student backpacks), handheld radio (1 per group) ☐ Transmitter, computer from Lesson 19 ☐ Flashlight **Module Resources** ▪ Lesson 20 Resource: Blocking Radio Signals Investigation Setup Instructions **Alternative Pacing** Day 1: Launch through Investigate Blocking Radio Signals Day 2: Discuss Investigation Results through Land
Lesson 21 Investigate infrared signals to determine that there are types of light that humans cannot see, including radio signals.	**Preparing to Teach** ☐ Test the infrared remote with a cell phone or laptop camera to make sure that the signal is detectable. **Materials** ☐ Infrared Light Investigations: infrared remote, 3-volt watch battery (CR2025), cell phone or laptop camera, materials used to test blocking radio waves, mirror, Sample Investigation Plans (Lesson 21 Resource A) ☐ *Amelia Lost* **Module Resources** ▪ Lesson 21 Resource A: Sample Investigation Plans ▪ Lesson 21 Resource B: Light Spectrum **Alternative Pacing** Day 1: Launch through Investigate Infrared Light Day 2: Investigate Infrared Light through Land
Lessons 22–24 *Phenomenon Question: How can we communicate with digitized information?*	
Lesson 22 Explore how Morse code can be used to digitize information.	**Preparing to Teach** ☐ Cue Morse code demonstration video (DOD 1966): http://phdsci.link/1106. ☐ Cue Morse code translator website (Phillips 2015–2017): http://phdsci.link/1105. **Materials** ☐ Science Logbook (Lesson 22 Activity Guide)

	☐ Computer or tablet with internet connection (1 per pair or group) ☐ Morse code translator (Phillips 2015–2017): (http://phdsci.link/1105) ☐ *Amelia Lost* ☐ Class radio communication event timeline from Lesson 18 **Module Resources** ▪ Lesson 22 Resource: International Morse Code **Alternative Pacing** Day 1: Launch through Create Morse Code Messages Day 2: Send and Receive Messages through Land
Lesson 23 Investigate different methods of transferring information across a distance.	**Preparing to Teach** ☐ Cue Morse code versus texting race video ("Morse vs SMS" 2015): http://phdsci.link/1107. **Materials** ☐ Science Logbook (Lesson 22 Activity Guide) ☐ Science Logbook (Lesson 23 Activity Guide) ☐ Materials to send and receive messages (per pair): flashlight, string ☐ Class radio communication event timeline from Lesson 18 ☐ Class communication system model from Lesson 19 **Module Resources** ▪ Lesson 22 Resource: International Morse Code **Alternative Pacing** Day 1: Launch through Send and Receive Messages across a Distance Day 2: Revise Class Communication System Model through Land
Lesson 24 Apply new understandings of communication systems to the anchor model.	**Preparing to Teach** None **Materials** ☐ Computer or tablet with internet connection (1 per pair or group) ☐ Morse code translator (Phillips 2015–2017): (http://phdsci.link/1105) ☐ Science Logbook (Lesson 24 Activity Guide) ☐ Class communication system model from Lesson 19 **Module Resources** ▪ Lesson 22 Resource: International Morse Code **Alternative Pacing** Day 1: Launch through Revise Anchor Model Day 2: Conceptual Checkpoint through Land

Application of Concepts: Socratic Seminar and End-of-Module Assessment (Lessons 25–27)

Lessons 25–27

Essential Question: Why didn't Amelia Earhart complete her journey?

Lesson 25 Explain how light allows us to see objects and how we can communicate across a distance. (Socratic Seminar)	**Preparing to Teach** None **Materials** ☐ Science Logbook (Lesson 25 Activity Guides A, B, and C) **Alternative Pacing** Day 1: Launch through Prepare for Socratic Seminar Day 2: Engage in Socratic Seminar through Land
Lesson 26 Explain how light allows us to see objects and how we can communicate across a distance. (End-of-Module Assessment)	**Preparing to Teach** None **Materials** ☐ End-of-Module Assessment **Alternative Pacing** Day 1: Launch through Complete End-of-Module Assessment (begin assessment) Day 2: Complete End-of-Module Assessment (complete assessment) through Land
Lesson 27 Explain how light allows us to see objects and how we can communicate across a distance. (End-of-Module Assessment Debrief)	**Preparing to Teach** ☐ Score End-of-Module Assessments and write individual feedback. ☐ Select End-of-Module Assessment responses to share with students. ☐ Prepare visual for student connections between module concept statements and Systems Crosscutting Concepts (Lesson 27 Resources A and B). **Materials** ☐ End-of-Module Assessment Rubric ☐ Sample of End-of-Module Assessment responses that meet expectations (either sample responses from Teacher Edition or sample from class) **Module Resources** ▪ Lesson 27 Resource A: Module Concept Statements ▪ Lesson 27 Resource B: Systems Crosscutting Concepts

	Alternative Pacing Day 1: Launch through Debrief the End-of-Module Assessment **Day 2: Revise End-of-Module Responses through Land**

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Credits