Preparation Guide

Level 5 Module 3

Orbit and Rotation

with Capstone Project on Forces and Energy

Materials: This section lists the quantity of each material necessary for the lesson. Lesson materials may be from a *PhD Science® TEKS EDITION* materials kit or they may be school supplied. In addition to the listed materials, teachers should have access to the following common classroom items: sticky notes, chart paper, pencils, a whiteboard, and markers. This section also lists items in the current lesson that are reused in future lessons. Note that items found in a typical elementary classroom (e.g., glue, tape, scissors) are not listed for reuse.

Resources: This section lists module resources (from Appendix A in the Teacher Edition) and core texts used in the lesson. Classrooms also need daily access to the module's Teacher Edition, Science Logbooks, and, if applicable, PhD Projected. A symbol (🖵) identifies resources that appear in PhD Projected. The Teacher Resource Pack provides additional supports and directions for some investigations as well as Spanish support resources with alternatives for Spanish-speaking students. The Teacher Resource Pack is available at https://greatminds.org/resources.

Preparation: This section identifies preparation teachers should complete before the lesson, including media teachers must cue before the lesson and activities that require setup. This section also describes advance preparation for upcoming lessons. For example, if teachers need to prepare 1 day in advance for an activity in Lesson 11, an advance preparation note appears in the Preparation section for Lesson 10. A symbol (📅) identifies lessons with advance preparation notes.

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Advance Materials Preparation

Several activities in this module require advance preparation. A version of this list appears in the Module Overview of the Teacher Edition. The expanded version in this guide identifies all lessons for which preparation may take longer than a planning period. A symbol (†) identifies preparation that can be done earlier than the suggested time.

Lesson	Time in Advance	Investigation	Description
1	3 or more days before†	Sky Observation	Have students make observations of the sky at the same time and from the same location once a day for 3 consecutive days. Students should choose an area of the sky where the Sun is visible. Warn students not to look directly at the Sun, as this can cause permanent eye damage. Students record their observations in their Science Logbooks.
3	1 day before†	Light Scattering Demonstration	Prepare bins for light scattering demonstration. (See Lesson 3 Resource B.)
7	1 day before†	Shadow Observation	Take a picture of a shadow cast from the school building in the early morning before school and record the time that the photograph was taken. The picture should show the full shadow as well as at least part of the building casting the shadow. If possible, use chalk to record the shadow's position.
22	1 day before†	Distance and Brightness Investigation	Assemble light intensity comparers. (See Lesson 22 Resource B.)

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Orbit and Rotation Lesson Preparation

Lesson 1

Materials	Kit Items None	School Supplied Items None
Resources	☐ Lesson 1 Resource A: Sky Photographs (optional) ☐ Lesson 1 Resource B: Pacific Ocean Photograph ☐ Lesson 1 Resource C: Polynesian Triangle Map ☐ Lesson 1 Resource D: Location Mapping Instructions ☐ Lesson 1 Resource E: "Polynesia's Genius Navigators" (Clark 2000)	
Preparation	☐ Use Google Earth™ mapping service to bookmark the three locations that make up the corners of the Polynesian Triangle (see Lesson 1 Resource D) (http://phdsci.link/1310).	
	Advance Preparation for Lesson 1 ☐ **3 or More Days Before:** Have students make observations of the sky at the same time and from the same location once a day for 3 consecutive days. Students should choose an area of the sky where the Sun is visible. Warn students not to look directly at the Sun, as this can cause permanent eye damage. Students record their observations in their Science Logbooks (Lesson 1 Activity Guide A). If the class is unable to make these observations, use the photographs of the sky provided in Lesson 1 Resource A.	

Lesson 2

Materials	Kit Items None	School Supplied Items None
Resources	☐ Lesson 2 Resource: *Celestial Navigation* (Cornell 1958) ☐ *Look to the Stars* (Aldrin 2009)	
Preparation	None	
	Advance Preparation for Lesson 3 ☐ **1 Day Before:** Prepare bins for light scattering demonstration. (See Lesson 3 Resource B.)	

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Lesson 3

Materials	**Kit Items** ☐ Bins, clear plastic, 6 qt (2) ☐ Flashlight with batteries (1)	**School Supplied Items** ☐ Milk (10 mL) ☐ Water (8 qt)
Resources	☐ Lesson 3 Resource A: Sun Photographs ☐ Lesson 3 Resource B: Light Scattering Demonstration Setup Instructions and Procedure ☐ Lesson 3 Resource C: "What Is Space?" (European Space Agency 2010)	
Preparation	None	

Lesson 4

Materials	**Kit Items** None	**School Supplied Items** ☐ Globe (1)
Resources	☐ Lesson 3 Resource A: Sun Photographs ☐ Lesson 4 Resource A: Space Shuttle Atlantis Launch Videos ☐ Lesson 4 Resource B: Global Gravity Videos	
Preparation	☐ Cue one video of a space shuttle launch (see Lesson 4 Resource A). ☐ Cue several videos of the effects of gravity around the world (see Lesson 4 Resource B).	

Lesson 5

Materials	**Kit Items** ☐ Clay, modeling, nonhardening (0.5 lb) ☐ Lanterns with batteries (6) ☐ Protractors (6)	**School Supplied Items** ☐ Pencils, unsharpened (6) ☐ Meter sticks (6) ☐ Rulers, metric (6)
	Item Reuse ☐ Lesson 6 requires the shadow investigation materials. ☐ Lesson 8 requires the lanterns. ☐ Lesson 10 requires the unsharpened pencils. ☐ Lesson 21 requires 1 of the meter sticks. Save all the meter sticks for Lesson 22.	
Resources	☐ Lesson 5 Resource A: Gateway Arch Photographs ☐ Lesson 5 Resource B: Shadow Investigation Setup Photographs	
Preparation	None	

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Lesson 6

Materials	**Kit Items** None	**School Supplied Items** None
	Prepared Items from Previous Lessons ☐ Shadow investigation materials from Lesson 5 (6 sets)	
Resources	☐ Lesson 5 Resource A: Gateway Arch Photographs ☐ Lesson 5 Resource B: Shadow Investigation Setup Photographs	
Preparation	None	
	Advance Preparation for Lesson 7 ☐ **1 Day Before:** Take a picture of a shadow cast from the school building in the early morning before school and record the time that the photograph was taken. The picture should show the full shadow as well as at least part of the building casting the shadow. If possible, use chalk to record the shadow's position.	

Lesson 7

Materials	**Kit Items** ☐ Compasses (12)	**School Supplied Items** ☐ Camera, digital (1) ☐ Chalk (1 stick)
Resources	☐ Lesson 7 Resource A: Shadow Photographs (optional) ☐ Lesson 7 Resource B: Compass Instructions	
Preparation	None	

Lesson 8

Materials	**Kit Items** ☐ Lanterns with batteries (6)	**School Supplied Items** ☐ Scissors (1)
	Item Reuse ☐ Lesson 9 requires the lanterns.	
Resources	☐ Lesson 8 Resource A: Re and Nut ☐ Lesson 8 Resource B: Earth-View Student Model Resources ☐ Lesson 8 Resource C: Diagram of Earth's Solar System ☐ Lesson 8 Resource D: "Galileo and the Moons of Jupiter" (Helies 2002)	
Preparation	☐ Prepare a set of east and west direction cards (Lesson 8 Resource B, Figure 1) for each group. Consider laminating the cards for future use. ☐ Cue "One Year on Earth—Seen From 1 Million Miles" video (NASA Goddard 2016): http://phdsci.link/1363.	

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Lesson 9

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Globes, mini, 3” (6)
☐ Lanterns with batteries (6)
☐ Polystyrene foam discs, 4” × 4” × 1” (6)
☐ Sticks, wooden, 7” (6)</td><td>School Supplied Items
☐ Toothpicks (6)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 10 requires the lanterns.
☐ Lesson 11 requires the prepared mini Earth models.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 9 Resource A: Space-View Model Setup Instructions
☐ Lesson 9 Resource B: World Cities Live Camera Feeds</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Cue “One Year on Earth—Seen From 1 Million Miles” video (NASA Goddard 2016): http://phdsci.link/1363.
☐ Cue a live camera feed from a city experiencing nighttime during class (see Lesson 9 Resource B).</td></tr>
</table>

Lesson 10

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Clay, modeling, nonhardening (0.5 lb)
☐ Compasses (6, optional)
☐ Lanterns with batteries (6)</td><td>School Supplied Items
☐ Pencils, unsharpened (6)
☐ Scissors (6)
☐ Tape, clear (1 roll)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 11 requires the lanterns.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 10 Resource A: Sun Above the Horizon Photograph
☐ Lesson 10 Resource B: Ancient Egyptian Sundial Photograph</td></tr>
<tr><td>Preparation</td><td colspan="2">None</td></tr>
</table>

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Lesson 11

Materials	**Kit Items** ☐ Lanterns with batteries (6)	**School Supplied Items** ☐ Scissors (1) ☐ Toothpicks (12)
	Prepared Items from Previous Lessons ☐ Mini Earth models from Lesson 9 (6)	
	Item Reuse ☐ Lesson 11 requires the prepared space-view sundial models. ☐ Lesson 14 requires the lanterns with batteries.	
Resources	☐ Lesson 11 Resource: Time Zone Map	
Preparation	☐ Prepare 2 mini sundials for each group by cutting out paper circles approximately 1 cm in diameter.	

Lesson 12

Materials	**Kit Items** None	**School Supplied Items** None
	Prepared Items from Previous Lessons ☐ Space-view sundial models from Lesson 11 (6)	
	Item Reuse ☐ Lesson 12 requires the prepared space-view sundial models.	
Resources	None	
Preparation	None	

Lesson 13

Materials	**Kit Items** None	**School Supplied Items** None
	Prepared Items from Previous Lessons ☐ Space-view sundial models from Lesson 11 (6)	
	Item Reuse ☐ Lesson 13 requires the lanterns and prepared mini Earth models.	
Resources	☐ Lesson 13 Resource: Conceptual Checkpoint, Part I	
Preparation	None	

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Lesson 14

Materials	**Kit Items** ☐ Lanterns with batteries (6)	**School Supplied Items** ☐ Spoons, clear plastic (24)
	Item Reuse ☐ Lesson 15 requires the lanterns.	
Resources	☐ Lesson 3 Resource A: Sun Photographs ☐ Lesson 14 Resource A: Sunrise Data ☐ Lesson 14 Resource B: Sunrise Photograph ☐ Lesson 14 Resource C: Laser Light Photographs ☐ Class Light Model from Lesson 5	
Preparation	☐ Cue sunrise video: http://phdsci.link/1902. ☐ Prepare a set of laser light photographs (Lesson 14 Resource C) for each group.	

Lesson 15

Materials	**Kit Items** ☐ Lanterns with batteries (6) ☐ Polystyrene foam balls, small, 2” (6) ☐ Polystyrene foam discs, 4” × 4” × 1” (6) ☐ Sticks, wooden, 7” (6)	**School Supplied Items** ☐ Scissors (1) ☐ Toothpicks (6)
	Prepared Items from Previous Lessons ☐ Mini Earth models from Lesson 9 (8)	
	Item Reuse ☐ Lesson 16 requires the lanterns, prepared mini Earth models, and prepared mini Moon models.	
Resources	☐ Lesson 8 Resource B: Earth-View Student Model Resources—Group Roles, Figure 2: Earth Student ☐ Lesson 15 Resource A: Moon Cards ☐ Lesson 15 Resource B: Space-View Model Setup Instructions—Figure 1: Lesson 15 Arrangement ☐ Lesson 15 Resource C: 24-Hour Clock Diagram ☐ Lesson 15 Resource D: Greek Myth of Selene (D’Aulaire 1962)	
Preparation	☐ Prepare a set of the Moon cards (Lesson 15 Resource A) for each group. ☐ Cue time-lapse video of the Sun and the Moon: http://phdsci.link/1372. ☐ Use chart paper to prepare a large version of the 24-hour clock diagram for each group. ☐ Assemble mini Moon model. (See Lesson 15 Resource B.)	

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Lesson 16

<table>
<tr><td rowspan="3">Materials</td><td>Kit Items
☐ Lanterns with batteries (6)</td><td>School Supplied Items
☐ Scissors (1)</td></tr>
<tr><td colspan="2">Prepared Items from Previous Lessons
☐ Mini Earth models from Lesson 9 (6)
☐ Mini Moon model from Lesson 15 (1)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 17 requires the lanterns and prepared mini Moon models.
☐ Lesson 19 requires the mini Earth models.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 15 Resource B: Space-View Model Setup Instructions—Figure 2: Lesson 16 Arrangement
☐ Lesson 16 Resource A: Moon During the Daytime Photograph
☐ Lesson 16 Resource B: Moonrise and Moonset Times</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ (Optional) Check local moonrise and moonset times to see whether the Moon will be visible from the school's location during class time.
☐ Print and cut out one moonrise and moonset times table and a blank 24-hour timeline for each group. (See Lesson 16 Resource B.)</td></tr>
</table>

Lesson 17

<table>
<tr><td rowspan="3">Materials</td><td>Kit Items
☐ Lanterns with batteries (6)
☐ Protractors (6, optional)</td><td>School Supplied Items
☐ Scissors (1)</td></tr>
<tr><td colspan="2">Prepared Items from Previous Lessons
☐ Mini Moon models from Lesson 15 (6)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 16 requires the lanterns and prepared mini Moon models.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 15 Resource C: 24-Hour Clock Diagram
☐ Lesson 17 Resource: Moonrise and Moonset Data Tables</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Print and cut out a set of moonrise and moonset data tables (Lesson 17 Resource) for each group.
☐ Print a copy of the 24-hour clock diagram (Lesson 15 Resource C) for each group.</td></tr>
</table>

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Lesson 18

<table>
<tr><td>Materials</td><td>Kit Items
☐ Clay, modeling, nonhardening (1 lb)
☐ Flashlights with batteries (6)
☐ Photo boxes, black, approx 4” x 8” x 12.25” (6)
☐ Mirror, small (1)</td><td>School Supplied Items
☐ Construction paper, black, 9” x 12” (18 sheets)
☐ Knife, precision (1)
☐ Pencils, hexagonal or triangular (6)
☐ Pushpin (1)
☐ Ruler (1)
☐ Tape, clear (partial roll)</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 18 Resource A: Moon Photograph
☐ Lesson 18 Resource B: Light Ray Box Setup Instructions
☐ Lesson 18 Resource C: Reflection Demonstration Photographs</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Prepare the light ray boxes for each group. (See Lesson 18 Resource B.)
☐ Cue reflected light video (Surrey NanoSystems 2016): http://phdsci.link/1098.</td></tr>
</table>

Lesson 19

<table>
<tr><td rowspan="3">Materials</td><td>Kit Items
☐ Lanterns with batteries (6)</td><td>School Supplied Items
None</td></tr>
<tr><td colspan="2">Prepared Items from Previous Lessons
☐ Mini Earth models from Lesson 9 (6)
☐ Mini Moon models from Lesson 15 (6)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 20 requires the lanterns, prepared mini Earth models, and prepared mini Moon models.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 18 Resource A: Moon Photograph
☐ Lesson 19 Resource A: Apollo 11 Moon Landing Photograph
☐ Lesson 19 Resource B: Space-View Model Setup
☐ Look to the Stars (Aldrin 2009)</td></tr>
<tr><td>Preparation</td><td colspan="2">None</td></tr>
</table>

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Lesson 20

<table>
<tr><td rowspan="3">Materials</td><td>Kit Items
☐ Lanterns with batteries (6)</td><td>School Supplied Items
☐ Markers, permanent, black (6)</td></tr>
<tr><td colspan="2">Prepared Items from Previous Lessons
☐ Mini Earth models from Lesson 9 (6)
☐ Mini Moon models from Lesson 15 (6)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 22 requires the lanterns.
☐ Lesson 24 requires the mini Earth models.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 20 Resource A: Crescent Moon Photograph
☐ Lesson 20 Resource B: Moon Shading Instructions
☐ Lesson 20 Resource C: Conceptual Checkpoint</td></tr>
<tr><td>Preparation</td><td colspan="2">None</td></tr>
</table>

Lesson 21

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Balls, rubber (2)
☐ Bead, 2 mm (1)
☐ Hand pump with needle (1)

Module 2 Kit
☐ Ball, table tennis (1)
☐ Ball, tennis (1)</td><td>School Supplied Items
☐ Basketball, adult size (1)
☐ Meter stick (1)
☐ Spherical objects (e.g., beach ball, basketball, tennis ball, table tennis ball, marble), different sizes with 2 large and of the same size (at least 4)</td></tr>
<tr><td colspan="2">Resources
☐ Lesson 3 Resource A: Sun Photographs
☐ Lesson 19 Resource A: Apollo 11 Moon Landing Photograph
☐ Lesson 21 Resource A: Stars in the Night Sky Photograph
☐ Lesson 21 Resource B: “All About Stars” (Scholastic, n.d.)</td></tr>
<tr><td rowspan="2">Preparation</td><td colspan="2">☐ Print a copy of “All About Stars” (Lesson 21 Resource B) for each student.</td></tr>
<tr><td colspan="2">Advance Preparation for Lesson 22
☐ 1 Day Before: Assemble light intensity comparers. (See Lesson 22 Resource B.)</td></tr>
</table>

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Lesson 22

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Lanterns with batteries (6)
☐ Paraffin blocks, 4.5” × 2.25” × 0.75” (6)
☐ Tape, electrical (1 roll)
☐ Tealights, LED, nonflickering (12)</td><td>School Supplied Items
☐ Aluminum foil, 4.5” × 1.13” (6)
☐ Knife, serrated (1)
☐ Meter sticks (6)
☐ Ruler, metric (1)
☐ Scissors (1)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 23 requires the lanterns.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 22 Resource A: Star Field Image
☐ Lesson 22 Resource B: Light Intensity Comparer Setup Instructions and Procedure
☐ Look Up! Henrietta Leavitt, Pioneering Woman Astronomer (Burleigh and Colón 2013)</td></tr>
<tr><td>Preparation</td><td colspan="2">None</td></tr>
</table>

Lesson 23

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Lanterns with batteries (6)
☐ Star stickers (100)</td><td>School Supplied Items
None</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 24 requires the lanterns and star stickers placed on walls.</td></tr>
<tr><td>Resources</td><td colspan="2">None</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Set aside half of the vinyl star stickers for use in Lesson 24.
☐ Cue time-lapse video of Sirius and Orion: http://phdsci.link/1379.
☐ Cue time-lapse video of Sirius and moonset: http://phdsci.link/1380.
☐ Cue time-lapse video of the night sky in the desert: http://phdsci.link/1381.</td></tr>
</table>

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Lesson 24

<table>
<tr><td rowspan="3">Materials</td><td>Kit Items
☐ Lanterns with batteries (6)
☐ Star stickers (50)</td><td>School Supplied Items
None</td></tr>
<tr><td colspan="2">Prepared Items from Previous Lessons
☐ Mini Earth models from Lesson 9 (6)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 26 requires the lanterns, prepared mini Earth models, and star stickers placed on walls.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 24 Resource: Ursa Minor with Outline of Little Dipper</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Cue time-lapse video of the night sky in the desert: http://phdsci.link/1381.</td></tr>
</table>

Lesson 25

<table>
<tr><td>Materials</td><td>Kit Items
None</td><td>School Supplied Items
None</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 25 Resource A: Star Map Instructions and Samples
☐ Lesson 25 Resource B: Star Maps
☐ Lesson 25 Resource C: Sample Class Data Table</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Generate local star maps for two different dates or use provided samples (See Lesson 25 Resource A).
☐ Print a copy of Lesson 25 Resource B and provide each group with two star maps: one for a month in 2017 and another for the same month in 2018.</td></tr>
</table>

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Lesson 26

Materials	**Kit Items** ☐ Lanterns with batteries (6)	**School Supplied Items** None
	Prepared Items from Previous Lessons ☐ Mini Earth models from Lesson 9 (6)	
Resources	☐ Lesson 25 Resource C: Sample Class Data Table ☐ Lesson 26 Resource A: Constellation Images ☐ Lesson 26 Resource B: Classroom Constellation Map ☐ Lesson 26 Resource C: Mars Sunset Photograph ☐ Class diagram from Lesson 8 (Lesson 8 Resource C)	
Preparation	☐ Print a copy of Lesson 26 Resource A. ☐ Prepare signs for each month of the year, and post them around the classroom (Lesson 26 Resource B). ☐ Cue time-lapse video of a solar eclipse: http://phdsci.link/1382.	

Lesson 27

Materials	**Kit Items** None	**School Supplied Items** ☐ Glue sticks (24) ☐ Scissors (24)
Resources	None	
Preparation	None	

Lesson 28

Materials	**Kit Items** None	**School Supplied Items** None
Resources	☐ *Look to the Stars* (Aldrin 2009)	
Preparation	None	

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Lesson 29

Materials	**Kit Items** None	**School Supplied Items** ☐ Scissors (1)
Resources	☐ Lesson 29 Resource: Content Standards	
Preparation	☐ 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 learning and content standards. (See Lesson 29 Resource.)	

Capstone Project on Forces and Energy Preparation

Lesson 1

Materials	**Kit Items** None	**School Supplied Items** ☐ Aluminum foil, 8 cm x 30 cm (1) ☐ Glue stick (1) ☐ Markers, 3 colors (1 set) ☐ Pencils, 3 colors (24 sets)
Resources	☐ Lesson 1 Resource: Light Rail Train Diagram	
Preparation	☐ Prepare class model. Print and cut out the diagram from Lesson 1 Resource. Glue or tape the diagram near the top of a sheet of chart paper. Leave space at the top of the chart paper for a title and space below the diagram for additional models. Have markers in three colors available to update the model during the lesson. ☐ Cue the DART Rail introduction and DART Rail train leaving station videos: http://phdsci.link/1989 and http://phdsci.link/1985.	

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Lesson 2

<table>
<tr><td>Materials</td><td>Kit Items
☐ Hall’s cars (6)
☐ Spring scales, push, 5 N (6)
☐ Stopwatches (6)

Module 1 Kit
☐ Safety goggles, student (24)
☐ Safety goggles, teacher (1)</td><td>School Supplied Items
☐ Markers, permanent (6)
☐ Meter sticks (6)
☐ Paper, scratch (6 sheets)
☐ Tape, masking (6 rolls)</td></tr>
<tr><td></td><td colspan="2">Item Reuse
☐ Lesson 3 requires the force investigation materials.
☐ Lesson 4 requires the cars, spring scales, and stopwatches.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 2 Resource A: Spring Scale Calibration Instructions
☐ Lesson 2 Resource B: Investigation Materials Setup Instructions
☐ Lesson 2 Resource C: Sample Force Investigation Testing Procedure (optional)</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Calibrate push spring scales. (See Lesson 2 Resource A.)
☐ Set up materials for the force investigation (optional). (See Lesson 2 Resource B.)
☐ Cue video of a DART Rail train leaving the station: http://phdsci.link/1985.</td></tr>
</table>

Lesson 3

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
None

Module 1 Kit
☐ Safety goggles, student (24)
☐ Safety goggles, teacher (1)</td><td>School Supplied Items
☐ Paper, scratch (24 sheets)</td></tr>
<tr><td colspan="2">Prepared Items from Previous Lessons
☐ Force investigation materials from Lesson 2 (6 sets)</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 2 Resource C: Sample Force Investigation Testing Procedure (optional)</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Calibrate push spring scales. (See Lesson 2 Resource A.)
☐ Set up materials for the force investigation (optional). (See Lesson 2 Resource B.)
☐ Cue video of passengers boarding a DART Rail train: http://phdsci.link/1986.</td></tr>
</table>

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Lesson 4

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Erasers, wedge, medium (18)
☐ Hall's cars (6)
☐ Spring scales, push, 5 N (6)
☐ Stopwatches (6)

Module 1 Kit
☐ Erasers, wedge, medium (12)
☐ Safety goggles, student (24)
☐ Safety goggles, teacher (1)</td><td>School Supplied Items
☐ Markers, permanent (6)
☐ Paper, scratch (6 sheets)
☐ Tape, masking (6 rolls)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 5 requires the cars and spring scales.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 4 Resource A: DART Rail Train Interior Photographs
☐ Lesson 4 Resource B: Crowded Train Photograph
☐ Lesson 4 Resource C: Mass Investigation Procedure
☐ Lesson 4 Resource D: Traction Motor Diagram</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Calibrate push spring scales. (See Lesson 2 Resource A.)
☐ Set up materials for the force investigation (optional). (See Lesson 2 Resource B.)
☐ Prepare to distribute the setup and testing procedure sheets and (optional) photographs from Lesson 4 Resource C to each group.
☐ Set up materials for mass investigation (optional). (See Lesson 4 Resource B.)</td></tr>
</table>

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Lesson 5

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Felt, 9” x 12” (12 sheets)
☐ Hall’s cars (6)
☐ Hook and loop fastener, 6” strips (12)
☐ Sandpaper (12 sheets)
☐ Spring scales, push, 5 N (6)

Module 1 Kit
☐ Safety goggles, student (24)
☐ Safety goggles, teacher (1)</td><td>School Supplied Items
☐ Tape, masking (6 rolls)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 13 requires one of the Hall’s cars and two of the spring scales.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 5 Resource A: Magnetic Friction Brake Photograph
☐ Lesson 5 Resource B: Sand Brake Photograph</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Calibrate push spring scales. (See Lesson 2 Resource A.)
☐ Prepare 6” pieces of hook and loop fasteners for each group. Cut enough strips so that each group receives two 6” strips of the hook side and two 6” strips of the loop side.
☐ Cue DART Rail train arriving at station video: http://phdsci.link/1991.</td></tr>
</table>

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Lesson 6

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Batteries, D (7)
☐ Battery holders, D (6)
☐ DC motors (6)
☐ Flashlight bulb, incandescent (1)
☐ Tape, copper foil, 1 cm wide (900 cm)
☐ Tape, electrical (partial roll)</td><td>School Supplied Items
☐ Highlighters (24)
☐ Ruler, metric (1)
☐ Scissors (6)
☐ Tape, masking (6 rolls)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 7 requires the batteries, battery holders, and copper foil tape.
☐ Lesson 8 requires the DC motors and incandescent bulb.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 6 Resource A: Circuit Troubleshooting Guide (optional)
☐ Lesson 6 Resource B: Closed Circuit Demonstration Setup Instructions
☐ Lesson 6 Resource C: Light Rail Circuit Diagram
☐ Lesson 6 Resource D: Light Rail Circuit Model Setup Instructions</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Cue DART Rail train at night video: http://phdsci.link/2066.
☐ Prepare the circuit for the closed circuit demonstration. (See Lesson 6 Resource B.)
☐ Prepare materials for the light rail circuit model investigation. (See Lesson 6 Resource D.)
☐ Cue pantograph motion and DART Rail train pantograph videos: http://phdsci.link/2064 and http://phdsci.link/2065.</td></tr>
</table>

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Lesson 7

<table>
<tr><td>Materials</td><td>Kit Items
☐ Batteries, D (6)
☐ Battery holders, D (6)
☐ Erasers, wedge, medium (7)
☐ Tape, copper foil, 1 cm wide (180 cm)

Module 2 Kit
☐ Bingo chips (6)</td><td>School Supplied Items
☐ Beads, glass, flat (6)
☐ Cotton balls (6)
☐ Highlighters (24)
☐ Nails, steel (6)
☐ Pencil lead (6)
☐ Pennies (6)
☐ Ruler, metric (1)
☐ Scissors (6)
☐ Tape, masking (6 rolls)</td></tr>
<tr><td></td><td colspan="2">Item Reuse
☐ Lesson 8 requires the batteries and battery holders.
☐ Lesson 13 requires the copper foil tape.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 6 Resource A: Circuit Troubleshooting Guide (optional)
☐ Lesson 7 Resource A: Pantograph Photograph
☐ Lesson 7 Resource B: Pantograph Materials Investigation Photographs (optional)
☐ Lesson 7 Resource C: Pantograph Diagram</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Measure and cut copper foil tape into 10 cm long strips. Prepare three strips for each group.
☐ Cue DART Rail train at the end of the line video: http://phdsci.link/2067.</td></tr>
</table>

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Lesson 8

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Alligator clip cords (24)
☐ Batteries, D (12)
☐ Battery holders, D (12)
☐ Buzzers (4)
☐ DC motors (4)
☐ Flashlight bulbs, incandescent (4)
☐ Lightbulb holders (4)

Module 1 Kit
☐ Safety goggles, student (24)
☐ Safety goggles, teacher (1)</td><td>School Supplied Items
None</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 9 requires the alligator clip cords, batteries, battery holders, buzzers, DC motors, bulbs and light bulb holders.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 6 Resource A: Circuit Troubleshooting Guide (optional)
☐ Lesson 8 Resource: Device Stations Setup Instructions</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Cue the DART Rail interior video: http://phdsci.link/2097.
☐ Prepare the device stations. (See Lesson 8 Resource.)</td></tr>
</table>

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Lesson 9

<table>
<tr><td>Materials</td><td>Kit Items
☐ Alligator clip cords (36)
☐ Batteries, D (12)
☐ Battery holders, D (12)
☐ Buzzers (6)
☐ DC motors (6)
☐ Flashlight bulbs, incandescent (6)
☐ Lightbulb holders (6)

Module 1 Kit
☐ Safety goggles, student (24)
☐ Safety goggles, teacher (1)</td><td>School Supplied Items
☐ Glue stick (1)
☐ Markers, 3 colors (1 set)</td></tr>
<tr><td></td><td colspan="2">Item Reuse
☐ Lesson 10 requires the alligator clip cords, one of the batteries, one battery holder, and one of the bulbs.
☐ Lesson 13 requires the buzzers, alligator clip cords, batteries, and battery holders.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 6 Resource A: Circuit Troubleshooting Guide (optional)
☐ Lesson 9 Resource A: Circuit Diagram Key
☐ Lesson 9 Resource B: Circuit Diagram Card</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Prepare materials for circuits with multiple devices activity. Place the batteries into the battery holders. Place the incandescent flashlight bulbs into the light bulb holders.
☐ Prepare to distribute one circuit diagram card to each group. (See Lesson 9 Resource B.)
☐ Prepare class model. Print and cut out the diagram from Lesson 6 Resource C. Glue or tape the diagram under the class model from Lesson 1. Leave space above the new model for a title and space below the diagram for an additional model. Have markers in three colors available to update the model during the lesson.</td></tr>
</table>

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Lesson 10

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Alligator clip cords (2)
☐ Battery, D (1)
☐ Battery holder, D (1)
☐ Flashlight bulb, incandescent (1)
☐ Flashlights with batteries (6)</td><td>School Supplied Items
☐ Computers or tablets with internet access (8)
☐ Glue stick (1)
☐ Markers, 4 colors (1 set)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 11 requires the incandescent bulb and the flashlights.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 10 Resource: Video Station Photographs</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Cue the DART Rail at night video: http://phdsci.link/2066.
☐ Prepare two of each video station. Prepare two sets of the photographs from Lesson 10 Resource, and place each photograph at a station. Cue the side panel lights video, Greenband indicator lights video, headlights video, and stair lights video at the appropriate stations: http://phdsci.link/2101, http://phdsci.link/2102, http://phdsci.link/2103, http://phdsci.link/2104.
☐ Prepare the circuit for the headlight demonstration. Build a circuit containing an incandescent flashlight bulb in holder, a D battery in holder, and two alligator clip cords. Keep the circuit open until immediately before the demonstration to prevent draining the battery.
☐ Prepare class model. Print and cut out the diagram from Lesson 1 Resource. Glue or tape the diagram under the class model from Lesson 9. Leave space above the new model for a title. Have markers in four colors available to update the model during the lesson.</td></tr>
</table>

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Lesson 11

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Flashlight bulbs, incandescent (6)
☐ Flashlights with batteries (6)
☐ Mirrors (12)
☐ Protractors (6)</td><td>School Supplied Items
☐ Binder clips, large (24)
☐ Glue stick (1)
☐ Index cards, 3” x 5” (12)
☐ Objects 4” to 6” tall (12)
☐ Pencil (1)
☐ Pencils, 3 colors (6 sets)
☐ Rulers (12)
☐ Scissors (1)
☐ Tape, masking (partial roll)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 13 requires two of the incandescent bulbs.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 11 Resource A: DART Rail Train Headlights Photograph
☐ Lesson 11 Resource B: DART Rail Train Diagrams
☐ Lesson 11 Resource C: Side Mirror Exploration Setup Instructions and Procedure
☐ Lesson 11 Resource D: Reflection Investigation Setup Instructions
☐ Lesson 11 Resource E: Reflection Investigation Procedure Sheet and Photographs</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Gather materials for the side mirror exploration. (See Lesson 11 Resource C.)
☐ Prepare modified flashlights for the reflection investigation. (See Lesson 11 Resource D.)
☐ Prepare to distribute a copy of the procedure sheet from Lesson 11 Resource E to each group.</td></tr>
</table>

Lesson 12

<table>
<tr><td>Materials</td><td>Kit Items
None</td><td>School Supplied Items
☐ Computers or tablets with internet access (6)</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 12 Resource A: Broken Traffic Light Photograph
☐ Lesson 12 Resource B: Communication Light Station Photographs
☐ Lesson 12 Resource C: Communication Light Charts</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Cue traffic light video: http://phdsci.link/2100.
☐ Prepare two of each communication light station. Prepare two sets of the photographs from Lesson 12 Resource B, and place each photograph at a station. Cue the side panel lights video, Greenband indicator lights video, and crosswalk lights video at the appropriate stations: http://phdsci.link/2101, http://phdsci.link/2102, http://phdsci.link/2105.
☐ Prepare to distribute a copy of Lesson 12 Resource C to each group.</td></tr>
</table>

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Lesson 13

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
☐ Alligator clip cords (4)
☐ Batteries, D (4)
☐ Battery holders, D (4)
☐ Buzzers (2)
☐ Clay, modeling, nonhardening (1/4 lb)
☐ Flashlight bulbs, incandescent (2)
☐ Hall's car (1)
☐ Light bulb holders (2)
☐ Pencils, graphite, artist, 6B (2)
☐ Spring scales, push, 5 N (2)
☐ Tape, copper foil, 1 cm wide (12")
☐ Tape, electrical (partial roll)
☐ Toy cars (2)</td><td>School Supplied Items
☐ Aluminum foil, 2" x 2" (4)
☐ Blindfolds (2, optional)
☐ Brads (4)
☐ Cardboard, 6" x7" (2)
☐ Cellophane, colored (2 sheets, optional)
☐ Chenille stems (2)
☐ Computers or tablets with internet access (2)
☐ Craft sticks, wax (4)
☐ Craft sticks, wooden (4)
☐ Craft sheet, foam, 2" x 2" (4)
☐ Glue stick (1)
☐ Hole punch, single hole (1)
☐ LEDs, colored (2, optional)
☐ Manila folders (2)
☐ Markers, 3 colors (1 each color)
☐ Marker, permanent (1)
☐ Paper clips (4)
☐ Pens, ballpoint (2)
☐ Poster board, 11" x 14" (2 sheets)
☐ Rubber bands (2)
☐ Ruler (1)
☐ Scissors (1)
☐ String (partial spool)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 14 requires the engineering challenge materials.
☐ Lessons 14 and 17 require the prepared models for Darryl, Eliza, and Patrick.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 13 Resource A: Engineering Challenge Rubrics
☐ Lesson 13 Resource B: Engineering Design Process Visual
☐ Lesson 13 Resource C: Light Rail Model Setup Instructions
☐ Lesson 13 Resource D: Rider Stations Setup Instructions
☐ Lesson 13 Resource E: Audio Files Transcript Card
☐ Lesson 13 Resource F: Rider Cards
☐ Lesson 13 Resource G: Accessible Design Cards
☐ Class model from Lesson 12</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Cue the riding DART Rail video: http://phdsci.link/2120.
☐ Cue train accessibility video: http://phdsci.link/2119.
☐ Prepare light rail models. (See Lesson 13 Resource C.)</td></tr>
</table>

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	☐ Prepare rider stations. (See Lesson 13 Resource D.) ☐ Prepare to distribute the selected rider card to each student. (See Lesson 13 Resource F.) If more than two groups choose the same rider, prepare additional copies of the relevant cards as needed.

Lesson 14

<table>
<tr><td rowspan="3">Materials</td><td>Kit Items
☐ Alligator clip cords (36)
☐ Batteries, D (8)
☐ Battery holders, D (8)
☐ Buzzers (2)
☐ Clay, modeling, nonhardening (1 lb)
☐ Flashlight bulbs, incandescent (6)
☐ Hall’s cars (2)
☐ Light bulb holders (6)
☐ Pencils, graphite, artist, 6B (2)
☐ Spring scales, push, 5 N (2)
☐ Stopwatches (4)
☐ Tape, copper foil, 1 cm wide (2 rolls)
☐ Tape, electrical (partial roll)
☐ Toy cars (2)

Module 1 Kit
☐ Safety goggles, student (24)
☐ Safety goggles, teacher (1)</td><td>School Supplied Items
☐ Aluminum foil, 2” x 2” (1 roll)
☐ Blindfolds (2, optional)
☐ Brads (100)
☐ Cellophane, colored (6 sheets, optional)
☐ Chenille stems (30)
☐ Computers or tablets with internet access (2)
☐ Craft sticks, wax (30)
☐ Craft sticks, wooden (30)
☐ Craft sheet, foam, 9” x 12” (5)
☐ LEDs, colored (20, optional)
☐ Paper clips (25)
☐ Pens, ballpoint (2)
☐ Rubber bands (25)
☐ String (partial spool)</td></tr>
<tr><td colspan="2">Prepared Items from Previous Lessons
☐ Models for Darryl, Eliza, and Patrick from Lesson 13 (2 of each)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 15 requires the Materials Area and Models and Research Area materials.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 13 Resource A: Engineering Challenge Rubrics
☐ Lesson 13 Resource B: Engineering Design Process Visual
☐ Lesson 14 Resource A: Engineering Challenge Areas Setup Instructions
☐ Lesson 14 Resource B: Area Cards
☐ Lesson 14 Resource C: Sample Engineering Challenge Solutions</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Prepare the Writing, Models and Research, Materials, and Meeting Areas. (See Lesson 14 Resource A.)
☐ Prepare for project proposal meetings. Prepare and review copies of the Project Proposal Rubric in Lesson 13 Resource A and the sample Engineering Challenge solutions (Lesson 14 Resource C).</td></tr>
</table>

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Lesson 15

<table>
<tr><td rowspan="3">Materials</td><td>Kit Items
☐ Hook and loop fastener, 6” strips (12, optional)

Module 1 Kit
☐ Safety goggles, student (24)
☐ Safety goggles, teacher (1)</td><td>School Supplied Items
☐ Glue, liquid, white (2 bottles)
☐ Glue sticks (6)
☐ Scissors (6)
☐ Tape, clear (6 rolls)
☐ Tape, double-sided (6 rolls, optional)</td></tr>
<tr><td colspan="2">Prepared Items from Previous Lessons
☐ Materials Area materials from Lesson 14
☐ Models and Research Area materials from Lesson 14</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 16 requires the Materials Area materials, the Models and Research Area materials, and the Engineering Challenge building tools.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 13 Resource A: Engineering Challenge Rubrics
☐ Lesson 13 Resource B: Engineering Design Process Visual</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Prepare the Writing, Models and Research, Materials, and Meeting Areas. (See Lesson 14 Resource A.)
☐ Prepare for project proposal meetings. Prepare and review copies of the Project Proposal Rubric in Lesson 13 Resource A and the sample Engineering Challenge solutions (Lesson 14 Resource C).
☐ Prepare additional light rail models as needed. (See Lesson 13 Resource C.)</td></tr>
</table>

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Lesson 16

<table>
<tr><td rowspan="3">Materials</td><td>Kit Items
None

Module 1 Kit
☐ Safety goggles, student (24)
☐ Safety goggles, teacher (1)</td><td>School Supplied Items
None</td></tr>
<tr><td colspan="2">Prepared Items from Previous Lessons
☐ Materials Area materials from Lesson 14
☐ Models and Research Area materials from Lesson 14
☐ Engineering Challenge building tools from Lesson 15 (6 sets)</td></tr>
<tr><td colspan="2">Item Reuse
☐ Lesson 17 requires the prepared student Engineering Challenge models.</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 13 Resource B: Engineering Design Process Visual</td></tr>
<tr><td>Preparation</td><td colspan="2">☐ Prepare the Writing, Models and Research, Materials, and Meeting Areas. (See Lesson 14 Resource A.)
☐ Prepare additional light rail models as needed. (See Lesson 13 Resource C.)</td></tr>
</table>

Lesson 17

<table>
<tr><td rowspan="2">Materials</td><td>Kit Items
None</td><td>School Supplied Items
None</td></tr>
<tr><td colspan="2">Prepared Items from Previous Lessons
☐ Models for Darryl, Eliza, and Patrick from Lesson 13 (2 of each)
☐ Engineering Challenge models (6)</td></tr>
<tr><td>Resources</td><td colspan="2">☐ Lesson 13 Resource A: Engineering Challenge Rubrics</td></tr>
<tr><td>Preparation</td><td colspan="2">None</td></tr>
</table>

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