Learning Plan
Days 4 and 5: Detecting the Invisible

Targeted Idea: We can sense light beyond what our eyes can see using various detectors and devices. Some of this light may be blocked by filters and other substances.

Overview of Days 4-5:

Just as our ears cannot hear all wavelengths of sound, our eyes cannot see all wavelengths of light. We can use devices to detect this invisible light.

Part I: Students explore a discrepant event using a remote control and smart phone cameras. They are asked to discuss their group observations and generate a tentative explanation for why the smart phones could detect light that their eyes cannot. Following this, students use a photocell detector circuit to collect evidence that there is additional "light" transmitted beyond the visible region of the spectrum. The focus here is the collection of data, and that they will use as evidence to construct an explanation that "invisible light" exists and that we can detect this light with instruments other than our eyes.

Part II: Students watch the teacher demonstrate how the same detector recognizes "unseen light" beyond the red ends of the spectrum. The students draft a Claim/Evidence/Reasoning (CER) paragraph to support the statement that that light exists beyond the visible spectrum, and that we can detect this light with instruments.

Students will build upon these prior Middle School Performance Expectations (PEs) and Disciplinary Core Ideas (DCIs) in Days 4 and 5:

PE MS-PS4-2 Waves and their Applications in Technologies for Information Transfer
Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.]

DCI MS-PS4.A Wave Properties
A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

DCI MS-PS4.B Electromagnetic Radiation
When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

Students will build their understanding toward the following High School DCIs during Days 4 and 5:

PS4.B.1 Electromagnetic Radiation
Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave ~~of changing electric and magnetic fields or as particles called photons~~. The wave model is useful for explaining many features of electromagnetic radiation ~~while the particle model explains other features~~.

NASA SMD SciAct AAA

PS4.A Wave Properties
Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and ~~sent over long distances as a serie~~s of ~~wave pulses.~~

PS4.C Information Technologies and Instrumentation
Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

Students are building their skills in / understanding of these Science and Engineering Practices (SEPs) in Days 4 and 5:

Engaging in Argument from Evidence

- Evaluate claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
- Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Obtaining, Evaluating, and Communicating Information

- Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

<table>
<tr><th>Instructional Materials</th><th>Resources</th></tr>
<tr><td>

Handouts:
• Claim Evidence Reasoning (CER) handout
• Science Case Study: M2-9 Planetary Nebula

Materials:
• Various digital cameras (e.g. smart phone cameras, regular digital cameras, webcams)
• Various remote controls (1 per group)
• Button battery with black electrical tape on one side (1 per student)
• 5 mm LEDs (one of each color: white, green, red, blue) (1 set per group)
• Set of three filters (red, green, blue) (1 set per group)
• Squares of black plastic (garbage bag)

Photocell detector circuit (multiply this by the number of groups)*:
• Solar cell
• Amplifier/Speaker
• Audio cable with 1/8” mini-plug on one end
• Mini-pin by pin adapter
• 2 Jumper cables with alligator clips on both ends
• 9-Volt battery for Amplifier/ Speaker
• Optional: Fan and/or Comb

For classroom demonstration:
• Overhead projector
• Masking tape
• 2 pieces of 8” x 10” black construction paper
• Holographic diffraction grating
• IR Camera

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** Ideally, students will work with materials in small groups. This requires the purchase of enough materials for each group to have their own photocell detector. The emphasis here is on students having time to discuss observations and data, rather than the assembly of the detectors (see instructions), so it is ideal if the teacher can preassemble these materials in advance.*

If using student phones, students may need to be asked in advance to bring their cell phones, depending upon school policy.

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Day 4	
Teacher Role Part 1:	**Student Role Part 1:**
• Prompt students to look for evidence that forms of light exist beyond what the human eye can detect.	• Collect evidence to support their explanation of how we know there is light beyond the visible spectrum. • Decide what constitutes the evidence for their explanation.

Steps to follow:

1) Remind students that yesterday, they explored the idea that there are cameras or sensors that are sensitive to light that our eyes cannot see. Also, some substances are opaque to certain wavelengths but transparent to others. You have an unusual thing for them to observe. Today, they will explore instruments that detect light that eyes cannot see, and what are some substances filter or block or reflect this light?

2) Explore: Ask students to break into groups of 3-4 and explore how a cell phone camera (or other digital camera) can detect a remote control light. See photos below as a sample of what students might see.
    - Provide one or more remotes, plus one webcam or digital camera per table (if available) for student to test.
    - Students should list any "Other tests we would like to try" with either the remote control or the other digital cameras.
    - Students should discuss the phenomenon and if they have any tentative explanations. Share out.

Potential teacher prompts:

- Did you try all camera options on your phone?
- How many different types of cell phones or digital cameras did your group try?

Remote control - iPhone selfie camera

Remote control - iPhone camera

NOTE: Collect the remote controls for the next portion of this activity.

TEACHER TIP: For best results, turn off any overhead lighting in the classroom for the next steps after the detector circuits are assembled. Some lighting (e.g.- fluorescent lights) generates a constant hum or may have other operational aspects which can interfere with students' hearing sound from the remote control LEDs.

3) *Explore continued:* Next, students will be using a photocell (which collects light and is usually used to power appliances in homes, etc.) as a means of sensing the presence or absence of light. The photocells will be connected to a speaker to allow them to 'hear the presence of light'.
    - Explain that when the cell detects light, a current is created that generates sound in the speaker.
    - To produce sound in the speaker, the current needs to change in some way.
    - Demonstrate how to "chop" (interrupt) the light source (or use a comb or a fan or wave the LED back and forth quickly) to generate a clicking sound.

4) Distribute the photocell detector circuits, LEDs, and filters to the groups. Give students approximately 5 minutes to experiment with chopping, holding the cell up to various light sources or possibly varying the distance between photocell detector circuit and light source. While the teacher may provide suggestions for possible things to try, there is no specific set of investigations for them to follow here.
    - Ask the groups to demonstrate one interesting thing they observed with the photocell detector circuits, what they heard, and what they think might be happening.
    - Ask groups for evidence that the solar cell is detecting light (and not something else).

5) Ask students to predict: Would the solar cell be able to detect the remote control in the same way that the digital cameras did? Why?
    - Distribute a variety of remote controls. Allow students to try remotes with photocell detector circuits.
    - Ask the groups to test out the light blocking capabilities of sheets of white paper, cardboard, the filters, and plastic.
    - Share out.

6) Distribute the M2-9 Planetary Nebula Case Study.

7) *Assign Homework*: Read the Science Case Study and complete the Case Study graphic organizer questions.

<table>
<tr><th colspan="2">DAY 5</th></tr>
<tr><th>Teacher Role Part 2:</th><th>Student Roles Part 2:</th></tr>
<tr><td>Prompt students to look for evidence that forms of light exist beyond what the human eye can detect.</td><td>Collect evidence to support their explanation of how we know there is light beyond the visible spectrum.
Decide what constitutes the evidence for their explanation.</td></tr>
<tr><td colspan="2">Steps to follow:

1) Discuss the homework reading and answers to graphic organizer questions.

2) Introduce the overhead projector spectrum. (Note: the room must be dark for this demonstration to be effective. The alternate demonstration is the Herschel experiment. Thermometers are then the detector that identify a light that we can’t see with our eyes. The light heats the thermometers.) Explain that the white light of the overhead projector is passing through the diffraction grating and being bent and distributed into the visible colors in order of wavelength, similar to a rainbow. Turn on the light so the students can see the spectrum projection. Suggest that we might be able to use the photocell detector circuit to search for light that we can’t see with our eyes.
Place the detector first inside of the projected color region, but not beyond, and chop the signal with a comb or fan.
Ask students what they think will happen if you move the detector beyond the visible red?
3) Hold the detector in the red end of the projected spectrum (while chopping) and then move it slowly just beyond the visible red, and then even further beyond the visible red. Ask students to record observations (repeat as needed) and to discuss this data (the fact that the sensor is picking up something beyond the visible light) in their groups.
Questions to consider: What does it mean that we can still “hear the presence of” light beyond the visible red?
4) Distribute the Claim Evidence Reasoning (CER) handout and review content with the students to check for understanding.

5) Assign Homework: Students complete Claim Evidence Reasoning Statement regarding invisible light and add to the Unit Organizer for Days 4 and 5.</td></tr>
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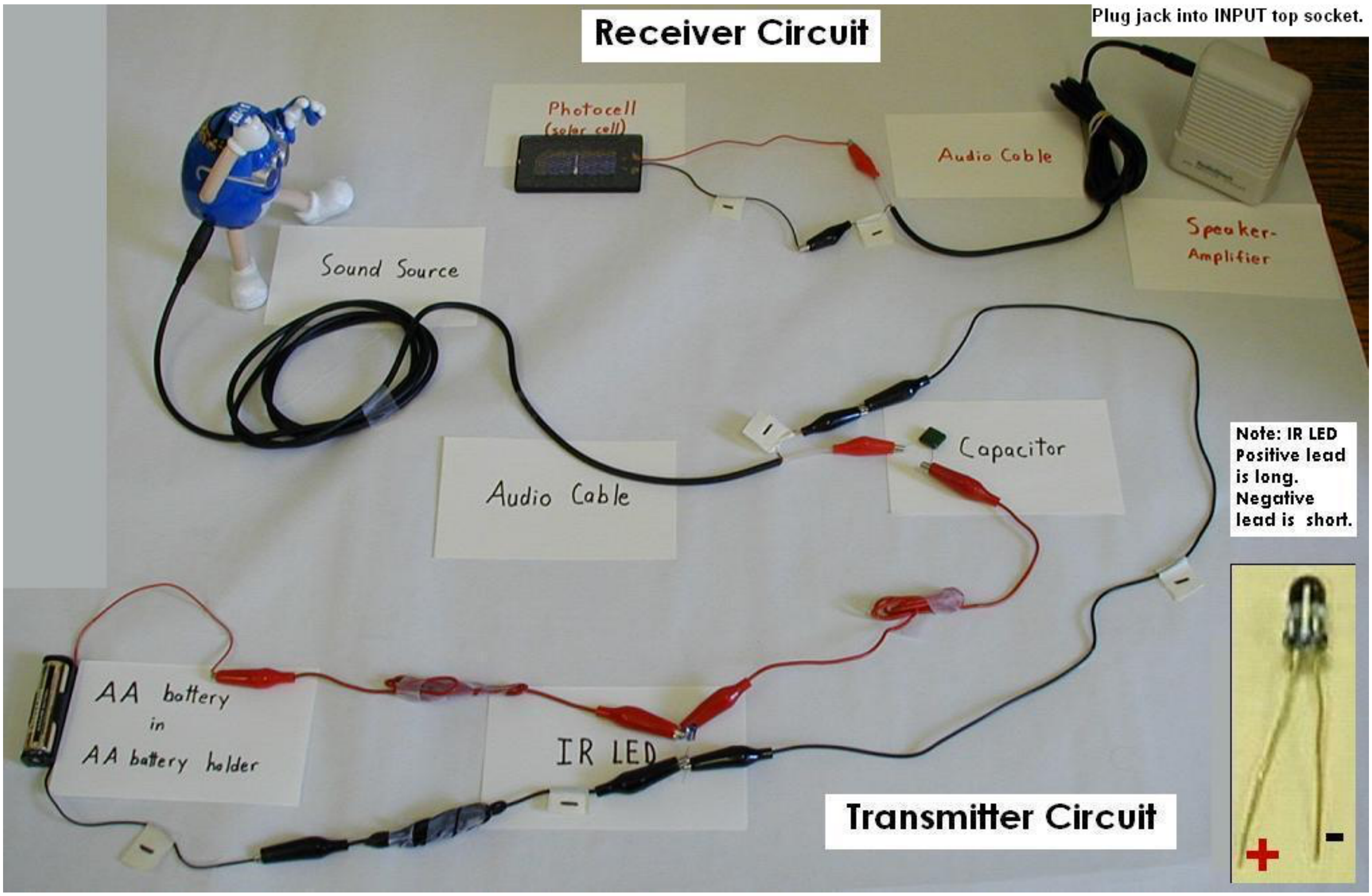
Receiver Circuit
Plug jack into INPUT top socket.
Photocell
(solar cell)
Audio Cable
Speaker-
Amplifier
Sound Source
Audio Cable
Capacitor
Note: IR LED
Positive lead
is long.
Negative
lead is short.
AA battery
in
AA battery holder
IR LED
Transmitter Circuit
+
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SCIENTIFIC EXPLANATIONS

CLAIM

Statement about the results of an investigation

- A one-sentence answer to the question you investigated.
- It answers, **what can you conclude?**
- It should not start with **yes** or **no.**
- It should describe the relationship between **dependent** and **independent** variables.

EVIDENCE

Scientific data used to support the claim

Evidence must be:

- **Sufficient** — Use enough evidence to support the claim.
- **Appropriate** — Use data that support your claim. Leave out information that doesn't support the claim.
- **Qualitative** — (Using the senses), or **Quantitative** (numerical), or a combination of both.

REASONING

Ties together the claim and the evidence

- Shows **how** or **why** the data count as evidence to support the claim.
- Provides the justification for why **this** evidence is important to **this** claim.
- Includes one or more **scientific principles** that are important to the claim and evidence.

* ***Remember:*** Read what you've written to be sure it makes sense as a whole explanation.

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