Infrared Light and Infrared Astronomy

Learning Plan
Days 1 and 2: Filters and Wavelength

Targeted Idea: 'Parts of light' can be blocked by filters or substances.

Overview of Days 1-2:

Students are given an opening probe and asked to select an answer that most closely matches their ideas with a written response explaining their current thinking. Students are given the opportunity to explore light passing through various color filters (with differing degrees of light and color absorption) to gather data and support an explanation/model of properties of visible light and how humans detect light. They then evaluate their own explanation/model against a sample student model. The sample student model presents them with a tentative model that they can evaluate in terms of merits and limitations and then refine to explain further observations. The classroom activities are supported by homework: (1) finding substances that block or partially filter LED lights, and (2) reading / answering questions about a Science Case Study. They return to the classroom to share substances, their understandings and questions about the Case Study in classroom discussions.

Students will build their understanding toward these Disciplinary Core Ideas (DCIs) in Days 1-2:

PS4.B 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.

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 series of wave pulses~~.

Middle School Performance Expectations (PE) / Disciplinary Core Idea (DCI) also relevant to today's work:

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.]

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 are building their skills in/understanding of these Science and Engineering Practices (SEPs) in Days 1-2:

- Asking Questions
- Developing and Using Models
- Constructing Explanations
- Obtaining, Evaluating, and Communicating Information

Materials	Resources
Handouts (one per student unless otherwise indicated) • Fancy Cameras • Sample Student Model A • Unit Graphic Organizer • Science Case Studies Focus Ques-tions • Science Case Study: Pluto Occultation (Reader page 11) • Visible Light Spectrum Review **Materials (per group unless otherwise indicated)** • Button battery with black electrical tape on one side (1 per student) • 5 mm LEDs (one of each color: white, green, red, blue) • Set of three filters (red, green, blue) • Large sheet of white paper • Set of colored (ROYGBV) pencils, crayons or markers	• PowerPoint for Days 1-2 • An enlarged version of the Classroom Unit Graphic Organizer - either on a white board, bulletin board, or with large sheets of chart paper

Day 1	
Teacher Role	**Student Role**
• Distribute handouts. • Encourage students to work independently. • Reassure that you are only looking for thoughts, not the “right answer”. • Watch for misconceptions, but do not use this time to instruct. • Provide reading support as needed while going through Science Case Study. Rephrase and paraphrase as needed. Suggest reading strategies for students.	• Review handout options and select answer that most closely represents thinking. • Listen closely to ideas of peers. • Share own thoughts and reasoning. • Make observations through each provided filter. • Test each LED light through the filters. • Be aware of own understanding and not understanding while reading the Science Case Study. • Record thoughts and questions about the Case Study on the Reading Organizer and in their own notes.

Steps to follow:

1) *Engage:* Introduce the lesson by telling students you would like them to individually respond to the Fancy Cameras probe. You are not concerned about the “right answer”, but rather, discovering what they think. They will have an opportunity to talk to discuss the probe *after* everyone has completed it.
    - Distribute the Probe. Allow students to complete it individually.
    - By show of hands, survey the students’ answers.
    - In small groups students briefly discuss their answer.

2) *Explore:* Tell the students “we will investigate Juan’s answer to the probe.”
    - Introduce the use of the word filter to describe the gel filters. Ask “What is a filter? How does it work?” Student responses will vary. Point out that in astronomy, the emphasis is upon what passes through. For example, a blue filter allows blue light to pass through.
    - Introduce the blue filters.
    - Pass them around the classroom and ask students to observe the classroom through the gel.
    - What do they notice about the color of white objects? red objects?

3) Distribute the 4 LEDs (white, blue, green, red) and the green and red filters.
    - Ask the groups to test and record how EACH light appears through each filter.
    - They should decide as a group how best to capture and record the data.
    - If they have time, they should create a section on their observations page for “Other tests we tried” (for example, they might try multiple combinations of filters).

4) Distribute the Unit Graphic Organizer and Science Case Study Focus Questions.

Tell the students that these handouts will help them to think about the unit experiences, as well as the readings, and that you will create a large graphic organizer for the entire class-room.

5) Distribute Science Case Study: Chasing Pluto's Shadow (Pluto Occultation) and look it over together as a class.
    - Explain that during the unit, the students will read a variety of Case Studies to help them get a better understanding of how scientists do astronomy research.
    - Reassure them that though the readings may have some challenging parts, you will tackle them together as a class.
    - As a class, read through some of the Pluto Occultation Case Study.
    - Review the questions on the Graphic Organizer. Ensure that students understand the questions:
        - Who completed the study?
        - What object was being studied? Why was that object selected?
        - How the object was observed? (With what instruments? Wavelengths?).
        - Describe one piece of data collected, and how it was used to construct an explana-tion of the scientists' results.
        - Why was this result important?
        - What were things you didn't understand or questions you had?

6) *Assign Homework:* Give the students two tasks: 1) to read the Pluto Occultation Case Study and make entries on the Case Study Organizer, and 2) to take a colored LED light home and try it out with a variety of materials.
    - Shine one red LED light into individually wrapped red and green hard candy (e.g. Jolly Ranchers or flat lollipos) or other common green substance, as an example.
    - Students should find a material at home that is mostly opaque to one color of light (will not let it pass), but is also very transparent a different color of light (lets the maximum amount of light through). Hint: glass or plastic materials work well
    - Reiterate that a material should fully block/absorb one wavelength, and then allow other wavelengths to pass through.
    - Look for a material that reflects the light.
    - The students should bring in an image/picture or a description of their items and be pre-pared to discuss their findings.
    - Distribute LED lights and batteries (or check-out as necessary).

Day 2	
Teacher Role	**Student Role**
• Provide materials, data, and examples. • Ask students to generate tentative explanations.	• Participate in discussing homework • Participate in discussion of Case Study Graphic Organizer questions • Generate a tentative explanation (including a model) and share with peers.

Steps to follow:

1) Collect homework and discuss the responses to the Case Study Graphic Organizer questions. Discuss the reflecting, absorbing, and transmitting materials.

2) *Explain:* In groups, students now generate a one page explanation with a drawn model to best illustrate how they think only some of the white light was able to pass through the blue filter and create an image in their mind, using the Visible Light Spectrum Review Sheet as reference, as needed.

3) Allow one group to share their explanation and model; ask if there is another group with something to add, or something vastly different.

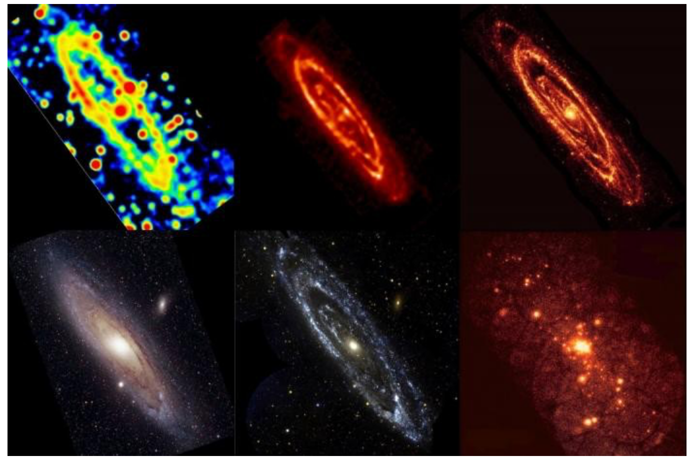
4) *Elaborate:* Distribute Sample Student Model A. Tell the students to review the Sample Student Model A, and to think about the student's model in light of their own.
   - How is it similar/different to their own model?
   - Do they see any strengths or weaknesses in their peer's model or description?
   - Does it do a better job of explaining the observations?
   - How would they adjust or modify the model to improve it?
   - Does the model adequately account for all of their observations?
   - We will return to this Sample Student Model to see if we can improve it, if it holds up under further observations, and if we can use it to explain additional phenomenon.

5) Distribute the Unit Graphic Organizer and look over the document together as a class. Review the questions on the Unit Graphic Organizer. Ensure that students understand the questions. Ensure the students that not every day will address all of the questions, but that after each lesson, some of the boxes will be completed.
   - What are some properties of visible radiation?
   - What are some properties of IR radiation?
   - What can IR radiation tell us about objects in the universe?
   - How do we know (what is the evidence to support the idea) that there is more "light" beyond what our eyes can see?
   - What are the different ways we can detect and record IR radiation data?
   -

6) *Assign Homework:* Make entries into the Unit Graphic Organizer for Days 1-2, as applicable.

Fancy Cameras

A friend was surfing the internet and came across these images of the same galaxy. They were labeled as radio, microwave, infrared, optical, UV, and X-ray. She pointed it out to her group of friends. They all thought it was really cool but wondered how the same object could look so different in photos. They had a lot of different ideas about the image. Here is what they said:



Credit: NASA

Wei: "I don't think cameras can photograph different wavelengths of light. It's just like one of those Instagram filters that changes colors around after you take the photo."

Latoya: "These can't be real photos. Galaxies don't produce microwaves, radio waves can only be heard and not seen, and the Sun is the only thing that produces UV light."

Juan: "I think they used filters, so that the camera only recorded certain colors of visible light coming from the galaxy. When you combine them together, it makes a photo just like what you would ordinarily see with your own eyes."

Sofia: "I think each image is recording a different wavelength of light coming from the object. So, the camera must have a sensor that can detect those wavelengths, and then it shows that as different colors.

Jared: "Each image looks different because of the speed of the waves. Like, the radio images looks different because that light travels much slower than visible light, and the infrared light travels the fastest. "

Which student(s) do you agree with the most? ___________________

Explain why you agree.

Case Studies Focus Questions:
How do NASA infrared observatories help astronomers know more about the Universe?

	Who completed the study?	What object was being studied? Why was that object selected?	How was the object observed? (With what instruments? At what wavelengths?)	Describe one piece of data collected, and how it was used to construct an explanation of the scientists' results.	Why is this result important?	What were things you didn't understand or questions you had?
Pluto Occultation (Chasing Pluto's Shadow)						
'First Light' Image of Jupiter (Jupiter, a Cool First Target)						
M2-9 Planetary Nebula (How the Universe Recycles Elements)						
The Milky Way Galaxy's Circumnuclear Ring (Dusty Ring Around a Black Hole)						
Water in Sunlit Lunar Soil (Secrets Hidden in Moonlight)						

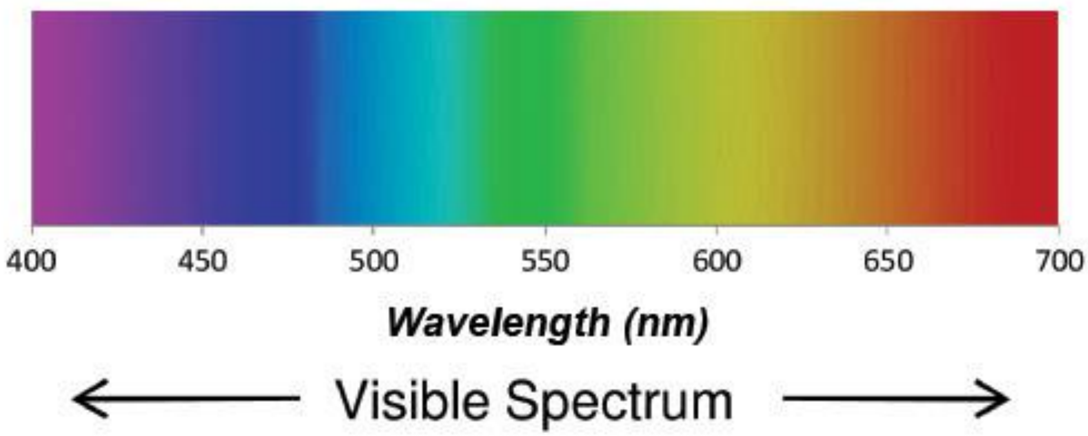
Infrared Light and Infrared Astronomy

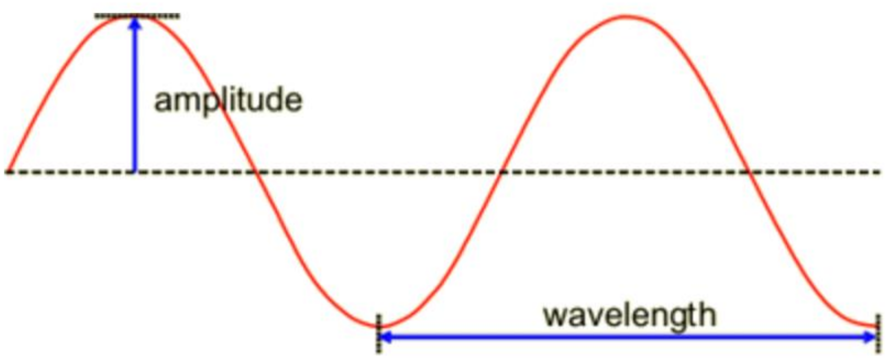
How do astronomers know what they know about the Universe?

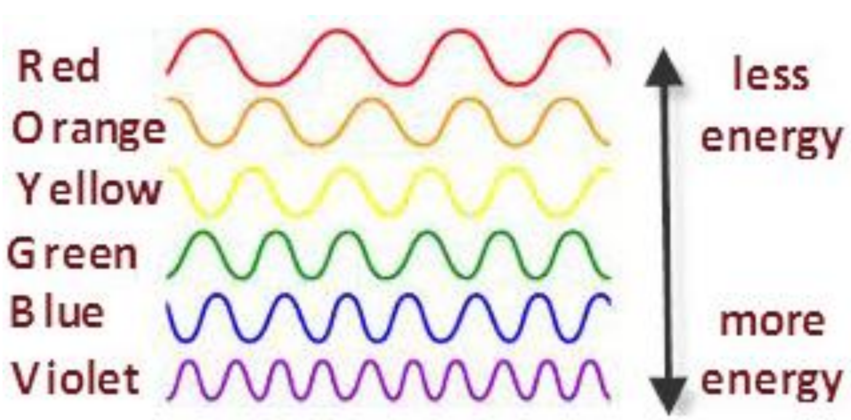
	What are some properties of visible radiation?	What are some properties of infrared (IR) radiation?	What can infrared radiation tell us about objects in the universe?	How do we know (what is the evidence to support the idea) that there is more "light" beyond what our eyes can see?	What are the different ways we can detect and record infrared radiation data?	What are the different instruments and how do they collect information about objects in the universe?
Days 1-2						
Day 3						
Days 4-5						
Day 6						
Days 7-8						
Day 9						

Visible Light Spectrum Review

Light within certain ranges of wavelength, frequency, and photon energy values can be seen by human eyes and is useful to us. The visible spectral region starts at red color and ends at violet color. From red to violet, the wavelength decreases and energy per photon (particle of light) increases. The speed of light is constant across the spectrum.







Sample Student Model A