Science Grade 08 Unit 11 Exemplar Lesson 01: Components of the Universe

This lesson is one approach to teaching the State Standards associated with this unit. Districts are encouraged to customize this lesson by supplementing with district-approved resources, materials, and activities to best meet the needs of learners. The duration for this lesson is only a recommendation, and districts may modify the time frame to meet students' needs. To better understand how your district may be implementing CSCOPE lessons, please contact your child's teacher. (For your convenience, please find linked the TEA Commissioner's List of State Board of Education Approved Instructional Resources and Midcycle State Adopted Instructional Materials.)

Lesson Synopsis

Students learn that distances between stars, galaxies, and other components of the universe are measured by using light waves. Other wavelengths of the electromagnetic spectrum are used to gather other information about the properties of these objects. This is the first time students have studied waves. Students will explore how the electromagnetic spectrum is used to study distances and properties of components in the universe.

TEKS

The Texas Essential Knowledge and Skills (TEKS) listed below are the standards adopted by the State Board of Education, which are required by Texas law. Any standard that has a strike-through (e.g. ~~sample phrase~~) indicates that portion of the standard is taught in a previous or subsequent unit. The TEKS are available on the Texas Education Agency website at http://www.tea.state.tx.us/index2.aspx?id=6148.

8.8 Earth and space. The student knows characteristics of the universe. The student is expected to:

8.8C Explore how different wavelengths of the electromagnetic spectrum such as light and radio waves are used to gain information about distances and properties of components in the universe.
Supporting Standard

Scientific Process TEKS

8.3 Scientific investigation and reasoning. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions and knows the contributions of relevant scientists. The student is expected to:

8.3D Relate the impact of research on scientific thought and society, including the history of science and contributions of scientists as related to the content.

8.4 Scientific investigation and reasoning. The student knows how to use a variety of tools and safety equipment to conduct science inquiry. The student is expected to:

8.4A Use appropriate tools to collect, record, and analyze information, including lab journals/notebooks, ~~beakers, meter sticks, graduated cylinders, anemometers, psychrometers, hot plates, test tubes, spring scales, balances, microscopes, thermometers,~~ calculators, computers, spectroscopes, ~~timing devices,~~ and other equipment as needed to teach the curriculum.

GETTING READY FOR INSTRUCTION

Performance Indicators

Grade 08 Science Unit 11 PI 01

Create a layered book, displaying research conducted regarding how astronomers use light and radio waves to show distances and composition of the galaxies, nebulae, and stars of the universe.
Standard(s): 8.3D , 8.8A , 8.8C
ELPS ELPS.c.1C , ELPS.c.2C , ELPS.c.5B

Key Understandings

- Astronomers use the electromagnetic spectrum to study the properties of the components of the universe.
  — What is a wave, and what are its main parts and properties?
  — What is the pattern between frequency of a wave and its wavelength?
  — What is a spectroscope, and what can it tell us about the properties of objects in the universe?
  — Why is the electromagnetic spectrum an important tool for studying the components of the universe?
  — How are light waves used to gain information about components in the universe?

Vocabulary of Instruction

- electromagnetic spectrum
- wavelength
- frequency
- nanometers
- crest
- trough
- Hertz
- radio wave
- microwave
- infrared waves
- visible light
- ultraviolet rays
- X-ray
- gamma rays
- spectroscope

Materials

- paper (plain or construction, various per class)
- colored pencils (multiple red, orange, yellow, green, blue, purple, per class)
- classroom textbooks or other campus based resources (per class)
- spectroscope (1 per pair of students)
- diffraction grating (optional,1 per pair of students)
- CD (1 per pair of students)
- bright flashlight (1 per pair of students)
- colored pencils (1 set per pair of students)
- prism (optional, 1 per pair of students)
- rope (8 meters, 1 per class)

Attachments

All attachments associated with this lesson are referenced in the body of the lesson. Due to considerations for grading or student assessment, attachments that are connected with Performance Indicators or serve as answer keys are available in the district site and are not accessible on the public website.

Teacher Resource: PowerPoint: This and the Universe Too

Teacher Resource: Anatomy of a Wave (1 for projection)

Teacher Resource: Spectroscopes (1 per pair of students)

Teacher Resource: Spectral Lines (1 for projection)

Teacher Resource: Electromagnetic Spectrum Diagram (1 for projection)

Teacher Resource: Research - Light Waves and The Universe (1 per pair of students)

Teacher Resource: Performance Indicator Instructions KEY (1 for projection)

Resources

None Identified

Advance Preparation

1. Collect, assemble, and prepare all materials.
2. Prior to Day 5:

- Arrange for student computer/Internet access (1 per pair of students) for use on Days 5 and 6.
- Provide access to the following site for students to complete an interactive lab: http://www.cfa.harvard.edu/seuforum/galSpeed/

3. Prepare attachment(s) as necessary.

Background Information

This lesson addresses distances and properties of components of the universe. Students learn that distances in space are measured by using light waves and how spectral lines can be used to gain information about the temperature and chemical composition of objects in the universe.

Prior to this unit, in Grade 8, students studied the effects resulting from cyclical movements of the Sun, Earth, and Moon. Cycles within the Earth, Sun, and Moon systems are studied as students learn about seasons, tides, and lunar phases. The previous lesson and this one are the first time students investigate the universe beyond our solar system, including how different wavelengths of the electromagnetic spectrum are used to gain information about distances and properties of components of the universe. After this unit, the electromagnetic spectrum is studied in depth in Physics.

Students have not studied the concept of electromagnetic (EM) waves or wave basics. The focus of this lesson is to enable students to understand how the different wavelengths of the electromagnetic spectrum are used by astronomers and other scientists to gain information about distances and properties of the components in space. Students need to know the basics of Electromagnetic Spectrum, such as there are a great variety of electromagnetic waves: radio waves, microwaves, infrared waves, visible light, ultraviolet rays, X-rays, and gamma rays. These wavelengths vary from radio waves, the longest, to gamma rays, the shortest with the shorter wavelengths having the most energy. They will also need a simplified explanation of wave structure. They will study waves in greater detail in IPC or Physics.

STAAR Note:
Readiness Standard (8.8A), the components of the universe and models such as the Herztsprung-Russell diagram, Supporting Standard (8.8B), recognition of the Sun as a medium-sized star near the edge of a disc-shaped galaxy, and Supporting Standard (8.8C), exploring how different wavelengths of the electromagnetic spectrum, are used to gain information about distances and properties of components in the universe will be assessed under Reporting Category 3: Earth and Space on the STAAR Grade 8 Science Assessment.

INSTRUCTIONAL PROCEDURES

Instructional Procedures	Notes for Teacher
ENGAGE – What's the Relationship?	**NOTE: 1 Day = 50 minutes** **Suggested Day 1**
1. Inform students that you are going to project some photos of objects using the Teacher Resource: PowerPoint: **This and the Universe Too** and you would like them to think about two things: • **What do the objects have in common?** • **What might they have to do with learning about the universe?** 2. Allow students to discuss the images and questions with a partner, and then ask volunteers to share with the large group. Do not tell students what the connection is yet. 3. Inform students that they will find out the connection during this lesson.	**Attachments:** • Teacher Resource: PowerPoint: **This and the Universe Too**
EXPLORE – The Wave	**Suggested Days 1 (continued)**
1. Ask/Say: • **Have you ever been involved in a human way at a sporting event?** (Responses will vary.) • **We are going to use the “human wave” to model parts of a wave.** 2. Divide the class into two groups. One group should form a single straight line, and the other group should observe. The groups will switch roles during this activity. 3. Give the first group of students the rope to hold. The group should stand in a straight line, facing the rest of the class. They should hold the rope in both hands. Their arms should be held straight, with their hands about shoulder width apart and resting on their thighs. 4. Instruct the students to hold the rope about 1 meter from the ground. 5. Instruct those students observing to draw a diagram of the rope in their science notebooks. 6. Instruct the students holding the rope that they are going to perform the human wave while holding on to the rope. • Students should not move their arms until they feel the tug on the rope from the person beside them. It is better if the students look ahead, rather than at the person beside them. • Practice the human wave a couple of times. • After the students have practiced, instruct them to do the human wave once more, but this time, they will continue the wave until the teacher says “stop”. • Let students perform the wave for about 15 seconds, and then say STOP. • Instruct students who are observing draw the rope in this “stopped” position in their notebooks. 7. Instruct the two groups to change places, and repeat the activity.	**Materials** • rope (8 meters, 1 per class) **Instructional Notes:** The length of rope depends on how many students comprise half the class. Use rope that is heavy enough to drape when held. String, yarn, or thin plastic rope will not work well. This takes a little practice to get the students not to jump ahead of the wave. If done properly, a visual of crests and troughs can be seen by seated students as well as energy being moved through the wave. The rope only moves up and down (oscillates), not the length of the wave. This activity could be done outdoors, if weather permits, or in the hallway, if the room is too crowded. **Science Notebooks:** Students enter the wave drawing in their notebooks.
EXPLAIN – Anatomy of a Wave	**Suggested Days 1 (continued) and 2**
1. Ask for a student volunteer to draw a model of the wave on the board. Ensure that there is more than one crest and trough in the drawing. Ask: • **What is a wave?** (*Answers will vary, but lead students to the definition that a **wave** is a disturbance that transfers energy.*) 2. Instruct students to add the wave definition in a section under the drawing of their wave. There will be several terms for them to write down.Instruct students to put an **x** at the highest position of the wave they drew and a ● at the lowest position of the wave. Ask: • **What are some of its parts?** *Accept all answers at this time.* 4. Label the highest position of the wave (at the X) the **crest** and the lowest position of the wave (at the ●) the **trough**. Draw a line mid-way across the length of the wave. Model on the board.	**Attachments:** • Teacher Resource: **Anatomy of a Wave** (1 for projection) **Instructional Notes:** Instruct students to leave space for additional drawings in their notebooks. They should make a section below the drawing area to write terms and descriptions of parts of a wave as they are presented. **Science Notebooks:** Students enter drawings, terms, and definitions in their notebooks. **Check For Understanding:**

5. Point out that there are more than one crest and trough on the diagram. Instruct students to draw a line connecting two adjacent crests or two adjacent troughs.
   Ask:
   - **What does this line represent?** (*The distance between two waves*)
6. Instruct students to label the area "wavelength."
7. Instruct students to leave space for additional drawings in their notebooks. Students should record the following in the terms section under their drawing space:
   Project or write on the board, and say:
   - **The distance between two crests or two troughs that are adjacent (side-by-side) is called its wavelength. The shorter the wavelength, the more energy the wave has. Wavelengths can be measured in nanometers. This is a unit used to measure very small objects. A nanometer equals 1 billionth of a meter and is written as 10^{-9} m.**
   - **Frequency is another term associated with waves. Frequency is the number of wave crests that pass a point during one second. A unit called a Hertz measures frequency. A frequency of one cycle per second is one Hertz (abbreviated as Hz).**
8. Instruct students to draw a wave with short wavelengths and a wave with longer wavelengths. Model on the board.
   Ask/Say:
   - **How are wavelength and frequency related?** *(Shorter wavelengths have higher frequency and more energy; longer wavelengths have lower frequency and less energy.)*
9. Instruct students to label which wave has the most energy and explain why in their notebooks.
   Ask:
   - **What are the parts of a wave?** *(The crest, trough, and wavelength)*
   - **Which parts of a wave are measured?** *(The wavelength)*
   - **How is the energy level of a wave determined?** *(The wavelength and frequency)***The frequency and wavelength of a wave determines how much energy a wave has.**
10. Project the Teacher Resource: **Anatomy of a Wave**. Allow students to correct any error they may have recorded in their notebooks. Instruct students to label the frequency and which wave has more energy.
11. Explain to students that light travels in waves and that understanding properties of light waves helps scientists collect data from objects in our universe; distance, chemical composition, and temperature.
12. Say:
    - **We will spend the next few days exploring how scientists use light to determine distances and properties of objects in the universe.**

Students should check their recorded work against the projection.

EXPLORE/EXPLAIN – Spectroscopes	**Suggested Day 3**

1. Divide the class into pairs.
2. Distribute materials to each pair of students.
3. Instruct students to follow the instructions on the Teacher Resource: **Spectroscopes**.
4. Monitor students, and assist as necessary.
5. Explain to students that they are observing the type of light known as the visible spectrum; light that is visible to the human eye.
6. Ask:
   - **What are the colors of the visible spectrum (in order)?** *(Red, orange, yellow, green, blue, and violet)*
   - **Have you ever observed anything else with this order of colors?** *(A*

Materials

- spectroscope (1 per pair of students)
- diffraction grating (optional,1 per pair of students)
- CD (1 per pair of students)
- bright flashlight (1 per pair of students)
- colored pencils (1 set per pair of students)
- prism (optional, 1 per pair of students)

Attachments:

- Teacher Resource: **Spectroscopes** (1 per pair of students) *rainbow. When the light refracts from water droplets, the colors of the visible spectrum are revealed.)*

1. Instruct students to use colored pencils to draw the order of the visible spectrum in their notebooks.
2. Project the Teacher Resource: **Spectral Lines**, and discuss the following. Instruct students to record notes in their notebooks:
   - **Visible light is the type of light the human eye can see.**
   - **Each different wavelength of visible light has a different color.**
   - **These waves combine to make white (visible) light.**
   - **The colors represent different wavelengths.**
   - **The color with the longest wavelength is red.**
   - **The red end of the spectrum has waves with lower frequency and lower energy.**
   - **The color with the shortest wavelength is violet.**
   - **The violet end of the spectrum has waves with higher frequency and higher energy.**
   - **Powerful telescopes are equipped with spectroscopes to determine the color of distant objects in the universe.**
   - **The patterns of the spectral lines tell us the chemical composition (which elements are present) of objects in the universe.**
   - **There is a relationship between the spectral colors and the temperature of objects.**
   - **Red objects are the coolest and violet are the hottest.**
   - **The colors of the wavelengths of the visible spectrum are represented by spectral lines on a spectrograph.**
   - **The colors of the spectrum can be used by scientists to determine distances, chemical compositions, and temperatures of objects in the universe such as galaxies, nebulae, and stars** (see Instructional Notes)**.**

1. Ask:
   - **What is a spectroscope, and what can it tell us about the properties of objects in the universe?** *A spectroscope is an instrument used to observe light. It splits the light into different wavelengths represented by color. The colors are represented by spectral lines on a spectrograph, and the patterns of the lines tell us which elements are present in objects in the universe. The spectral colors can give us information about the temperature of objects.*

- Teacher Resource: **Spectral Lines** (1 for projection)

Instructional Note:
Galaxies, nebulae, and stars will be studied more specifically in the next lesson.

EXPLAIN – The Electromagnetic Spectrum	Suggested Day 3 (continued) and 4

1. Project the Teacher Resource: **Electromagnetic Spectrum Diagram**.
2. Discuss each row beginning with "Penetrates Earth's Atmosphere".
   Ask:
   - **Which types of electromagnetic waves cannot penetrate the atmosphere?** *(Microwaves, ultraviolet, X-ray, and gamma ray)*
   - ***Which types of electromagnetic waves can penetrate the atmosphere?*** *(Radio, visible, and a few wavelengths of the infrared range can pass through the atmosphere. Infrared waves are not seen, but felt as heat.)*

1. Instruct students to look at the wavelength in meters and the scale for that wavelength.
   Ask:
   - **What do you notice as the size of a wave gets smaller?** *(The smaller the size, the steeper or closer the wavelengths are.)*
   - **Do the numbers for wavelength get larger or smaller, as they move to the right?** *(The numbers get smaller.)*

1. Direct students' attention to the frequency bar.
   Ask:
   - **Do the numbers indicating frequency get larger or smaller, as they move to the right?** *(The numbers get larger.)*
   - **Is there a pattern between wavelength and frequency?** *(Yes. As the*

Attachments:

- Teacher Resource: **Electromagnetic Spectrum Diagram** (1 for projection)
- Teacher Resource: PowerPoint: **This and the Universe Too** (from previous activity)

STAAR Notes:

Supporting Standard (8.8C), exploring how different wavelengths of the electromagnetic spectrum, is used to gain information about distances and properties of components in the Universe will be assessed under Reporting Category 3: Earth and Space on the STAAR Grade 8 Science Assessment.

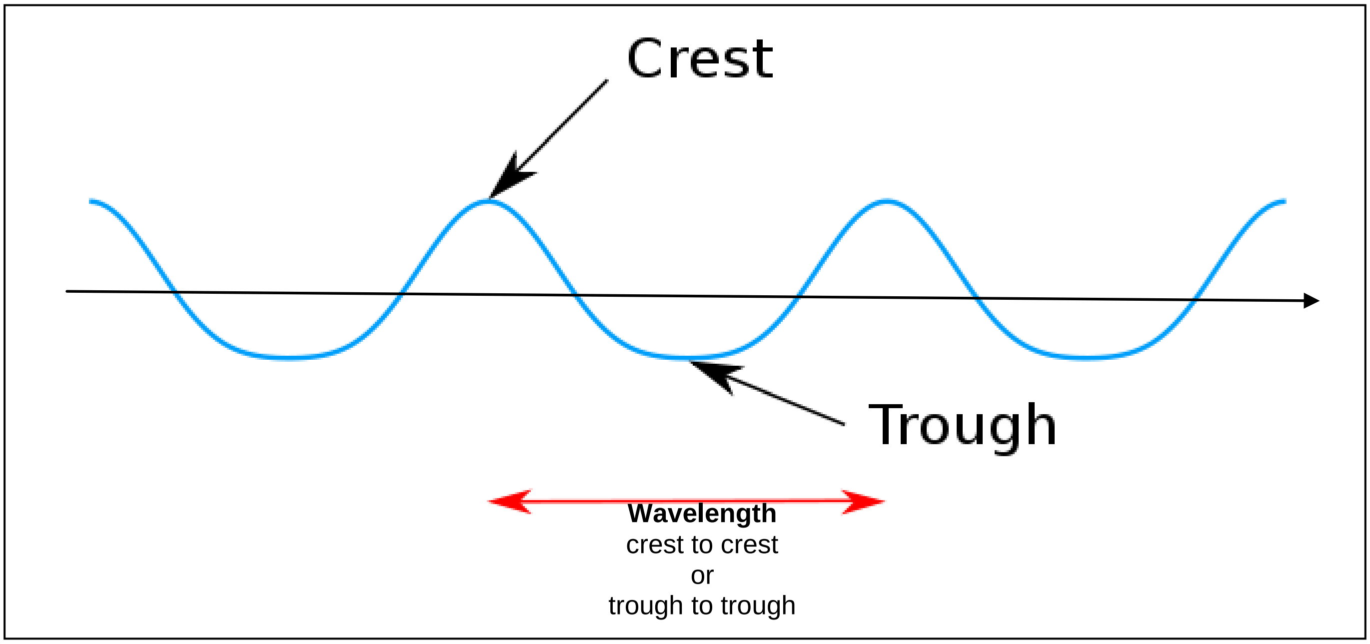
frequency increases, the wavelength decreases.)

1. Instruct students to summarize the relationship between wavelength, frequency, and energy in their notebooks. *(The shorter the wavelength is, the higher its frequency. The higher the frequency, the higher the wave's energy is.)*
2. Instruct students to draw and label the electromagnetic spectrum in their notebooks.
3. Briefly discuss how the applications of each type of wave. Note: *Students are not responsible for knowing modern applications of light waves with the exception of how they are related to gaining information about objects in the universe.*
4. Project the Teacher Resource: PowerPoint: **This and the Universe Too!** again. Remind students that the first time they watched this PowerPoint, you had asked them to think about two questions.
   Ask:
   - **What might the objects have in common?** *(All of the objects use some form of electromagnetic waves.)*
   - **What do the objects have to do with learning about the universe?** *(The electromagnetic waves help us see characteristics of components of the universe that are normally invisible to our eyes.)*
   - **What is a wave, and what are its main parts and properties?** *A wave transfers energy from one place to another. Waves have a crest, trough, and resting position. The frequency of a wave is the number of crests or troughs that pass a given point in one second. The amplitude is the measurement from the resting point to the top of the crest or the bottom of the trough. The wavelength is the distance between two crests or two troughs.*
   - **What is the pattern between frequency of a wave and its wavelength?** *Longer wavelengths have lower frequency and lower energy; shorter wavelengths have higher frequency and higher energy.*
   - **Why is the electromagnetic spectrum an important tool for studying the components of the universe?** *The EMS is used to gather information about the distances and properties of objects in the universe.*

EXPLAIN – Research: Light Waves and The Universe	**Suggested Day 4 (continued) and 5**
1. Divide the class into pairs. 2. Distribute the Teacher Resource: **Research - Light Waves and The Universe** to each pair of students. 3. Instruct students to divide a page in their notebooks into three columns and label each column distance, chemical composition, and temperature respectively. 4. Instruct students to read the passages and record information regarding how scientists use light waves to gain information about the distances, chemical compositions, and temperatures of objects in the universe. 5. Monitor students, and check for accuracy of notes. 6. Ask each pair of students to pair up with a different partner and compare notes. 7. Ask for three student volunteers to project and share one column of their notes with the class. Additionally, ask someone else in the class to point out where that information was found in the passage. Allow time for students to modify their notes as necessary. 8. As students share, ensure the accuracy of information and clarify any misconceptions (see Instructional Notes). 9. Instruct students to summarize in their notebooks how light waves are used to gain information about components in the universe. *The different wavelengths, frequencies, and spectra give us information about the distance, temperature, and chemical composition of objects in the universe.*	**Attachments:** • Teacher Resource: **Research - Light Waves and The Universe** (1 per pair of students) **Instructional Notes:** How light is used to gain information about distances of objects in the universe (Doppler effect; red shift; blue shift) is specifically addressed in the reading passages. **Check For Understanding:** Summaries may be used as a formative assessment. **Science Notebooks:** Students record information from passages in their notebooks. Students record summaries in their notebooks.
ELABORATE – Spectroscopy	**Suggested Day 5 (continued) and 6**
1. Inform students that they are going to work in pairs to complete an interactive lab on the computer. 2. Divide the class into pairs, and instruct them to access the following site: http://www.cfa.harvard.edu/seuforum/galSpeed/ to complete the interactive lab. 3. Monitor students, and assist as necessary. Optional: Print sets of the spectrograph strips (1 set per pair of students) for the elements, and instruct	**Instructional Note:** Consider bookmarking or pre-setting computers to the site link.

EVALUATE – Performance Indicator	Suggested Day 7
students to analyze them to determine the elements represented by the strips (see Advance Preparation).	
Grade 08 Science Unit 11 PI 01 Create a layered book, displaying research conducted regarding how astronomers use light and radio waves to show distances and composition of the galaxies, nebulae, and stars of the universe. Standard(s): 8.3D , 8.8A , 8.8C ELPS ELPS.c.1C , ELPS.c.2C , ELPS.c.5B 1. Refer to the Teacher Resource: **Performance Indicator Instructions KEY** for information on administering the performance assessment.	**Materials** • paper (plain or construction, various per class) • colored pencils (multiple red, orange, yellow, green, blue, purple, per class) • classroom textbooks or other campus based resources (per class) **Attachments:** • Teacher Resource: **Performance Indicator Instructions KEY** (1 for projection) **Science Notebooks:** Students may access their notebooks to complete the Performance Indicator.

Anatomy of a Wave



Wave – a disturbance that transfers energy

Crest – the highest point of a wave

Trough – the lowest point of a wave

Wavelength – the distance between two adjacent crests or troughs

Frequency – the number of waves that pass a given point in one second; measured in Hertz (Hz)

http://upload.wikimedia.org/wikipedia/commons/6/62/Crest_trough.svg

Spectroscopes

Materials:

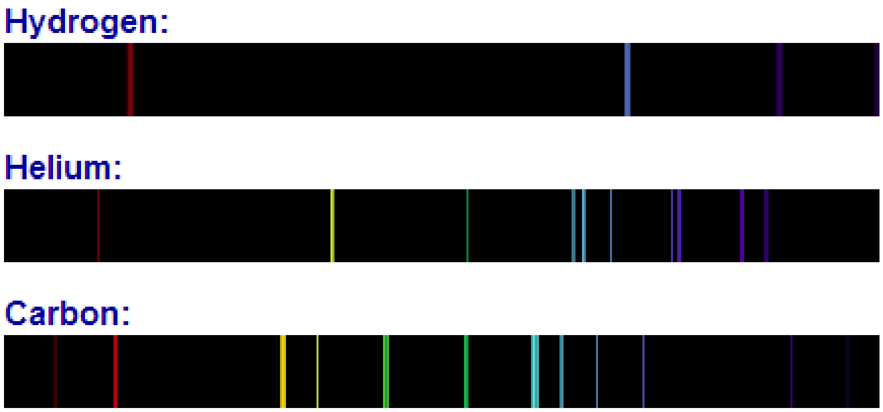
- CD
- prism (optional)
- bright flashlight
- colored pencils
- spectroscopes
- diffraction grating (optional)

A **spectroscope** is an instrument used to observe visible light. It splits the light into different wavelengths represented by color. The colors are represented by spectral lines on a spectrograph, and the patterns of the lines tell us which elements are present in objects in the universe. The spectral colors can also give us information about the temperature and distance of objects.

Directions:

1. Hold a CD so the silvery side (the one you record on) is facing up.
2. Hold a bright flashlight so that it shines across the surface of the CD.
3. What do you see? Record your observations in your notebook.
4. Look through the spectroscope at the classroom lights. What do you see? Record your observations in your science notebook.
5. Optional: Look through the spectroscope at the classroom lights using the diffraction grating. What do you see? Record your observations in your notebook.
6. Optional: Hold a prism up toward the light, and observe what happens. Shine a flashlight on a prism at different angles, and observe what happens. Record your observations in your notebook.

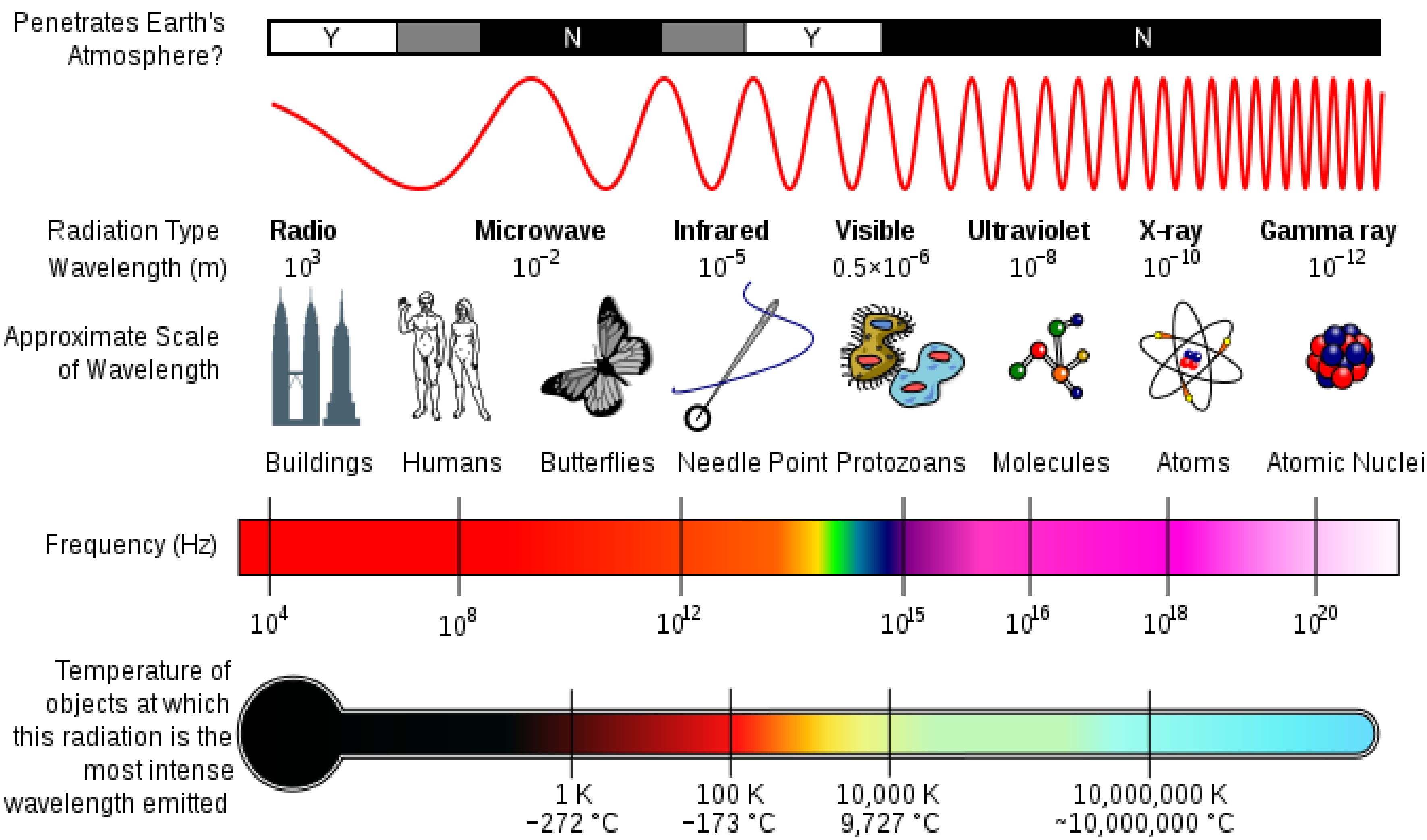
Spectral Lines



http://imagine.gsfc.nasa.gov/docs/teachers/lessons/xray_spectra/background-spectroscopy.html

- **Visible light is the type of light the human eye can see.**
- **Each different wavelength of visible light has a different color.**
- **These waves combine to make white (visible) light.**
- **The colors represent different wavelengths.**
- **The color with the longest wavelength is red.**
- **The red end of the spectrum has waves with lower frequency and lower energy.**
- **The color with the shortest wavelength is violet.**
- **The violet end of the spectrum has waves with higher frequency and higher energy.**
- **Powerful telescopes are equipped with spectroscopes to determine the color of distant objects in the universe.**
- **The patterns of the spectral lines tell us the chemical composition (which elements are present) of objects in the universe.**
- **There is a relationship between the spectral colors and the temperature of objects.**
- **Red objects are the coolest and violet are the hottest.**
- **The colors of the wavelengths of the visible spectrum are represented by spectral lines on a spectrograph.**
- **The colors of the spectrum can be used by scientists to determine distances, chemical compositions, and temperatures of objects in the universe such as galaxies, nebulae, and stars.**

Electromagnetic Spectrum



http://upload.wikimedia.org/wikipedia/commons/c/cf/EM_Spectrum_Properties_edit.svg

Research – Light Waves and The Universe

How do scientists gain information about objects in the universe? The **electromagnetic spectrum** represents all of the different types and wavelengths of light. Only a small portion of light, the visible spectrum, is visible to the human eye. Optical telescopes with **spectroscopes** use visible light to gain information about chemical compositions, temperatures, and distances of galaxies, nebulae, and stars in the universe. This is known as **spectroscopy.** Since some objects in the universe emit **radio waves** that cannot be detected by the human eye, scientists also use radio telescopes to gain information about objects in the universe.

Chemical Composition

Spectroscopy uses visible light to figure out the chemical composition of distant objects in the universe. When light from a galaxy, planet, or star passes through an instrument called a **spectroscope**, it splits the light into different wavelengths represented by colors. Each different wavelength of visible light has a different color. This is known as the **visible spectrum**. This can be compared to shining a light through a prism or the formation of a rainbow when light refracts from water droplets. The color with the longest wavelength is red. The red end of the spectrum has waves with lower frequency and lower energy. The color with the shortest wavelength is violet. The violet end of the spectrum has waves with higher frequency and higher energy. When the light is heated or electrically charged, specific chemicals will emit light at particular wavelengths and colors. These wavelengths show up as **spectral (emission) lines**. This is called “chemical fingerprinting.” Each element emits different spectral lines, so scientists can look at the lines to determine which elements make up an object.

Distance

1. Hold your thumb out at arm’s length by completely extending your arm directly in front of you focusing on an object in the far background.

2. Close one eye, and note where your thumb is and how it lines up with the background.

3. Now, open your eye, and close the other one; note where your thumb is lined up with the background. Shift back and forth between right and left closed eyes to compare.
4. Compare and contrast the two with your partner. Was your thumb in the same place when viewed from different eyes? Hold that thought…
5. Repeat steps 2-4 by holding your thumb out at a closer distance with your elbow bent.
6. Compare and contrast the distances the positions of your thumb are apart when your arm is extended to when your elbow was bent. Were the positions of your thumb closer or farther apart with the arm extended compared to the elbow bent?

Spectroscopy can also be used to find out if objects in the universe are moving toward or away from us. When objects are moving toward or away, the **frequency** of the wavelength will change. This is known as the **Doppler effect**. Objects moving away from you will cause light waves to shift to longer wavelengths toward the red end of the spectrum. This is called the **red shift**. Oppositely, when objects move toward you, the light waves shift to shorter wavelengths toward the blue end of the spectrum. This is called **blue shift**. Your thumb-investigation should have revealed that when your thumb was farther from you, there was a smaller distance between the two positions of your thumb when you switched back and forth between eyes. When your thumb was closer to you, there should have been a larger distance between the two positions of your thumb. The closer an object is to us, the more it shifts.

Scientists can take pictures of a star six months apart and compare them. The second picture is taken when the Earth has revolved half way around the Sun. At this point, the star is farther away from us. Scientists can compare how much the star shifted in that time. Knowing how much the star shifts can help scientists figure out its distance from Earth. If it is moving away from us, it has longer wavelengths, which is an indication that it has shifted toward the red end of the spectrum. If it is moving toward us, it has shorter wavelengths, which indicates it shifted toward the blue end of the spectrum. This phenomenon is thought to occur as objects move into and out of gravitational fields of objects in the universe. The occurrence of red shift is used as evidence to support the concept that our universe is still expanding.

Radio waves are the longest waves on the electromagnetic spectrum. They do more than transmit radio, TV, and cell phone signals. Radio astronomy uses radio telescopes to study objects that emit the longest wavelengths of light. Light travels at 300,000 km per second (186,000 miles per second). Did you know it takes sunlight approximately eight minutes to reach the Earth? Satellites are used to send beams of radio waves back to Earth from locations of certain objects in space. If scientists know the speed of light (v) and how long it takes light to reach an object from Earth (t), they can figure out the distance (d=vt). Do you remember how speed equals distance divided by time (s=d/t)? In this case, distance equals velocity times time. This concept is how scientists know that the average distance of the Sun from Earth is approximately 93,000 miles. The Sun's distance from Earth is called and **astronomical unit** (AU). Astronomers take what they know, the AU, and apply it as a tool for measuring distances in space.

Temperature

There is a relationship between the spectral colors and the temperature of objects. Objects that emit longer wavelengths toward the red end of the spectrum are the coolest. Objects that emit shorter wavelengths toward the violet end of the spectrum are the hottest. Stars with temperatures above 6,000 degrees C are hotter than the Sun and emit most of their light in the blue end of the spectrum. Stars with temperatures below 5,000 degrees C are cooler that the Sun and emit most of their light in the red end of the spectrum. Therefore, hotter objects have shorter wavelengths and more energy. Cooler objects have longer wavelengths and less energy.

DO:

In your notebook, summarize how scientists use the electromagnetic spectrum to gain information about objects in the universe.

Terms:

Galaxy – A group of billions of stars, planets, gas, and dust that is held together by gravity and extends many thousands of light years. The Earth is in the Milky Way galaxy.

Nebula (Nebulae *plural)* – A region of space dust or gas that appears as a hazy or bright or dark area in space

Star – A gaseous mass in space. The Sun is an average sized star.

Performance Indicator Instructions KEY

Performance Indicator

- Create a layered book, displaying research conducted regarding how astronomers use light and radio waves to show distances and composition of the galaxies, nebulae, and stars of the universe.
  (8.3D; 8.8A, 8.8C)
  ELPS 1C; 2C; 5B

Materials:

- paper (plain or construction, various per class)
- colored pencils (multiple red, orange, yellow, green, blue, purple, per class)
- classroom textbooks or other campus based resources (per class)

Instructional Procedures:

1. There are many varieties of layered books. Choose one, or allow students to pick one on which to record their information. Instruct students to reference their notebooks.

2. Describe how light waves are used to:
   - determine the chemical composition of objects in the universe
   - determine the temperature of objects in the universe
   - measure distances of objects in the universe