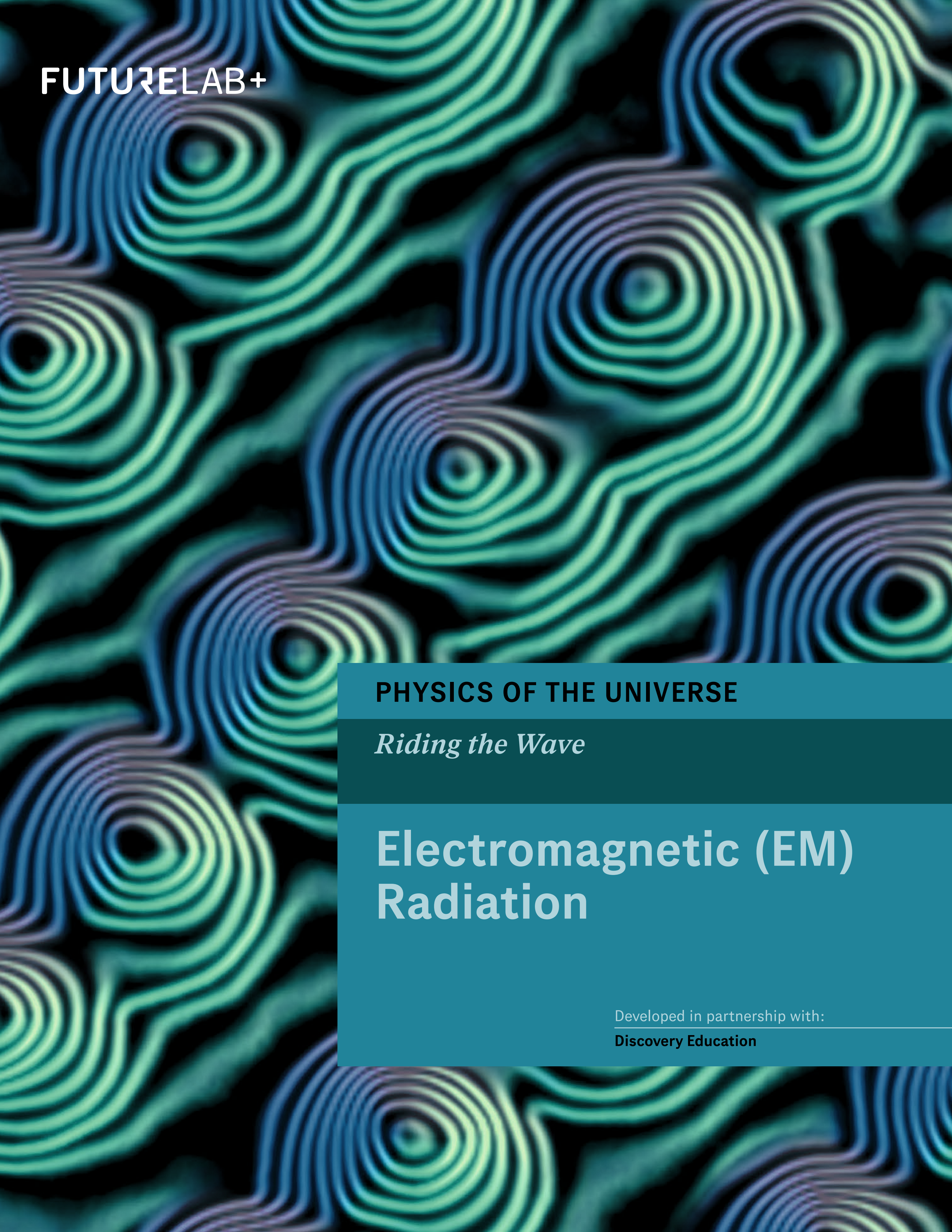


FUTURELAB+

PHYSICS OF THE UNIVERSE

Riding the Wave

Electromagnetic (EM) Radiation

Developed in partnership with:
Discovery Education

In this Lesson Plan:

Print the **Teacher Section** →

Print the **Student Section** →

This document is separated into two sections, For Teachers [T] *and* Student Resources [S], *which can be printed independently.*

Select the appropriate printer icon above to print either section in its entirety.

Follow the tips below in the Range field of your Print panel to print single pages or page ranges:

Single Pages (use a comma): T3, T6

Page Range (use a hyphen): T3–T6

Cover Image
Image of magnetic flux lines around nickel nanodots.

PHYSICS OF THE UNIVERSE / DETECTING THE UNKNOWN

Riding the Wave of Electromagnetic Radiation

DRIVING QUESTION

What is light and what are the applications, benefits, and drawbacks of electromagnetic radiation?

OVERVIEW

The electromagnetic spectrum encompasses all electromagnetic radiation, which is energy that spreads out as it travels. The electromagnetic spectrum extends from radio waves (low frequency) to Gamma-rays (high frequency). Between these extremes, there exists a whole world of waves—microwaves, visible light waves, UV rays, and more.

The properties of electromagnetic waves influence how they behave and how they can be used. Scientists are now exploring how electromagnetic radiation can be used to remedy diseases like cancer and diabetes in a treatment called millimeter wave therapy.

In the opening to this lesson, students will be introduced to the electromagnetic spectrum by watching a video from NASA. They will work in small groups to investigate EM radiation and create a comprehensive list of the many uses of the EM spectrum in their homes or in public spaces by creating a poster about one of these uses. Then, the class will participate in a Gallery Walk to see what their classmates came up with and to add to their own lists of everyday uses of EM radiation.

Continues next page >

ACTIVITY DURATION

Three Days (45-minute sessions)

ESSENTIAL QUESTIONS

What are everyday uses of various forms of electromagnetic radiation?

How can we understand light using the Wave-Particle Duality Principle?

How do we distinguish and choose between the wave and particle models?

What are the benefits and drawbacks of millimeter high-frequency wave technology?

OBJECTIVES

Students will be able to:

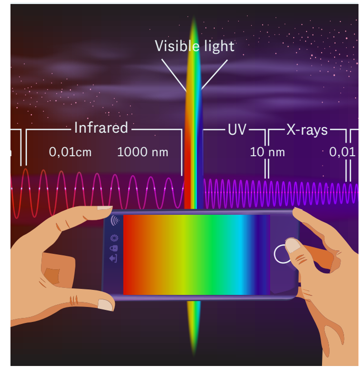
Identify the seven types of EM radiation and compare their wavelength, frequency, and energy.

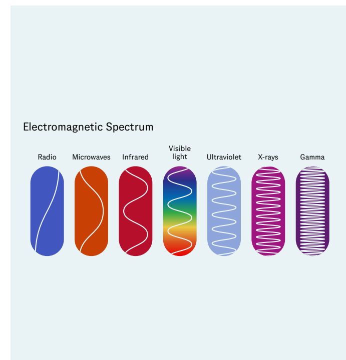
Brainstorm and present various everyday uses of EM radiation.

Explore and evaluate the evidence for how light behaves as a particle and a wave.

Research the pros and cons of millimeter high-frequency wave technology.

Summarize the characteristics, practical uses, benefits, and possible harmful effects of a specific type of electromagnetic radiation of their choosing.





OVERVIEW (CONTINUED)

In the next segment, students will explore how light exhibits both properties of a wave and properties of a particle—a principle known as Wave-Particle Duality. They will watch videos detailing the findings of the Photoelectric Effect and Double Slit experiments as evidence that light behaves as a particle and a wave. Then, students will participate in a scientific argument in which they support their position of whether light is a particle or a wave using evidence from their research.

To extend their knowledge, students will assume the role of biomedical scientists and electronics engineers as they uncover the benefits and consequences of millimeter high-frequency wave technology. Lastly, students will choose one type of EM radiation to research, focusing on key characteristics, properties, practical uses, benefits, and potentially harmful effects. They will convey the information using a medium of their choice (skit, video, slide presentation, poster, etc.).

STUDENT TASKS

Day 1	*Day 2*	*Day 3*
Watch NASA Video: *Tour of the EM Spectrum.* List the Seven Different Types of EM Radiation in Order from Lowest Energy (Frequency) to Highest Energy (Frequency). Review Properties and Types of EM Waves. Create a Poster: *Everyday EM Radiation*. Participate in a Gallery Walk.	Watch Videos: *Einstein's Photoelectric Effect and Original Double Slit Experiment*. Make Predictions and Engage in Follow-Up Discussion of Key Questions. Engage in a Discussion: *Is Light a Particle or a Wave?*	Assume the Role of Biomedical Scientists and Electronics Engineers. Research the Pros and Cons of Millimeter High-Frequency Wave Technology. Research a Specific Type of Electromagnetic Radiation and Complete the Final EM Radiation Project.

MAKE CONNECTIONS!

How does this connect to careers?

Medical physicists are scientists who specialize in matter and energy. They use their knowledge of the electromagnetic spectrum to develop safe radiation treatments, like MRI scans and ultrasound images.

Biomedical scientists work in laboratories testing the effectiveness of various treatments for diseases, as well as developing new treatments. Through research and observation, safe experimentation, project management, and data analysis, they explore ways to use EM radiation in therapies for patients.

Biomedical engineers are responsible for developing and improving complex medical and biotech equipment systems. They work closely with project engineers to develop performance, safety, and Human Factors Engineering specifications. They may be required to function as the subject matter expert in the field of biomedical engineering, directly supporting specialized clinical technology, including service, system administration, training, quality assurance, and life-cycle management.

Biomedical Technicians are responsible for highly complex biomedical equipment used in the biotech and medical industries. They are tasked with the operation, inspection, and maintenance of many types of biotechnology devices. They often have the skills to disassemble and reassemble these complex devices.

Radiation therapists carry out treatments prescribed by radiation oncologists. They often work with patients who have been prescribed radiation as part of their cancer treatment.

Clinical product managers oversee the process of bringing new medical technologies to market. Imaging clinical product managers specialize in imaging medical devices, such as MRI machines.

How does this connect to our world?

Radiation is one of the most powerful things in the universe—it has impacts on both the biggest and smallest scales, from giant stars in space to microscopic particles. Since scientists began to understand the properties of radiation, they have wondered how it might be harnessed for our benefit. Radiation could be one of the most promising technologies of the future, but bad experiences and missteps in the past make many people fear that giving radiation a bigger place in our power system might have disastrous consequences. Scientists and engineers are working together to make groundbreaking technologies that use radiation for good and minimize its bad effects. Radiation will always be a part of our lives, so it is very important that we figure out the best ways to live with it.

Pedagogical Framing

Instructional materials are designed to meet national education and industry standards to focus on in-demand skills needed across the full product development life cycle—from molecule to medicine—which will also expose students and educators to the breadth of education and career pathways across biotechnology.

Through this collection, educators are equipped with strategies to engage students from diverse racial, ethnic, and cultural groups, providing them with quality, equitable, and liberating educational experiences that validate and affirm student identity.

Units are designed to be problem-based and focus on workforce skill development to empower students with the knowledge and tools to be the change in reducing health disparities in communities.

SOCIAL-EMOTIONAL LEARNING

In this lesson, students will have multiple opportunities to present their learning to their peers, as well as critically, yet respectfully, engage with their peers' presentations and participate in an organized discussion. Students will exhibit communication and cooperative skills as they work in various student groups. They will practice social awareness and self-management skills by resisting inappropriate social pressure, negotiating solutions to conflict, and seeking help when needed.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

This lesson applies culturally and linguistically responsive instruction to student research into how EM radiation impacts the health and well-being of various communities differently. Students begin to get a clear picture of how the benefits and consequences of technologies, such as those using millimeter high-frequency wave technology, can disproportionately affect communities of color and low-income communities. Some groups may have greater access to more of the benefits, such as healthcare treatments, expensive smartphones, and tablets, while others experience more of the drawbacks.

COMPUTATIONAL THINKING PRACTICES

Computational thinking strategies are useful tools for understanding complicated concepts like electromagnetic radiation. In this lesson, students use the computational thinking strategies of collecting data, analyzing data, and decomposition to understand, make sense of, and explain the different properties of EM radiation.

ADVANCING INCLUSIVE RESEARCH

Advances in EM radiation have allowed scientists to use technology like MRI machines to detect diseases. According to a 2008 report from the World Health Organization, over 90% of the world does not have access to MRI machines. This prevents scientists and researchers from conducting clinical trials that are as diverse and accessible as possible. As access to MRI machines continues to grow, more of the world's population will have access to this powerful diagnostic tool.

CONNECTION TO THE PRODUCT LIFE CYCLE

As students examine different products and procedures that use electromagnetic radiation, they are exploring devices and treatments that reside in the manufacturing phase of the **Product Life Cycle**. These include common diagnostic tools like X-ray and MRI machines.

Day 1

Slides 1–9

INDUSTRY AND CAREER CONNECTION

Physicists are scientists who specialize in studying the electromagnetic spectrum. Medical and health physicists, in particular, examine how electromagnetic radiation can be harnessed into treatments and/or how radiation poses hazards to people and the environment.

Slides 1–7

Students watch the NASA Video: *Tour of the EM Spectrum* and generate notes listing the different types of EM radiation. (15 minutes)

1. Introduce students to the lesson objectives and the concepts of the electromagnetic spectrum and differences in energy (frequency).

2. Tell students that they will watch a video from NASA. While they watch, use *Pause and Play* and instruct students to take notes about the seven different types of EM radiation, taking notice of their relative frequency (which ones have higher frequency and which have lower frequency).

3. As a class, watch the *NASA video: Tour of the EM Spectrum (5 minutes, 4 seconds)*.

4. Using equitable calling strategies, such as *Pick a Stick*, have students report the different types of EM radiation in order from lowest energy (frequency) to highest energy (frequency). Review the image from the video showing the accurate order, correcting any student misconceptions.

Slides 8–9

In small groups, students review the properties and types of EM waves, brainstorm their everyday uses, and create a poster about one of these uses. Then, students participate in a poster Gallery Walk as a class. (30 minutes)

COMPUTATIONAL THINKING IN ACTION

As students brainstorm ways they encounter EM radiation in their daily lives and conduct a gallery walk, they are using the computational thinking strategy of collecting data.

1. Next, tell students that they will be working in small groups to investigate different types of EM radiation. Using the *Brainstorm* strategy, students will explore their uses in everyday household items or technology they might encounter in public spaces, and use this information to make a group poster and participate in a class *Gallery Walk*.

2. Break students into small groups of three to four and tell them to review the *Notes Slides on Properties and Types of EM Waves*. (Note: Make the link to the Notes Slides available on your class platform, so groups can access it easily from their devices. Inform students that the slide titles link to different pages within the NASA website for more information about each type of EM radiation.)

Continues next page >

Day 1

Continued

Slides 8–9

3	In their groups, students should *Brainstorm* ten different uses for EM radiation in household items or in public spaces. Each student should keep their own list of the brainstormed uses for EM radiation. They will add to it later as they participate in the *Gallery Walk*.
4	Instruct students to create a poster: *Everyday EM Radiation* in their groups that contains the following for each item on their brainstormed list: • Name of the device • Sketch of the device or visual representation • Type of EM wave the device uses • Brief description of how each device uses waves to function Pass out poster paper and markers or colored pencils. Encourage students to be creative, using pictures and different colors to make their poster visually appealing.
5	Post students' group posters around the room, and tell students to walk around the room in a *Gallery Walk* to view other groups' work. Inform students that they should take their brainstormed list of everyday uses with them as they walk around, adding to their own lists of everyday uses of EM radiation with unique examples they see on the other posters.

Teacher Note > *Alternatively, students could create a digital poster or infographic and participate in a digital Gallery Walk.*

Day 2

Slides 10–14

INDUSTRY AND CAREER CONNECTIONS

As students observe the different products and services that make our modern lives possible, they are observing the work of electrical engineers. These professionals use the particle-wave duality of electromagnetic radiation to design technology like TVs, radios, cell networks, and other things we haven't even seen yet!

COMPUTATIONAL THINKING IN ACTION

As students examine how light exhibits properties of waves and particles, they use the computational thinking strategy of decomposition to break down light into its component parts: photons.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Snowball Fight is a great strategy to promote thinking, reflection, and sharing between peers in a non-threatening manner. It also promotes the skills needed to cite evidence, identify key ideas and details, and summarize content from learning materials.

Slides 10–14	
Students will explore Wave-Particle Duality in two videos, make predictions about how light behaves, and engage in a follow-up discussion. (15 minutes)	
1	Inform students that they will build on their understanding of the EM spectrum introduced in Day 1 where they learned about the wave-like nature of light. Tell them that today they will explore how light also behaves like a particle (a small localized object which can be described as having volume, density, or mass).
2	Pass out *Is Light a Particle or a Wave?* capture sheet. Tell students that evidence for light as a particle will be discussed in the first video, while the second video will explore light as a wave. While they watch the first video, instruct students to take notes in the first column of their capture sheet.
3	As a class, watch *Einstein's Photoelectric Effect (3 minutes, 4 seconds)*, using *Pause and Play* to allow time for students to record their responses.
4	Using a *Train or Pass It On* strategy, engage in a follow-up class discussion of Key Questions from the video: • What are photons? • How did the experimental results differ with visible light versus ultraviolet light? How do you account for this difference? • How does the photoelectric effect provide evidence for the particle-like nature of light?
5	As a class, watch the first three minutes of the *Original Double Slit Experiment (7 minutes, 39 seconds)*. While they watch the video, instruct students to take notes in the second column of their capture sheet. Pause the video as needed for students to complete their notes.
6	Stop the video around the three minute mark. Ask students to make a prediction: *What will you see inside the box?* Use the *Snowball Fight* strategy for students to record their predictions. Then, ask several students to share the "snowball" they picked up with the class to share out various predictions.
7	Resume the video and stop it at 6 minutes 37 seconds.

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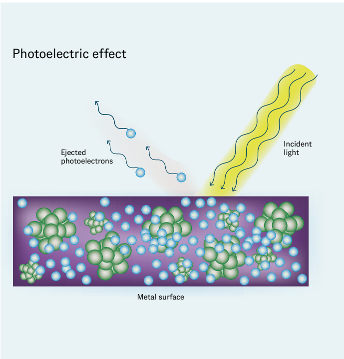
Day 2

Continued



Slides 10–17

8 Engage in a follow-up class discussion of Key Questions from the video, using the *Stand and Share* discussion protocol:

- Is light a wave or is it made of particles?
- What is the difference between constructive interference and destructive interference?
- How does Young's Double Slit Experiment demonstrate the wave-like properties of light?
- In the demonstration, what causes the rainbow effect (color differences) as light emerges from the central maximum?

9 Using the *Is Light a Particle or a Wave?* capture sheet answer key, review students' answers using the *Raise a Righteous Hand* discussion protocol.

Slides 15–17

Students will engage in a class discussion about whether light is a particle or a wave. (30 minutes)

1 Split the class in half to engage in a scientific argument: *Is Light a Particle or a Wave?* One side of the room will represent the "particle" team, while the other represents the "wave" team. Split each team in half again, creating an "argument" subgroup and a "rebuttal" subgroup for each team.

2 Pass out and review the *Group Discussion Rubric* with the class and let students know that they will be evaluated as a team, but a maximum score depends on the full participation of each team member.

3 Students should take five minutes to review the links listed below in their subgroups. (Note: Share these *Research Links* or post the QR code where all students have access.)

- *Wave-particle duality: light*
- *HyperPhysics—Wave Particle Duality*
- *NASA Imagine the Universe!—Electromagnetic Spectrum*

Each member of each subgroup should find a unique point (accompanied by a supporting fact) to present during the discussion. Every student will speak once, for no more than 30 seconds.

Continues next page >

Day 2

Continued

Slides 15–17

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Using a Plus/Delta strategy to evaluate individual design elements allows small groups to combine any elements from members' designs in such a way that all contributors have an equitable chance of being represented in the final design consensus.

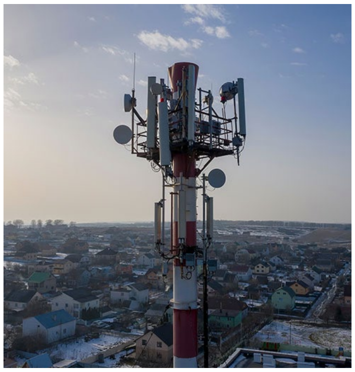
4 Review the guidelines for discussing scientific arguments:

- The "particle" team will begin the discussion by presenting the resolution ("Light is a particle") and their arguments and evidence in favor of this position.
- Each member of the "particle argument" subgroup will present their points one after the other. Each student may speak for no more than 30 seconds.
- Then, the "wave" team will present their arguments in opposition to the resolution ("Light is not a particle; it is a wave"). Again, each member of the "wave argument" subgroup will present their points one after the other. Each student may speak for no more than 30 seconds.
- As the argument subgroups are presenting, each team's rebuttal subgroup should review their prepared points and adjust them to appropriately respond to the opposing side's argument. (Note: if class time allows, you may want to have a short intermission to permit the teams to review and refine their rebuttal arguments together and prepare a closing statement for their argument, to be presented as the final rebuttal point.)
- Next, the rebuttal subgroups present using the same format described above, beginning with the "wave" rebuttal subgroup. The discussion concludes with the "particle" rebuttal subgroup's points.
- There cannot be any interruptions. Speakers must wait their turns and respect the time limit. (Tell students you will give them a visual cue when they have five seconds left.)

5 Using *Think, Pair, Share* as an exit ticket, ask students to write down whether they thought the argument was stronger in favor of light being a particle or a wave and the strongest piece of evidence for this position. Have them find a partner with a different opinion and discuss their responses.

Day 3

Slides 18–22



Slides 18–22	
Pairs of students assume the role of a biomedical scientist and electronics engineer to research the Pros and Cons of Millimeter High-Frequency Wave Technology. (20 minutes)	
1	Begin Day 3 by reviewing the types of EM radiation explored in Day 1 (gamma, x-rays, ultraviolet, visible, infrared, microwave, and radio), using a *Train or Pass It On* strategy. Introduce students to different career pathways that relate to EM radiation science.
2	Tell students that they will assume the role of two of these careers—biomedical scientists and electronics engineers—to explore the pros and cons of millimeter high-frequency wave technology.
3	Introduce the concept and examples of millimeter high frequency wave technology. These are technologies that use waves in the EM spectrum between 30 and 300 GHz, located between the microwave and infrared regions of the EM spectrum. These waves are used for high-speed wireless telecommunications, such as 5G networks, automotive radars, security screening, etc.
4	Pass out the *Millimeter High-Frequency Wave Technology Capture Sheet* or make it available digitally to students.
5	Pair students and instruct that one is to take the role of a biomedical scientist and the other an electronics engineer. Using the *online resources links*, students should take on the role of either an electronics engineer—researching the general benefits and drawbacks—or a biomedical engineer—researching benefits and drawbacks to human health. Then complete their respective sections of the capture sheet.
6	When finished with their individual research (five to seven minutes), instruct students to complete the other part of their capture sheet using their partner's research and answer the prompt at the bottom (five minutes).
7	Using a *Round Robin* strategy, have all student pairs share the pros and cons they identified.

INDUSTRY AND CAREER CONNECTION

Students inhabit the different perspectives of biomedical scientists and electrical engineers in order to evaluate the benefits and drawbacks of EM radiation technology. These professions help to harness the amazing things EM radiation can do, while also monitoring this powerful tool to make sure it doesn't cause harm.

Continues next page >

Day 3

Continued

COMPUTATIONAL THINKING IN ACTION

In this lesson, students are using the computational thinking strategies of collecting and analyzing data to process information about electromagnetic radiation. They use the suggested sources to collect verifiable, accurate data and analyze that data by synthesizing it into a medium of their choice.

Slides 23–24

Slides 23–24	
Students choose a specific type of Electromagnetic Wave Radiation to research and complete the Final EM Radiation Project. (25 minutes)	
1	Recalling the seven main types of electromagnetic radiation, tell each student to choose a region of the EM spectrum to research. (Note: they should not select high-frequency millimeter waves, as these were covered thoroughly in the previous activity.) Refer back to slide 19, if necessary, to remind students of all the different types they can choose from.
2	Explain that they will be using various resources (including the websites provided below) to explore their chosen type of electromagnetic radiation. Suggested Websites: • *NASA* • *The Electromagnetic Spectrum Home Page* • *Explain the Stuff: The EM Spectrum*
3	Review the project directions: Students may use a medium of their choice: skit, video, individual Paper Slide video, traditional slide presentation, poster, etc., and they must include the following aspects in their final project: • Title—Name of the region of the Electromagnetic Spectrum chosen. • Where is this type of radiation located on the Electromagnetic Spectrum in relation to other kinds of radiation? What properties of the wave define why it is found within this area of the spectrum? • Key characteristics of your type of radiation (wavelength, frequency, key facts). • Pictures or drawings—any visuals pertaining to this type of radiation, such as diagrams, pictures, etc. • How is it used or found in our everyday lives or certain industries? Identify and explain at least two uses. • Is it harmful, helpful, or both? Include evidence to support your statement.
4	Review how the students' work will be graded using the *Final Electromagnetic Radiation Project Rubric*.
5	If students do not finish the final project during class, they may finish it for homework.

National Standards

Next Generation Science Standards

Science Engineering Practices (SEP)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.

Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.

Disciplinary Core Ideas (DCI)

HS-PS-4. Waves and Their Applications in technologies for Information Transfer

HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

PS4.A: Wave Properties

Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.)

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, and the particle model explains other features.

Crosscutting Concepts (CC)

Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

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Is Light a Particle or a Wave? Capture Sheet

Directions

Evidence for light as a particle will be discussed in the first video, while the second video will explore light as a wave. While you watch the first video, take notes in the first column of the capture sheet. While you watch the second video, take notes in the second column of the capture sheet.

Evidence that Light is a Particle	Evidence that Light is a Wave

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Millimeter High-Frequency Wave Technology Capture Sheet

Directions

Take the role of biomedical scientist or electronics engineer as you work with a partner on this research assignment.

1. Indicate the role you will play for this research assignment.

Your Role
☐ Electronics Engineer
☐ Biomedical Scientist

2. Using the links provided in the Online Resources, research from the perspective of your role. The electronics engineer will examine the general benefits and drawbacks. The biomedical scientist will examine the benefits and drawbacks to human health.

Online Resources

Continues next page >

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Millimeter High-Frequency Wave Technology Capture Sheet

Continued

3. After your research is complete, fill out the table with the benefits and drawbacks based on your selected role. Electronics engineer should provide the general benefits and drawbacks. Biomedical scientist should provide the benefits and drawbacks to human health.

	Notes
A Benefits	
B Drawbacks	

Continues next page >

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Millimeter High-Frequency Wave Technology Capture Sheet

Continued

4. Based on your research and your partner's research, do the pros outweigh the cons for this technology?

   Answer in one or two complete sentences and make sure to justify your response.

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Group Discussion Rubric

Group Members ______________________________

____

Score	3	2	1
Viewpoint	Viewpoints are clear and organized	Most viewpoints are clear.	Viewpoints are unclear and disorganized.
Use of facts and examples	Arguments are supported with facts and examples.	Some arguments are supported with facts and examples.	Arguments lack factual support.
Relevance of supporting arguments	All supporting arguments are relevant.	Many, but not all, supporting arguments are relevant.	Few supporting arguments are relevant.
Strength of arguments	All arguments are strong and convincing.	Some arguments are convincing.	Arguments are not convincing.
Speaking voice	Voice can always be heard.	Voice is heard most of the time.	Voice is difficult to hear.
Preparation	Student is well prepared.	Student needs more preparation.	Student is unprepared to defend argument.
Final Score			

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Final Electromagnetic Radiation Project Rubric

Directions

Evaluate the presentation by responding with reflective comments based on the expectations below. Use the space in the center column to share evidence with the group. Use the Feedback column for areas of growth and the Exceeded column for areas that excel.

Feedback How can this presentation be improved?	Baseline How does this presentation meet expectations?	Exceeded How does the presentation exceed expectations?
	Overall appearance: project appears professional and polished, no obvious errors.	
	Background information, properties, and characteristics: project accurately describes background information, properties, and characteristics on the specific type of electromagnetic radiation.	
	Practical uses in everyday life or industry: project accurately describes uses of the specific type of electromagnetic radiation in everyday life or industry.	
	Benefits to humanity: project descriptions of the benefits to humanity are well laid out and detailed.	
	Potential harmful effects: project descriptions of the possible harmful effects are well laid out and detailed.	