## NGSS/Common Core State Standards

### Students who demonstrate understanding can:

**MS-PS4-1.** Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]

**MS-PS4-2.** 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.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]

### Science and Engineering Practices

- **Developing and Using Models**
  - Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
  - Develop and use a model to describe phenomena. (MS-PS4-2)

- **Using Mathematics and Computational Thinking**
  - Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.
  - Use mathematical representations to describe and/or support scientific conclusions and design solutions. (MS-PS4-1)

### Disciplinary Core Ideas

#### PS4.A: Wave Properties
- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1)
- A sound wave needs a medium through which it is transmitted. (MS-PS4-2)

#### 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. (MS-PS4-2)
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2)
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2)
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2)

### Crosscutting Concepts

- **Patterns**
  - Graphs and charts can be used to identify patterns in data. (MS-PS4-1)

- **Structure and Function**
  - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS4-2)

### Connections to other topics in this grade level:

- MS.LS1.D (MS-PS4-2)
Articulation across grade levels:
4.PS3.A (MS-PS4-1); 4.PS3.B (MS-PS4-1); 4.PS4.A (MS-PS4-1); 4.PS4.B (MS-PS4-2); HS.PS4.A (MS-PS4-1),(MS-PS4-2); HS.PS4.B (MS-PS4-1),(MS-PS4-2); HS.ESS1.A (MS-PS4-2); HS.ESS2.A (MS-PS4-2); HS.ESS2.C (MS-PS4-2); HS.ESS2.D (MS-PS4-2)

Common Core State Standards Connections:
ELA/Literacy -
SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-PS4-1),(MS-PS4-2)

Mathematics -
MP.2 Reason abstractly and quantitatively. (MS-PS4-1)
MP.4 Model with mathematics. (MS-PS4-1)
6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS4-1)
6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS4-1)
7.RP.A.2 Recognize and represent proportional relationships between quantities. (MS-PS4-1)
8.F.A.3 Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. (MS-PS4-1)

Interpretation & Description
Students will learn about the different types of UV rays and their effects on the body’s integumentary system (skin), particularly the effects of sunburn and skin cancer. Students will use ultraviolet sensitive paper to test four different sunscreens to see if there is a relationship between the SPF rating and the sunscreen’s ability to block UV rays before they are absorbed by an individual’s skin.

Learning Targets
By the end of this activity, students will be able to:
- Differentiate between the three different types of UV radiation.
- Compare and contrast visible light and UV radiation.
- Explain the difference between different SPF sunscreens and assess which sunscreen would be the best option to block UVA and UVB radiation.
- Develop and use a model to describe how when light shines, it is reflected, absorbed, or transmitted through a given object, depending on the material of the object and the frequency of the light.

Time

<table>
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<tr>
<th>Estimated Time</th>
<th>Actual Time (please make note below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-45 minutes</td>
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</table>

Note: Share the actual time on the forum (www.haspi.org) or at HASPI curriculum conference
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<tr>
<th>Supply</th>
<th>Provided (P) or Needed (N)</th>
<th>Reusable?</th>
<th>Quantity</th>
<th>Company/Item #</th>
<th>Approximate Cost</th>
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<td>20</td>
<td><a href="http://www.officemax.com/office-supplies/paper/construction-paper-1/product-prod4070282?R=21039573&amp;ssp=true&amp;fromUrl=TnRwYz0xJkQ9cGFwZ3IrYmxyd2smtNnRw0xJk50eT0xJk50eD1tb2RJcJlbfWF0Y2hhbGxwYXJoWFsJk50az1EZWZhdWx0Jk49MCZObz0wJkR4PW1vZGUiMmJtYXRjaGFsbHBncRpYWwmTnR0PXhcvK2JsYWNr">http://www.officemax.com/office-supplies/paper/construction-paper-1/product-prod4070282?R=21039573&amp;ssp=true&amp;fromUrl=TnRwYz0xJkQ9cGFwZ3IrYmxyd2smtNnRw0xJk50eT0xJk50eD1tb2RJcJlbfWF0Y2hhbGxwYXJoWFsJk50az1EZWZhdWx0Jk49MCZObz0wJkR4PW1vZGUiMmJtYXRjaGFsbHBncRpYWwmTnR0PXhcvK2JsYWNr</a></td>
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<td>Sunscreen SPF 15</td>
<td>P</td>
<td>N</td>
<td>5g</td>
<td><a href="http://www.amazon.com/Banana-Boat-Performance-Sunscreen-Lotion/dp/B0030ZCG8G/ref=sr_1_1?ie=UTF8&amp;qid=1403816494&amp;sr=8-1&amp;keywords=sunscreen+spf+15">http://www.amazon.com/Banana-Boat-Performance-Sunscreen-Lotion/dp/B0030ZCG8G/ref=sr_1_1?ie=UTF8&amp;qid=1403816494&amp;sr=8-1&amp;keywords=sunscreen+spf+15</a></td>
<td>$5.94 / 8 oz.</td>
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<td>Sunscreen SPF 30</td>
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<td>5g</td>
<td><a href="http://www.amazon.com/Banana-Boat-Performance-Sunscreen-Lotion/dp/B0030ZEGDY/ref=sr_1_1?ie=UTF8&amp;qid=1403816523&amp;sr=8-1&amp;keywords=sunscreen+spf+30">http://www.amazon.com/Banana-Boat-Performance-Sunscreen-Lotion/dp/B0030ZEGDY/ref=sr_1_1?ie=UTF8&amp;qid=1403816523&amp;sr=8-1&amp;keywords=sunscreen+spf+30</a></td>
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<td>Sunscreen SPF 50</td>
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<td>N</td>
<td>5g</td>
<td><a href="http://www.amazon.com/Banana-Boat-Family-Sunscreen-12-Fluid/dp/B004CDV7EY/ref=sr_1_2?ie=UTF8&amp;qid=1403816554&amp;sr=8-2&amp;keywords=sunscreen+spf+50">http://www.amazon.com/Banana-Boat-Family-Sunscreen-12-Fluid/dp/B004CDV7EY/ref=sr_1_2?ie=UTF8&amp;qid=1403816554&amp;sr=8-2&amp;keywords=sunscreen+spf+50</a></td>
<td>$12.03 / 12 oz.</td>
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### Additional Information

<table>
<thead>
<tr>
<th>Information</th>
<th>Page #</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>There is enough material provided for this lab to be completed in partners (20 groups).</td>
<td></td>
<td>SETUP</td>
</tr>
<tr>
<td>Cut the transparency sheets, UV sensitive paper, and black sheets into 1¼” x 5” strips.</td>
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<td></td>
</tr>
<tr>
<td><em>Be sure to keep the UV sensitive paper covered and free from light exposure as much as possible.</em></td>
<td></td>
<td>SETUP</td>
</tr>
<tr>
<td>This lab can be expanded to also test different brands of the same SPF rating, additional SPF ratings, or the differences between creams and sprays.</td>
<td></td>
<td>SETUP</td>
</tr>
<tr>
<td>The UV sensitive paper responds best to direct sunlight. UV rays are still present on a cloudy and rainy day, but you may want to check the weather forecast before doing this lab.</td>
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<tr>
<td>You may also want to discuss this point with your students.</td>
<td></td>
<td>SETUP</td>
</tr>
<tr>
<td>Students will need to rinse their UV sensitive paper with water toward the end of the lab. If you do not have sinks with running water in your classroom, be sure to set out a few bins of water for your students to simply dip the UV sensitive paper for 30-60 seconds.</td>
<td></td>
<td>SETUP</td>
</tr>
<tr>
<td>Be sure to remind students to keep the UV sensitive paper covered with the black sheets at all times until they reach Step 6.</td>
<td>213</td>
<td>Step 1</td>
</tr>
</tbody>
</table>
If providing black permanent markers is an issue, students may substitute with pencils. However, you may have to point out that a pencil mark will be difficult to see, but an indent should still be visible.

Students will only need a small amount of each sunscreen for this lab. Instead of separating the small amounts provided into even smaller amounts to distribute around the room, it is recommended that you keep the sunscreen containers in a single location and have students come up and dip their cotton swabs as the sunscreen is needed.

Resources & References

http://science.howstuffworks.com/life/131-how-sunburns-work-video.htm
http://www.webmd.com/skin-problems-and-treatments/guide/sunburn
http://www.pamf.org/teen/health/skin/sun.html
http://www.skincancer.org/news/tanning/fda
Lab 11 – Sunburns & Sunscreen
HASPI Middle School / Medical Physical Science

Background

Have you ever laid out in the sun hoping to get a nice golden tan, only to be left looking as red as a lobster placed in the pot to boil? Despite many health warnings about the damaging effects of sun exposure, many individuals still subject their skin to the sun’s burning rays and risk the consequences of getting sunburned. According to the Center for Disease Control, more than one-third of all American adults (and nearly 70% of children) admit they have been sunburned within the past year.

Ultraviolet Radiation
Besides producing visible light that distinguishes between day and night on Earth, the sun also gives off massive amounts of ultraviolet radiation, or UV rays. UV rays (100-400 nm) have wavelengths shorter than visible light (400-700 nm), making it invisible to the naked eye. There are three types of UV rays: UVA, UVB, and UVC rays. UVC rays are the most powerful, but do not reach the surface of the Earth because they are blocked out by the Earth’s ozone layer. UVB and UVA rays, on the other hand, not only reach the Earth’s surface but also penetrate your skin and can cause damage, including cancer.

When UVB and UVA rays hit your skin, many living cells become damaged and die, causing your body to react in a few different ways. At the deepest part of the epidermis (see image), there are cells called melanocytes. When UV rays hit your melanocytes, they produce a chemical called melanin. Melanin is a dark brown pigment that darkens your skin, causing you to tan. Melanin also protects your skin’s important structures by blocking further UV penetration. However, melanin does not block out all UV light.

Too much UV exposure can cause living skin cells to become damaged and die. When this happens, the immune system responds by removing damaged cells from the body. It increases blood flow to
the affected areas, opening up capillary walls so that white blood cells can clean up the mess. This increased blood flow also results in the first visible signs of sunburn, as the process makes your skin warm and red.

If given enough time, UVA rays can penetrate your skin all the way down to the dermis, where nerves and blood vessels are located. These UVA rays can trigger nerve endings for pain and send signals to the brain. This is why sunburned skin is sensitive to touch and stings.

**Skin Cancer**

UV radiation causes mutations in the DNA of living skin cells. This is the main culprit in premature aging and wrinkles. However, if these DNA mutations occur in parts of the DNA that control cell growth, uncontrolled cell growth occurs and tumors will form.

There are three main types of skin cancer, which are categorized by the type of skin cells they develop. Basal Cell Carcinoma affects the basal cells that lie just below the epidermis. This is the most common type of skin cancer, making up for about 75% of all reported skin cancers. These cancers look like shiny, waxy bumps on the skin. Squamous Cell Carcinoma affects the squamous cells that make up the majority of the epidermis and looks like a red, scaly bump or nodule on the skin. This type of cancer is more aggressive than basal cell carcinoma, but is easily treated when found early. Melanoma is the least common type of cancer but accounts for nearly 75% of all skin cancer-related deaths. Melanoma affects the melanocytes in the epidermis, which are the cells that produce the pigment melanin. This cancer commonly starts as a mole that becomes cancerous and appears as a large brown spot with irregular borders.

![Squamous Cell Carcinoma](http://uvahealth.com/Plone/ebsco_images/2526.jpg)

**Sunscreen**

Since the number one risk for skin cancer is sun exposure, the use of sunscreen is the best prevention. Sunscreens are made with chemical compounds, like zinc oxide and para-aminobenzoic acid (PABA), which form a thin, protective layer on the surface of the skin that will reflect or absorb ultraviolet light for a period of time before it penetrates the skin. Furthermore, some sunscreens only contain chemicals that block UVB rays while still allowing UVA rays to penetrate the skin. UVA radiation will not cause sunburns, but still poses a risk for cancer. Only **broad-spectrum** sunscreens provide both UVA and UVB protection.

A sunscreen’s efficacy is measured by the **sun protection factor**, or SPF. This is a measure of how long it will take for UVB rays to redden the skin when using a sunscreen, compared to how long skin would take to redden without the presence of sunscreen. For instance, someone using a sunscreen with an SPF of 30 will take 30 times longer to redden than a person without sunscreen. It is also important to note that everyone—even individuals with dark skin tones—can sunburn and develop skin cancers, including melanoma.
In 2012, the U.S. Food and Drug Administration (FDA) established new laws to help consumers better navigate sunscreen labels and understand which products offer the best protection from the sun’s harmful rays. The FDA’s regulations include strict testing guidelines for sunscreen manufacturers, a new labeling system, banned use of unproven claims about waterproof capabilities and all-day protection, and in some cases (such as when the product is not broad-spectrum, or below a certain SPF) a warning label that cautions how spending time in the sun can increase the risk of skin cancer and premature skin aging. The warning label may also explain that the product has only been shown to prevent sunburn, not skin cancer or early skin aging. These measures are designed to better educate individuals about the real harms of sun exposure without the proper sunscreen protections in use.

**Review Questions**

1. How does ultraviolet radiation differ from visible light?
2. What are the different types of ultraviolet radiation and how do they differ?
3. Explain how sun exposure causes an individual to tan.
4. What are a few different ways the human body responds to extended amounts of sun exposure?
5. What causes skin cancers to form?
6. What are the different types of skin cancer? How do they differ?
7. Fill in the blanks. Sunscreens are made with chemical compounds that ________________ or ____________________________ ultraviolet light before it penetrates the skin.
8. What is a broad-spectrum sunscreen?
9. What does SPF stand for and what does it measure?
10. Give three examples of regulations the Food and Drug Administration has recently put in place to protect consumers as they choose and use sunscreen products.
Lab 11 – Sunburns & Sunscreen
HASPI Middle School / Medical Physical Science

Scenario
It is logical to think that a sunscreen with SPF 30 is twice as effective as a product with SPF 15. However, many professionals say that is not exactly how it works, and that using a really high SPF is not necessarily advantageous for an individual.

In this activity, you will use UV sensitive paper to determine whether there is a difference in the amount of UV radiation that passes through sunscreens of varying SPFs.

Materials
- Transparency Sheet
- UV Sensitive Paper Sheet
- Black Paper Sheet
- Paper Towel
- Penny/Nickel
- Black Permanent Marker
- Timer
- Cotton Swabs (4)
- Sunscreen SPF 15
- Sunscreen SPF 30
- Sunscreen SPF 60
- Sunscreen SPF 100
- Water
- Tape

Directions

TASK

WARNING! The UV sensitive paper will react to any UV light, so it is important to keep the UV sensitive paper covered with the black sheet at all times except during the experiment.

Remember: UV radiation is characterized by a lower wavelength than visible light and may be present even if not detected by the human eye.

1. Obtain 4 cotton swabs, a transparency sheet, a UV sensitive sheet, a black sheet, and a penny/nickel.

Make sure the UV sensitive paper is covered with the black sheet at all times.
<table>
<thead>
<tr>
<th>Step</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Using the black permanent marker (or pencil) and the penny/nickel, draw five circles about 1 cm apart on the transparency sheet. A pencil mark will be difficult to see, but an indent should be visible.</td>
</tr>
</tbody>
</table>
| 3    | Label each of the 5 circles with the following:  

![Diagram](image)

The “C” stands for control and each number represents the SPF that will be used. |
| 4    | Leave the control circle blank.  
Using a cotton swab, collect a small amount of SPF 15 sunscreen and apply it to the circle labeled “15.” Make sure the circle is evenly covered before discarding the cotton swab. |
| 5    | Repeat step 4 for the SPF 30, SPF 60, and SPF 100 samples. Make sure to use a new cotton swab for each sunscreen. |
| 6    | Remove the black sheet from the UV sensitive paper and place the transparency sheet over the blue side of the UV sensitive paper. Use a small amount of tape to secure the edges of the transparency sheet to the UV sensitive paper to hold it in place. |
| 7    | Set the timer for 5 minutes and have it ready to “start.”  
Place the transparency + UV sensitive paper with the transparency side up in direct sunlight. Make sure to avoid shadows.  
Start the timer and leave the paper exposed to direct sunlight for 5 minutes. |
| 8    | At the end of the 5 minutes, quickly remove the transparency sheet from the UV sensitive paper and run water over (or submerge) the UV sensitive paper for 30 seconds to 1 minute. This will set the color and prevent UV light from causing any further color change. After this step, you will not need to worry about keeping the UV sensitive paper out of direct sunlight.  
Note: Images will turn lighter during this process. |
| 9    | Let the UV sensitive paper dry on a flat surface lined with a paper towel.  
Note: Images will darken to a richer blue as the UV sensitive paper dries. |
| 10   | Record the color changes, if any, to the UV sensitive paper after it has completely dried in Table 1 below. You may wish to include a colored pencil drawing of your results in your observations. |
Analysis & Interpretation

Table 1: UV Sensitive Paper Observations (record color changes)

<table>
<thead>
<tr>
<th></th>
<th>CONTROL</th>
<th>SPF 15</th>
<th>SPF 30</th>
<th>SPF 60</th>
<th>SPF 100</th>
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<td></td>
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Analysis Questions

1. What happened to the UV sensitive paper when it was exposed to UV radiation?
2. What was the purpose of the control circle in this experiment?
3. Which SPF sunscreen was most effective at blocking UV radiation? Provide evidence from your observations to support your answer.
4. Were there any SPF sunscreens that showed little or no difference in the effectiveness of the SPF level? Provide evidence from your observations to support your answer.
5. Sunscreens normally are only effective for up to 2 hours. What do you think would happen to the UV sensitive paper in this experiment if it were left in the sunlight for 5 hours? How does this relate to using sunscreen on your skin?
6. As mentioned in the lab scenario, many professionals argue that a sunscreen with a really high SPF is not necessarily advantageous over others. Drawing from the observations made in this experiment, would you agree or disagree with this claim? What SPF sunscreen would you recommend for use?

Connections & Applications

1. While most people are familiar with the dangers of spending too much time under the sun, many individuals have turned to using indoor tanning devices as an alternative way to gain an attractive tan. However, over the past decade there has been a great deal of research that has exposed the dangers of indoor tanning device usage. Such research has even sparked national and international debates over the regulation of these devices and their usage. http://www.skincancer.org/news/tanning/fda
Research the pros and cons of the use of indoor tanning devices and present your findings to your classmates in the form of a PowerPoint presentation, poster board, or a computer-generated, self-narrated video. Your presentation may include, but is not limited to, the following:

- Summaries of the arguments made both in favor of and against indoor tanning device usage
- Health risks associated with indoor tanning devices
- Research studies and statistics
- Previous and current regulations associated with indoor tanning devices (include specific years)
- Source citations for all of your research, including any images or video clips you used

2. Skin cancer is far and away the most common form of cancer in the United States. The Skin Cancer Foundation claims that one in five Americans will develop skin cancer in the course of a lifetime, and each year there are more new cases of skin cancer than the combined incidences of cancers of the breast, prostate, lung, and colon.

The different types of skin cancer were briefly introduced in the lab Background. Conduct more research to create an informative presentation on skin cancer. Your presentation may be in the form of a PowerPoint presentation, poster board, or computer-generated, self-narrated video and may include, but is not limited to, the following:

- Descriptions of each type of skin cancer (more elaborate than what was provided in lab Background)
- Risk factors associated with skin cancer
- Facts and statistics regarding the prevalence in the United States and worldwide
- Treatments associated with skin cancer
- Summarization of current research regarding skin cancer
- Prevention tips
- Source citations for all of your research, including any images or video clips you used

Resources & References

http://science.howstuffworks.com/life/131-how-sunburns-work-video.htm
http://www.coastalliving.com/lifestyle/fda-sunscreen-labeling-laws
http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm258416.htm#top
http://www.webmd.com/skin-problems-and-treatments/guide/sunburn
http://www.pamf.org/teen/health/skin/sun.html
http://www.skincancer.org/news/tanning/fda