**Upon receiving AND packing up this kit, make sure you have…**

All Stations:

* Station-Specific Instructions
* Electromagnetic Spectrum Chart

Station 1:

* 1 Corded LED Lamp
* 1 Corded Blacklight Lamp
* 3 Radiometers
* 1 Thermometer
* 6 Pairs of Diffraction Glasses

Station 2:

* 1 Green Laser Pointer
* 1 Acrylic Prism
* 1 Small LED Light
* 3 Pairs of Sunglasses
* 1 Roscolux® “Gel” Swatchbook
* 1 Roscolux® “#80” Chart
* 1 Roscolux® “#26” Chart
* 1 Roscolux® “#59” Chart
* 1 Roscolux® “#325” Chart

Station 3:

* 1 Spectrum Tube Carousel (Order Separately)
* 6 Pairs of Diffraction Glasses
* 1 Element Emission Spectra Chart (H, He, Na, Hg)

Station 4:

* 1 Blacklight Flashlight
* 1 Set Fluorescent Minerals
* 1 Green Laser Pointer
* 1 Green+Blue Laser Target
* 1 Pink Liquid Chalk Marker
* 1 Orange Liquid Chalk Marker
* 1 Green Liquid Chalk Marker
* 1 Blue Liquid Chalk Marker
* Sticky Notes (Supplied by Teacher)

Station 5:

* 1 Red Laser Pointer
* 1 Green Laser Pointer
* 1 Violet-UV Laser Pointer
* 1 Jar Petroleum Jelly
* 1 Bottle Tonic Water
* 1 Bottle Sprite®

Station 6:

* 1 Red Laser Pointer
* 1 Green Laser Pointer
* 1 Violet-UV Laser Pointer
* 1 Pack of Glow Stars
* 3 Phosphorescent Vinyl Sheets

**Incorporated/Related Standards:**

* **ICP.9.2** Develop and apply a simple mathematical model regarding the relationship among frequency, wavelength, and speed of waves in a medium as well.
* **ICP.9.5** Describe and provide examples of how modern technologies use mechanical or electromagnetic waves and their interactions to transmit information.

**When using this kit, these tips may help!**

* The 6 stations in this lab can be done in any order! Allowing students to freely move from station-to-station may work best with this (especially if you have more than 6 groups), as some stations may take longer than others.
* Set up the stations ahead of time! Depending on your classroom space, you may want to test how and where you place each station’s materials.
* Allow at least two days for students to work and think through this lab. If students are rushed, they may skip on investigating and chasing their curiosity just to finish the questions! *This should also leave some time at the end of class to make sure all of the lab materials are still there (there are many small objects that are easy to walk off with).*
* Focus on in-class observation! This activity works best when you can quickly check and guide group as they experiment with the materials. You could even follow up with questions on the spot! *It may be fitting to print your own versions of the instruction sheets and check off the questions as the groups finish them.*
* Cover the basics of light waves ahead of time (e.g. wavelength, frequency, energy, intensity, mostly for the visible light section of the electromagnetic spectrum). Students will have greater confidence (and therefore should be more determined) during the lab if they have a springboard into these topics!
* Discuss issues of safety and proper handling of equipment! *This could include not touching hot blacklight bulbs, not looking directly into flashlights and laser pointers, and not touching spectrum tubes (not just due to heat, but the oils from your skin can cause hotspots in the tubes and burst them).*

***Station 1: Incoming Energy, Distance, and Angle of Light***

1. **The blacklight lamp at this table releases violet-ultraviolet (UV) light, while the LED lamp releases a combination of all versions of visible light. Plug in the LED lamp, and make sure it is close enough to the middle of the radiometers.**
	* What happens inside the radiometers when the LED bulb shines onto them?
	* Does the thermometer change when the LED bulb shines onto it? What type of energy is the light converted into?
	* Put on a pair of Diffraction Glasses to separate out the light you’d normally see from the LED bulb into its individual wavelengths of light. What individual colors make up the white light coming from the LED bulb?
2. **Unplug the LED lamp and plug in the blacklight lamp, placing it in the same spot where the LED lamp was. This bulb will get hot, so do NOT touch it directly!**
	* What is different about the radiometers with the blacklight bulb shining on them instead of the LED bulb? Which bulb was brighter?
	* Does the thermometer change when the blacklight bulb shines onto it? If there is a change, is it a bigger or smaller change than with the LED?
	* Put on a pair of Diffraction Glasses to separate out the light you’d normally see from the blacklight bulb into its individual wavelengths of light. What individual colors make up the violet light coming from the blacklight bulb?
3. **Compare the energies of different kinds of light. The sun in our solar system puts off visible light in addition to a lot of other invisible wavelengths, including ultraviolet (UV) light. In this model, the radiometers represent the surface of the earth, and the blacklight lamp represents the sun.**
	* What is the average (middle) wavelength in visible light? What is the average (middle) wavelength in ultraviolet light?
	* The brightness of a bulb has to do with how much light is released, not how much energy the light has. What evidence do you have from the radiometers and the thermometers to supports this?
	* The surface of the Earth is curved, meaning the sun’s light must travel greater distances to reach the top and bottom of the earth, and more direct light hits near the equator. Are all the radiometers affected equally? If not, what could be the cause of this? Explain your reasoning.
	* Why should sunscreen be worn when outside in the sun? What evidence shows that ultraviolet light from sunlight could be damaging? (Hint: think about its energy!)

***Station 2: Reflectance, Absorbance, and Transmittance***

1. **Typical room lighting is visible light – a combination of red, orange, yellow, green, blue, and violet light wavelengths. The color of everyday objects comes from reflected (bounced-back) wavelengths of visible light, whereas the ones that are absorbed are NOT seen. Transmitted light (that passes through without reflecting or absorbing) does not affect color. Shine a green laser pointer directly through the triangle-shaped side of the acrylic (plastic) prism. NEVER shine a laser pointer at anyone, and NEVER look into the beam of light!**
	* When seen in regular room lighting, does the acrylic prism have a color?
	* Does the prism mostly absorb or transmit light?
	* If you angle the green laser light through the sides of the prism, you may get it to reflect the light. How does the direction of the light change when it hits the prism?
2. **Since visible light that is reflected causes the color we see, white objects reflect the whole range of visible light, and very little visible light is absorbed or transmitted by white objects. We can make deductions about dark objects based on this. Shine the small LED light directly through one of the shaded lenses of the sunglasses.**
	* When seen in regular room lighting, do the shaded lenses have a color?
	* Do the shaded lenses mostly absorb or transmit light?
	* Try angling and rotating the sunglasses in different ways. Does this affect how well the light is absorbed, reflected, or transmitted?
3. **Many objects in everyday life can reflect, transmit, and absorb light in differing levels all at once. The combination of these interactions determines an object’s appearance (what color it is, and what color it isn’t). “Gels” are light filters that allow us to change the color of light, typically for lighting in drama theatre and photography.**
	* Flip to the gel R80, “Primary Blue.” This gel should absorb most colors of white light, leaving blue light (along with a little red and violet light) to pass through and reflect on its own. Is this supported by the graph of transmittance on its card?
	* Flip to the gel R26, “Medium Red.” Would this gel absorb green light? Can the green laser pointer be used to support this?
	* Flip to the gel R59, “Indigo.” What colors of light should be absorbed by this gel? Which colors of light should be transmitted and reflected by this gel? (Hint: pick from red, orange, yellow green, blue, and violet!)
	* A student designs a gel that absorbs green, blue, and violet light. What color of light would pass through and reflect off this gel? (Hint: you can try to find a gel that does this! Test it with the small LED light!)

***Station 3: Gas Spectrum Tubes and Simple Spectroscopy***

1. **Turn on the Spectrum Tube Carousel (do not touch any of the lamps!) and examine Spectrum Tube 5, which contains hydrogen gas. In this apparatus, electricity energizes the electrons in the tube. That energy is then released from the electrons as light. The color of light that you see coming from each spectrum tube is a combination of multiple different wavelengths of light.**
	* What color is the light you see coming from the energized hydrogen gas inside Spectrum Tube 5?
	* Put on a pair of Diffraction Glasses to separate out the light you’d normally see from the tube into its individual wavelengths of light. What individual colors make up the light coming from the hydrogen gas?
	* Which individual color of light coming from this tube has the longest wavelength? Which has the shortest wavelength?
2. **Examine Spectrum Tube 7, which contains neon gas. Again, electricity will energize the neon gas’s electrons, which will then release light. Since the atoms of neon have a different arrangement of electrons than the hydrogen gas in Spectrum Tube 5, the light released will also be different.**
	* What color is the light released from the energized neon gas inside Spectrum Tube 7?
	* Put on a pair of Diffraction Glasses to separate out the light you’d normally see from the tube into its individual wavelengths of light. What individual colors make up the light coming from the neon gas?
	* Which individual color of light coming from this tube has the highest frequency? Which has the lowest frequency?
3. **Examine Spectrum Tube 3, which contains an unknown gas. In order to figure out what stars are made of, we can match the spectrum (individual colors) of light released from that star and match it to data we already have, like a fingerprint for an element.**
	* Put on a pair of Diffraction Glasses to separate out the light you’d normally see from the tube into its individual wavelengths of light. What individual colors make up the light coming from this unknown gas?
	* Which individual color of light coming from this tube has the highest energy? Which has the lowest energy?
	* Compare the colors of light coming from this sample to the chart of different elements’ light spectra. What gaseous element is most likely in Spectrum Tube 3?
	* The opposite process can also be used to identify elements – any colors of light that aren’t released by an element are absorbed instead. What colors of light might be absorbed by this gas?

***Station 4: Experimentation with Emitted Light***

1. **“Fluorescence” is a process where one color of light is absorbed by a substance, then a lower-energy color of light is released. This only happens while the energy is being absorbed – as soon as you stop putting energy in, the light stops being released. Use the blacklight flashlight to shine violet-ultraviolet (UV) light at the minerals on the table. NEVER shine the blacklight at anyone, and NEVER look into the beam of light!**
	* Does a lower-energy color of light get released from the minerals when the violet-ultraviolet light shines on them? If so, what color is released?
	* Do the minerals continue to glow (release light) when the blacklight flashlight is not shining on them?
	* Based on your findings, are these minerals fluorescent? Explain your reasoning.
2. **“Phosphorescence” also involves absorbing one color of light to release a lower-energy color of light, but instead, it glows – that color of light continues to release over time even after you stop putting energy in. Shine the green laser pointer onto the “Green+Blue Laser Target” (the pink disk). NEVER shine a laser pointer at anyone, and NEVER look into the beam of light!**
	* Does a lower-energy color of light get released from the disk when the green laser light shines on it? If so, what color is released?
	* Does the disk continue to glow (release light) when the green laser light is not shining on them?
	* Based on your findings, is this disk fluorescent or phosphorescent? Explain your reasoning.
3. **Some products are marketed as “fluorescent” or “glow-in-the-dark” to describe them as very bright or reflective colors, but they may not be scientifically fluorescent or phosphorescent. Scribble a tiny bit with each of the four colors of “liquid chalk” markers onto a sticky note, then test them for fluorescence or phosphorescence with the blacklight flashlight and the green laser pointer.**
	* Which marker ink colors release a lower-energy color of light when the violet-ultraviolet light shines on them? What new color of light is released?
	* Which marker ink colors release a lower-energy color of light when the green laser light shines on them? What new color of light is released?
	* Do any of the marker ink colors continue to glow (release light) when the violet-ultraviolet light or green laser light is not shining on them?
	* Based on your findings, are any of these marker ink colors truly fluorescent? Are any truly phosphorescent?

***Station 5: Energy of Fluorescence***

1. **Three powerful laser pointers are available at this station: red, green, and violet-ultraviolet (UV). NEVER shine a laser pointer at anyone, and NEVER look into the beam of light! Shine the laser pointers at your paper to clearly see their colors.**
	* Which laser pointer has the longest wavelength of light?
	* Which laser pointer has the highest frequency of light?
	* Which laser pointer has the lowest energy of light?
2. **When something “fluoresces,” one high-energy color of light is absorbed, then a lower-energy color of light is released. Therefore, high-energy wavelengths of light (usually green, blue, or violet-ultraviolet) can be used to detect fluorescent chemicals. One example of this is the fluorescent petroleum searched for when digging for oil. Try shining each of the three laser pointers into the container of petroleum jelly. DO NOT open the container!**
	* Which laser pointers make the petroleum jelly fluoresce? Which ones don’t?
	* When the petroleum jelly fluoresces, what color of light is released? Is this higher-energy or lower-energy than the original light used?
	* Using the electromagnetic spectrum, estimate the wavelength (in nanometers, nm) of the light fluorescing from the petroleum jelly.
3. **A student sees a video online that tonic water is fluorescent in violet-ultraviolet (UV) light. The tonic water and Sprite® available at this table have almost the same ingredients. Try shining the violet-ultraviolet (UV) laser pointer into the container of tonic water, as well as into the Sprite®. DO NOT open either bottle!**
	* Which beverage is fluorescent under violet-ultraviolet (UV) laser light: tonic water or Sprite®?
	* What is the color of light that is RELEASED from the fluorescence? Is it higher-energy or lower-energy than the incoming violet-ultraviolet (UV) laser light?
	* Check the ingredients on the backs of both bottles. What might be the unique fluorescent chemical in the fluorescent beverage?
	* Are either of the other laser pointer colors (red and green) high enough in energy to cause fluorescence? How can you tell?

***Station 6: Energy of Phosphorescence***

1. **Three powerful laser pointers are available at this station: red, green, and violet-ultraviolet (UV). NEVER shine a laser pointer at anyone, and NEVER look directly into the beam of light! Shine the laser pointers at your paper to clearly see their colors.**
	* Using the electromagnetic spectrum, estimate the wavelength (in nanometers, nm) of the red laser pointer.
	* Using the electromagnetic spectrum, estimate the wavelength (in nanometers, nm) of the green laser pointer.
	* Using the electromagnetic spectrum, estimate the wavelength (in nanometers, nm) of the violet-ultraviolet laser pointer.
2. **When something “glows-in-the-dark,” one color of light is absorbed, then a lower-energy color of light is released over a long period of time. This process is also called “phosphorescence.” If the absorbed light isn’t high enough in energy, no glowing will occur. Try shining each of the laser pointers onto the glow-in-the-dark stars.**
	* Which laser pointers make the glow-in-the-dark stars phosphoresce? Which don’t?
	* When the glow-in-the-dark stars phosphoresce, what color of light is released? Is this higher-energy or lower-energy than the original light used?
	* Does the glowing last the same amount of time for any laser pointer that causes the glow-in-the-dark stars to phosphoresce? If not, which ones are different, and why?
3. **Phosphorescent materials aren’t just for fun – they’re also useful tools in science! Different energies of light can be detected visually, as glowing spots will show up where the energy is absorbed. Shine the violet-ultraviolet (UV) laser pointer onto the phosphorescent vinyl sheet (like the one used in the discovery of the atomic nucleus).**
	* What can be done to change how long the glow lasts from the phosphorescent sheet? (Hint: try shining the light at different distances and angles from the sheet!)
	* When the phosphorescent sheet glows, what color of light is released? Is this higher-energy or lower-energy than the violet-ultraviolet light used?
	* Are there any other laser pointer colors (red or green) that can make the phosphorescent sheet glow? If so, which ones?
	* Using the laser pointer that couldn’t make the phosphorescent sheet glow, try forcing the sheet to glow by getting the laser pointer very close. Why won’t this work?