



Intern: Nikita, Engineering Physics Major

Topic: Electromagnetic Spectrum

Setting: Boynton Middle School Afterschool Program

Lesson Plan

Set up lab stations before the students arrive.

Question: What is a wave? If you were to draw an imaginary wave in the air right now, what would it look like?

Demo#1

Ask volunteer to hold one side of a slinky. Show a transverse wave and ask if this is a wave. Make some observations about the wave. Now show a compression wave. Is this a wave? What is the difference between the two waves I showed you?

Define wavelength and frequency. If I increase the speed the waves occur, what happens? You see more waves, right? But the lengths of these waves are shorter. We like to call the distance from one top part of the wave to the next top part of the wave the wavelength. We also like to call the time it takes one of these cycles (top to top) to happen, the period of the wave. The number of periods that occur in 1 second is called the frequency. One way to remember this is if you ask yourself, how frequently the cycles occur in 1 second.

Ask the students for examples of waves.

Ocean waves: You can see them move up and down

Sound waves: You cannot see them, but you can hear them. Sound waves act the same way the slinky did for a compression wave.

Radio Waves: When you drive in the car, you may listen to the radio. Have you noticed your car has an antenna? This antenna can pick up AM and FM radio. AM waves have a longer wavelength than FM radio signals.

Microwaves: How many of you use a microwave? Have you ever wondered how the food heats up? Also, how many of you use cell phones? Cell phones use microwaves to send and receive signals. Radar systems use microwaves as well.

X-Ray: How many of you have broken a bone before? Did you have to get an X-ray done? X-rays have very short wavelengths and have great penetrating power. That is why doctors are able to see your bones.

Energy: We just talked about how an X-ray has a lot penetrating power so it can let us see your bones. This is because the shorter the wavelength, the more energy the wave has.

One wave we did not talk about is light. There are different kinds of light based on the wavelength. Why are light waves important for space scientists?

Show the students the NASA Electromagnetic Spectrum poster and talk about light as a wave. The bottom of this chart shows an image of the same galaxy detected in different wavelengths. Radio waves have wavelengths that are as small as the size of humans and as big as the size of buildings. Microwaves are the size of a honeybee. Infrared is the size of a pinhead. When you get down to X-ray, it is the size of an atom. Gamma rays were not mentioned.

There are some light waves you can see and some that you cannot see. It is now your turn to be scientists. I've set up many lab stations. Each station has a source of light and a detector (what detects the light).

For example, this flashlight is a source of light and when you point it towards white paper, it is detected. What is detecting the light? Your eyes. Our eyes can detect visible light, but cannot detect light in other parts of the EM spectrum. Ask for a volunteer for each station and say what the source of light and the detector is. Now that you know what the detector for each station is, you can make some observations about each source of light. At each station, there are different materials. Demonstrate with visible light how to make predictions for which materials will transmit the light and which will block (or shield) the light. Show them how to fill in the worksheet with predictions and testing results for each station.

LAB STATIONS:

1. UV light – source: UV lamp (blacklight); detector: UV beads
2. Near Infrared – source: TV remote control; detector: photocell receiver circuit that converts light to sound and digital camera that can detect infrared
3. Thermal Infrared – source: heat lamp; detector: skin

Small groups predict and test at each station. Provide supervision and answer questions.

1. What are some other sources of light we can see?
 - a. Note: Moon reflects the light of the Sun and it isn't a source.
2. What are some light detectors that you know of?
 - a. Eyes, Cameras, camcorders, etc.
3. Have you ever put on sunscreen? Is it a transmitter or a shield? What type of light wave does it shield?
4. What kinds of waves are received/transmitted by a satellite TV dish?
 - a. Microwave
5. How fast do you think light travels?

You just worked with three different light waves. Can anybody identify them for me?

Visible Light: The rainbow of the colors

Infrared: Light as thermal or heat radiation

UV Light: Sunburn

Nikita told the students about a satellite project team she is involved with at Cornell, in which a group of undergraduate students is designing, building and launching a small satellite. On this satellite there will be a UV spectrometer, which will observe ultraviolet and visible light in

the atmosphere. They can use the UV spectrometer to detect different compounds like oxygen gas or water.

Sources:

Activities adapted from the *Comparing Wave Makers* and *Invisible Light Sources and Detectors* activities from the “Invisible Universe” LHS GEMS guide, and the *Invisible Light* session from the NASA *Afterschool Universe* program (<http://universe.nasa.gov/au/>).

NASA Electromagnetic Spectrum poster: NASA CORE catalog
<http://corecatalog.nasa.gov/item.cfm?num=300.1-41P>

Materials:

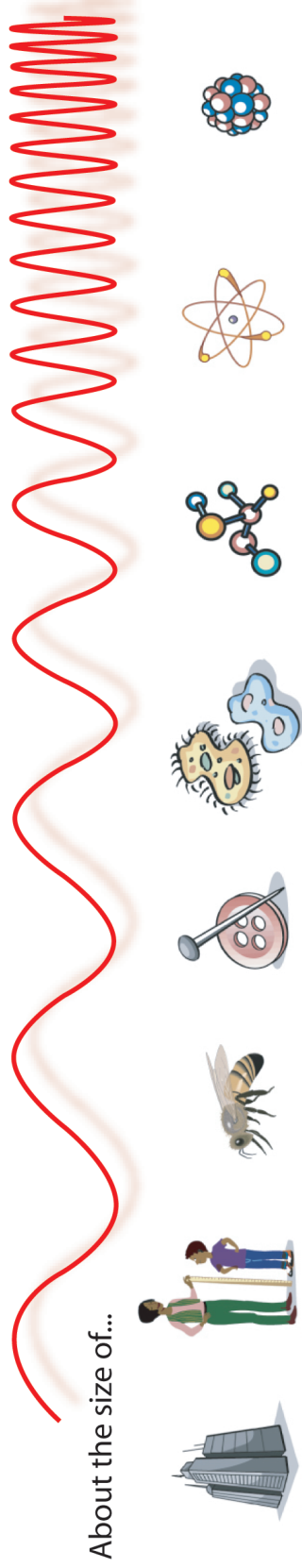
- Worksheets for station activity
- Slinky and/or other materials to demonstrate waves (springs, ropes, coiled telephone cord, plastic tubing, etc).
- Flashlight (for visible light demonstration)
- Photocell detector circuit (3-300 solar mini-panel from solar-world.com; jumper leads, mini audio amplifier/speaker, and shielded cable from Radio Shack (#278-1157, #277-1008, #42-2434), 9-volt battery for amplifier)
- Remote control
- Digital camera (optional)
- Heat lamp bulb and clamp lamp (caution – very hot!)
- Portable UV light and UV detecting beads (available from Educational Innovations, teachersource.com)
- Materials (~12”x12” pieces) to test light transmission or shielding: fabric, clear plastic, black plastic, wax paper, aluminum foil, white paper, black construction paper, etc
- Electromagnetic Spectrum poster and/or EM Spectrum handout/s

THE ELECTROMAGNETIC SPECTRUM

Penetrates Earth Atmosphere?

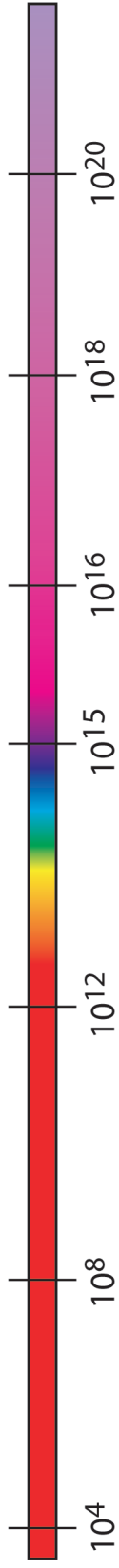


Wavelength (meters)



Buildings Humans Honey Bee Pinpoint Protozoans Molecules Atoms Atomic Nuclei

Frequency (Hz)



Temperature of bodies emitting the wavelength (K)

