**Lesson Planning Template**

**COSMOS EDUCATIONAL TOOLKIT:**

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| **Grade/ Grade Band**: 6-8 | **Topic:** Radio Waves in different media | **Lesson #** 1 **in a series of 1 lessons** |
| **Brief Lesson Description**: Students will use a walkie talkie as a transmitter of radio waves and the COSMOS nook as a receiver. They will compare the signal strength of the radio waves through different materials (wood, concrete, metal, etc.). |
| **Specific Learning Outcomes:** Students will understand how the Signal Strength of wireless signal is affected by the medium (material) between a wireless device and a COSMOS node. They will demonstrate that EM waves can travel well through air/empty space but not as well through solid materials or water. |
| **Narrative / Background Information**  |
| **Prior Student Knowledge Required:** Students should understand that EM waves do not need a medium to travel through. They should also have learned that sound waves cannot travel without a medium. If they are shaky on these concepts the lesson will hopefully help reinforce them.Students will also need to know that a walkie talkie functions by sending and receiving them and converting them to sound waves. (If students are not clear on this, they may be confused and think that they can hear radio waves, when what they actually hear is a sound signal modulated on a radio wave.) |
| **Problem Solving Practices (Ex: Standards for Mathematical Practice):** **Developing and Using Models****Develop a model to describe phenomena. (MS-PS4-2)****Scientific Knowledge is Based on Empirical Evidence** **Science knowledge is based upon logical and conceptual****connections between evidence and explanations (MS-PS4-1)** | **Main Content Ideas:** **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)****(NYSED) The path that light travels can be****traced as straight lines, except when it hits a surface between different transparent****materials (e.g., air and water, air and glass)****obliquely 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)****(NYSED) However, because light can travel****through space, it cannot be a mechanical****wave, like sound or water waves. (MS-PS4-2)** | **Possible Multidisciplinary Concepts:** **Cause and Effect Cause and effect relationships may be****used to predict phenomena in natural****or designed systems. (MS-PS1-4)** |
| **Possible Preconceptions/Misconceptions:** * **radio waves only come from radios (false - radio waves can come from other sources, especially stars in space)**
* **humans can see or hear radio waves (false - though sound can be an information signal carried on a radio wave)**
* **mechanical waves need a medium to travel (true)**
* **EM waves do not need a medium to travel (true)**
* **EM waves (light) cannot travel through walls (partially true - this depends on the wavelength of the light)**
* **Certain materials block EM waves (partially true - this depends on the material, its interaction or lack thereof with the EM wave, and the wavelength of the wave)**
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| **LESSON PLAN – 5-E Model**  |
| [**ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:**](http://www.youtube.com/watch?v=PUB1GU_tvpI&safe=active) Students discuss: * Could you and your best friend use walkie talkies to communicate underwater from opposite ends of the swimming pool? Why or why not?

(Hint: Do you think a walkie talkie could work underwater? Why or why not?) |
| **EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:** Briefly compare and contrast EM and mechanical waves with students: EM waves can travel without a medium while mechanical waves need a medium to move through.Students discuss: * what materials can we test in this room?
* which materials will allow EM waves to travel well? which materials will block or partially block EM waves?
* why?

Students make predictions about specific materials.Explain that students will prove for themselves that waves travel differently through different materials using a pair of walkie talkies and the COSMOS toolkit. |
| **EXPLAIN: Concepts Explained and Vocabulary Defined:** Students will need to learn that sound waves travel through water and salt water, but that radio waves (the basis for most modern communications) have difficulty traveling through water. Radio waves can also travel through solid materials such as buildings (this is how we can listen to the radio, etc.) - it depends on the solid material and the size of the wave.**Key Vocabulary:** * **sound wave**
* **radio wave**
* **frequency**
* **relative gain (dB)**
* **bandwidth**
* **signal strength**
* **attenuation**
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| **ELABORATE: Applications and Extensions:** * + CONCRETE:
		- Set up transmitter (walkie talkie) behind a concrete wall and the receiver (COSMOS Toolkit) on the other side of the wall
		- Ensure that the walkie talkie/transmitter remains in the same orientation the entire time
	+ Other options:
		- WOOD (WOODEN CLOSET DOOR)
		- METAL BOX (unplugged/unused microwave; metal classroom door)
		- AIR (control)
		- ALUMINUM FOIL
		- optional: WATER: Fill a 5 Gallon bucket with water
			* (5 gallon bucket = approx 19 liters. To make this into salt water of the same salinity as seawater--3.5% or 35 g/L--you’d need to add 665 g of salt and stir. 1 lb of salt from the grocery store is ~454 grams. So you’d need to add about 1.5 lbs of salt to your bucket.)
			* WATERPROOF: Double zip-lock bag the device (& tape/rubber band?)
			* ENSURE ORIENTATION: Attach a string to the base of the antenna
			* CALIBRATION: Determine the “zero” point at which the device’s antenna is at the top of the water
				+ Tape meter stick/tape measure to the side of the bucket
				+ Make a mark on the string where it will be easy to see
				+ Lower the device by the string until the base of the antenna is at the top of the water
				+ Record the value of the string’s mark as the “zero”
	+ TRANSMIT: Ensure wireless device is transmitting at a frequency
		- Walkie Talkie - Tape the “talk” button down
		- Set up PlutoSDR and bunny ear antenna
	+ SIGNAL STRENGTH: Setup COSMOS node to read the signal strength
		- Connect Pluto with proper antenna (based on the frequency)
			* Walkie Talkie - Bunny Ears
		- Run GNURadio program to see Signal Strength
	+ TAKE MEASUREMENTS:
		- Position the wireless device (walkie talkie) a set distance from the obstacle
		- Record the Signal Strength (in dBm)
	+ PLOT: Plot the data.
	+ Students ANALYZE their data and draw CONCLUSIONS
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| **EVALUATE:** **Formative Monitoring (Questioning / Discussion):** Questions to ask:* why is the signal strength different in different materials?
* compare and contrast materials based on their results
* how does this affect communications? for example, would people on a submarine be able to communicate with people in a boat at the ocean’s surface using walkie talkies? why or why not?
* how could the data we’ve found relate to students’ and teachers’ experiences with wireless Internet in our building?
* how could the data we’ve collected about different materials help people designing a city-sized wireless network?

**Summative Assessment (Quiz / Project / Report):** Students write a lab report summarizing their experiment. |
| **Elaborate Further / Reflect: Enrichment:** Students could explore how the design of city-scale wireless testbeds is engineered to account for the physical infrastructure of the city (roads, buildings, trees, etc.). |