**Lesson Planning Template**

**COSMOS EDUCATIONAL TOOLKIT: Signal Strength vs Distance**

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| **Grade/ Grade Band**: 6th - 8th | **Math Topics:** Ratios, Independent & Dependent Variable, Unit Rate | **Lesson #** \_\_1\_\_\_ **in a series of** \_\_1\_\_\_ **lessons** |
| **Brief Lesson Description**: In this lesson, students will use the GNU Radio to measure the signal strength of radio waves in order to solve real-world mathematical problems.  |
| **Specific Learning Outcomes:** * Students will be able to observe signal strength depending on various obstacles and interference
* Students will be able to write the rate using the correct units of measures
* Students will be able to calculate the unit rate of the signal strength over time
* Students will be able to determine the independent and dependent variables
* Students will be able to write equations based on the data found
* Students will be able to graph their findings
* Students will be able to use their graphs to determine proportionality
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| **Narrative / Background Information**  |
| **Prior Student Knowledge Required:** * Understand how to write a ratio and use ratio language to describe the relationship between two quantities.
* Able to identify independent and dependent variables
* Able to find and properly write unit rate and its units of measure.
* Able to use variables to represent quantities in real-world mathematical problems
* Decide whether two quantities are in a proportional relationship
* Interpret graphs for proportionality
* Convert decimals to fractions
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| **Problem Solving Practices (Ex: Standards for Mathematical Practice):** **MATH.PRACTICE.MP1** Make sense of problems and persevere in solving them.**MATH.PRACTICE.MP2** Reason abstractly and quantitatively.**MATH.PRACTICE.MP3** Construct viable arguments and critique the reasoning of others.**MATH.PRACTICE.MP4** Model with mathematics.**MATH.PRACTICE.MP5** Use appropriate tools strategically.**MATH.PRACTICE.MP6** Attend to precision.**MATH.PRACTICE.MP7** Look for and make use of structure.**MATH.PRACTICE.MP8** Look for and express regularity in repeated reasoning. | **Main Content Ideas:** **[CCSS.Math.Content.6.EE.C.9](http://www.corestandards.org/Math/Content/6/EE/C/9/)**Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation d = 65t to represent the relationship between distance and time.**[CCSS.Math.Content.6.RP.A.1](http://www.corestandards.org/Math/Content/6/RP/A/1/)**Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.**[CCSS.Math.Content.6.RP.A.3.b](http://www.corestandards.org/Math/Content/6/RP/A/3/b/)**Solve unit rate problems including those involving unit pricing and constant speed. **[CCSS.Math.Content.7.EE.B.4](http://www.corestandards.org/Math/Content/7/EE/B/4/)**Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.**[CCSS.Math.Content.7.RP.A.2](http://www.corestandards.org/Math/Content/7/RP/A/2/)**Recognize and represent proportional relationships between quantities.**[CCSS.Math.Content.7.RP.A.2.a](http://www.corestandards.org/Math/Content/7/RP/A/2/a/)**Decide whether two quantities are in a proportional relationship.**[CCSS.Math.Content.7.RP.A.2.b](http://www.corestandards.org/Math/Content/7/RP/A/2/b/)**Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.**[CCSS.Math.Content.7.RP.A.2.c](http://www.corestandards.org/Math/Content/7/RP/A/2/c/)**Represent proportional relationships by equations. **[CCSS.Math.Content.7.RP.A.2.d](http://www.corestandards.org/Math/Content/7/RP/A/2/d/)**Explain what a point (*x*, *y*) on the graph of a proportional relationship means in terms of the situation, with special attention to the points (0, 0) and (1, *r*) where r is the unit rate.**CCSS.MATH.CONTENT.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. For example, the function A = s2 giving the area of a square as a function of its side length is not linear because its graph contains the points (1,1), (2,4) and (3,9), which are not on a straight line. | **Possible Multidisciplinary Concepts:** **NY State Science Standards****MS-PS4-2.** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.**CSTA Computer Science Standards****2-CS-02.** Design projects that combine hardware and software components to collect and exchange data.**2-NI-04.** Model the role of protocols in transmitting data across networks and the Internet.**2-DA-07.** Represent data using multiple encoding schemes.**NY State ELA Standards**[**CCSS.ELA-Literacy.RI.8.1**](http://www.corestandards.org/ELA-Literacy/RI/8/1/)Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text.[**CCSS.ELA-Literacy.RI.8.8**](http://www.corestandards.org/ELA-Literacy/RI/8/8/)Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced. |
| **Possible Preconceptions/Misconceptions:** * Students may set up their unit rates incorrectly depending on how they record their data in the tables.
* When finding the rate from the table, students may put the wrong unit in the numerator.
* Students may not understand how walkie-talkies communicate with one another.
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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) What are some occupations where people are required to use two-way radios/ walkie-talkies?How do walkie-talkies work? How far apart can a set of walkie talkies be apart and still work?\*Students will discuss their thoughts in their table groups.  |
| **EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:** **Materials:** Ziplock bags, string (or yarn), plastic hard ruler (or tape measure), salt (sea salt, iodized salt, or hemelayn salt), Two 3 gallon plastic buckets **Hardware:** COSMOS Node, Walkie-Talkies, Raspberry Pi (Mobil Node), **Software:** GNU Radio Companion Software, Spectrogram, Chronograph |
| **EXPLAIN: Concepts Explained and Vocabulary Defined:** Day 1:* Teacher will explain how radio waves transmit and how electromagnetic waves are susceptible to interference. (10 mins)
* Teacher will open the COSMOS Node Signal Strength experiment.
* Students will use the Raspberry Pi (mobile node) to measure the signal strength between two walkie-talkies from the front of the school steps to the following various places:
	+ Front of the School Building
	+ Subway Station
	+ Grocery Store
	+ Harlem River Drive
	+ School Yard
* Students will record their data on their worksheet
* Students will use their data from Table 1 to answer real world mathematical problems

Day 21. Students will open the COSMOS Node and open the GNU Radio Companion software.
2. Students will put one walkie-talkie in a ziplock bag, close the bag then place that bag into another zip lock bag to ensure walkie-talkie does not get wet. (Be sure to tightly close both bags)
3. Measure out 10 inches of string and tie the string around the top of the ziplock bag to ensure the bag is closed tightly.
4. Students will measure out 3 gallons of water to put into each bucket.
5. Students will place the ruler inside both buckets.
6. Students will pour ¼ cup of salt in bucket A. Wait for salt to completely dissolve. (2-5 minutes)
7. Divide students into groups of 4 and assign the following tasks. One task per student.
	1. Student A will hold the walkie-talkie bag by the string and place the bag into the water. (Do not allow the bag to touch the bottom of the bucket or the sides of the bucket.)
	2. Student B will push the PTT button on the walkie-talkie and hold the button down while the bag is submerged in the water (do not open the bag)
	3. Student C will record the maximum decibels to measure the signal strength showing on the GNU Radio
	4. Student D will write their findings in the table and answer any procedural questions or comments from group members.
8. Student C will add another ¼ cup of salt to bucket A.
9. Students will repeat steps 7a-7d
10. Student C will add another ¼ of salt to bucket A.
11. Students will repeat steps 7a-7d
12. Student C will add another ¼ cup of salt to bucket A.
13. Students will repeat steps 7a - 7d
14. Student A will submerge the walkie-talkie bag in water in bucket B (fresh water) while holding the string to ensure the top of the bag (the seal) does not go underwater. (Do not allow the bag to touch the bottom of the bucket or the sides of the bucket.
15. Student B will push the PTT button on the walkie-talkie and hold the button down while the bag is submerged in the water (do not open the bag)
16. Student C will record the maximum decibels to measure the signal strength showing on the GNU Radio
17. Student D will write their findings in the appropriate space and answer any procedural questions or comments from group members.
18. Students will complete their tables and graph their findings.
19. Students will decide if the graph is proportional.

**Key Vocabulary:** Decibel - a unit used to measure the intensity of a sound or the power level of an electrical signal by comparing it with a given level on a logarithmic scale.Hertz - The SI unit for wave frequency, where 1 hertz equals 1 wave passing a fixed point in 1 secondWave Amplitude - The maximum distance of displacement of a particle on the medium from its rest position. Wavelength - The distance between two corresponding points on adjacent wavesWave Frequency - The number of waves that pass a fixed point in a given amount of time. Conductivity - the degree to which a specified material conducts electricity, calculated as the ratio of the current density in the material to the electric field that causes the flow of current. It is the reciprocal of the resistivity.Interference - a property that modifies a signal in a disruptive manner, as it travels from a source to the receiver |
| **ELABORATE: Applications and Extensions:** Extensions: Students may create a graph based on the data received in order to show the change in the data. |
| **EVALUATE:** **Formative Monitoring (Questioning / Discussion):** If the range between two walkie-talkies is 1 mile, why might they lose signal strength over a distance within the allotted range? Explain your answer and include data you found in your experiment. **Summative Assessment (Quiz / Project / Report):** This unit is complete a summative assessment may be given to students. |
| **Elaborate Further / Reflect: Enrichment:** Students may elaborate on possible signal interference |