# NAVAL HISTORY STEM-H LESSON PLAN

**LESSON PLAN**:  Ship, Submarine, and Sea Creature Sounds in the Sea

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**2012 NAVAL HISTORICAL FOUNDATION TEACHER FELLOWSHIP**

**ACTIVITY FOUR: Graphing Logarithmic Equations**

**OBJECTIVE**: Graphing logarithmic equations used in ship detection using sonar while at sea, provides a pictorial display of the information. Sound waves, water waves, and light waves including radar involve exponential and logarithmic functions.  Graphing an equation can help to evaluate the situation.

**MATERIALS**: Graph paper, pencil, calculator.

**INSTRUCTIONS**:  Graph $y = \log_4 (x)$.      Note that logs are not defined for negative x, or for x = 0.

> We know that $4^0 = 1$, then $\log_4 (1) = 0$, and (1,0) will be on the graph.

> And, $4^1 = 4$, so $\log_4 (4) = 1$, and (4,1) will be on the graph.

> And $4^2 = 16$, and $\log_4 (16) = 2$, and (16,2) will be on the graph.

> Let us now use negative exponent values…

> Now $4^{-1} = ¼ = 0.25$, so $\log_4(0.25) = -1$, and (0.25, -1)  is on the graph.

> So $4^{-2} = 1/16 = 0.0625$, so $\log_4(0.0625) = -2$, and (0.0625, -2) is on the graph.

Make a table to keep your data in order so that you can graph the information.

| $x$ | $y = \log_4 (x)$ | $(x,y)$ | Simplify |
|---|---|---|---|
| | | | |
| 0.25 | $\log_4(.25) = -1$ | (.25,-1) | (1/4, 1) |
| 0.0625 | $\log_4(0.0625) = -2$ | (.0625, -2) | (1/16, -2) |
| 1 | $\log_4(1) = 0$ | (1,0) | |
| 4 | $\log_4(4) = 1$ | (4, 1) | |
| 16 | $\log_4(16) = 2$ | (16, 2) | |
| 64 | $\log_4(64) = 3$ | (64, 3) | |
| | | | |
| | | | |
| | | | |

Graph (x,y) on a coordinate graph with an x-axis and a y-axis.

Students may graph the values of x and y on the graph in many ways.

The x values should be on the horizontal axis, and only positive values should be present.

The y values should be on the vertical axis, both positive and negative.

Axes should be labeled and a proportional scale should also be constructed.

**Questions:**

**1. After you plotted your points, connect them.   What type of shapes does it create? Describe it.**

The shape is similar to a downward opening hyperbola, but it is "logarithmic".  It has no negative x values, as y increases slightly, x increases much less.  As x approaches zero, y approaches negative infinity as an asymptote.

**2.  Why do you think it made this type of shape?**

$4^y$ = x, so as y gets larger positive, x gets even bigger. As y becomes more negative, x becomes an ever smaller fraction.  This is an easier way of looking at $y = \log_4 (x)$.

**3.  How does this shape /assist sonar and fire control specialists on submarines to calculate where other vessels are located?**

Sound energy in the water decreases exponentially as the range from the sound source increases. This is called transmission loss.  The transmission loss curve, combined with a sonar's capability and ocean conditions, can provide an estimated position of another vessel, based on its sound source.

Graphically, it is a logarithmic graph, with Range on the x-axis and transmission loss on the y-axis:
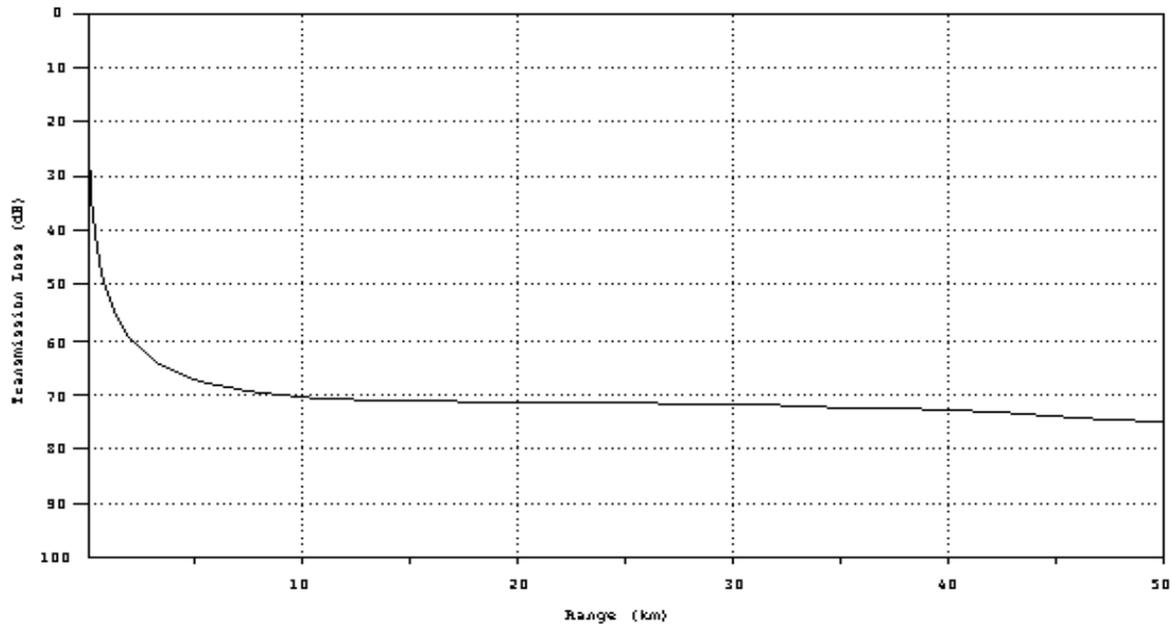


**4.  Why do you believe logarithms are used?**

The logarithm matches the natural world's behavior of sound, in water, air and other media.

**5.  Why do we need to condense our data into a small form of information?**

Automation: to enable high speed computers to do the many calculations necessary for evaluating real world sonar data, rather than relying only on the sonarman's ear listening to hydrophone outputs from original sonars.