Logarithmic Graph Name _____

Here is a list of the range of each type of electromagnetic wave:
I altered this slightly from before to include the longest (currently known) radio wave and the shortest (currently known) gamma ray, so the range has some boundaries (although in reality it may not!)

| **Type of Wave** | **Wavelength Range in SI (meters)** | **$Log_{10}$ Range** |
|---|---|---|
| Radio | 1 – 100,000 | 0 – 5 |
| Microwave | 1 to $1 \times 10^{-3}$ | |
| Infrared | $1 \times 10^{-3}$ to $8 \times 10^{-7}$ | |
| Visible Light | $8 \times 10^{-7} \times 4 \times 10^{-7}$ | |
| Ultraviolet | $4 \times 10^{-7}$ to $1 \times 10^{-8}$ | |
| X-Ray | $1 \times 10^{-8}$ to $1 \times 10^{-12}$ | |
| Gamma Ray | $1 \times 10^{-15}$ to $1 \times 10^{-12}$ | |

shortest gamma ray reference:
https://hypertextbook.com/facts/2001/ElenaWon.shtml

Longest radio wave reference:
https://www.livescience.com/50399-radio-waves.html

Our goal is to create a graph that shows the range of each piece of the electromagnetic spectrum. However, we won't be able to do this with a traditional linear graph.
Consider this: A gamma ray is 1 trillionth the size of a radio wave. So, if we made a graph of the whole spectrum based a linear scale of wavelength on a piece of paper, gamma rays would occupy less than 1 trillionth of the piece of paper! Or, we could make gamma rays occupy a whole page, if we used over 1 trillion pieces of paper!

Clearly, neither of these are realistic options at all, so instead we must create a *logarithmic scale*. In a logarithmic scale, the amount of space a range takes up is proportional not actual range but the range in orders of magnitude. In a linear scale, the range from 10 to 100 takes up 9 times as much space as the range from 1 to 10, and the range from 100 to 1000 takes up 90 times as much space! But, in a logarithmic scale, 1 to 10, 10 to 100 and 100 to 1000 all take equal amounts of space. Logarithmic scales are extremely useful for representing quantities that vary in order to magnitude, such as the wavelength of electromagnetic waves.

Logarithmic Graph Name _____

Steps to Creating a Logarithmic scale:

**Step 1:**
Get a piece of graph paper and create single axis that ranges from 5 to – 15.
Landscape is better than portrait for this graph.

Label this axis

$$\log_{10} \lambda$$

Or "log, base 10, of wavelength."

**Step 2:**
Take the logarithm (base 10) of each value on the table above.
[There is a space to write this down!]
Create a hash mark at each of these points on your axis.

**Step 3:**
For the ranges represented on the table, between each hash mark you made, write in the name of the electromagnetic wave represented in that range.

For example, between the hash marks at 0 and -3, write "microwaves."

**Step 4:**
Admire your graph! If you understand what it represents, that is really good, because this graph is located in nearly *every* college science textbook!

**Step 5:**
Let's make some inferences based on the graph.
Which type of wave contains the largest range?
Which type of the wave contains the smallest range?

What more can you learn?

**Step 6:**
Well….the answer to the question "Which type of the wave contains the smallest range?" ire pretty obvious, it's visual light!
Of the total range included your graph, how much is occupied by visible light?
What does this mean about the experience of being human?

**Step 7:**
Complete the tables on the next page. In these tables, you find ranges and log-ranges not only of wavelength, but also frequency and energy.

**Step 7:**

| **Type of Wave** | **Wavelength Range (meters)** | **Frequency Range (Hz)** | **Photon Energy Range (Joules)** |
|---|---|---|---|
| Radio | 1 – 100,000 | 0 – 5 | |
| Microwave | 1 to $1 \times 10^{-3}$ | | |
| Infrared | $1 \times 10^{-3}$ to $8 \times 10^{-7}$ | | |
| Visible Light | $8 \times 10^{-7}$ x $4 \times 10^{-7}$ | | |
| Ultraviolet | $4 \times 10^{-7}$ to $1 \times 10^{-8}$ | | |
| X-Ray | $1 \times 10^{-8}$ to $1 \times 10^{-12}$ | | |
| Gamma Ray | $1 \times 10^{-15}$ to $1 \times 10^{-12}$ | | |

| **Type of Wave** | **$Log_{10}$(Wavelength Range)** | **$Log_{10}$(Frequency Range)** | **$Log_{10}$(Photon Energy Range)** |
|---|---|---|---|
| Radio | 0 – 5 | | |
| Microwave | | | |
| Infrared | | | |
| Visible Light | | | |
| Ultraviolet | | | |
| X-Ray | | | |
| Gamma Ray | | | |

**Step 8:**
Now, create a graph similar to your first that has *all three scales* on it.

One scale is log-base 10- of wavelength.
The second is log-base 10-of frequency
The third is log-base-10-of energy.

IF the scales are properly lined up:
Each scale should have hash marks, and these should be in the *same place*s on each scale.
The ranges should also be in the same places on each scale.