MiSP Light and Sound Worksheet #2, L3

Name___________________________ Date_________

SPEED OF LIGHT (AND OTHER ELECTROMAGNETIC ENERGY WAVES)*

Introduction:

The following facts are important to remember:

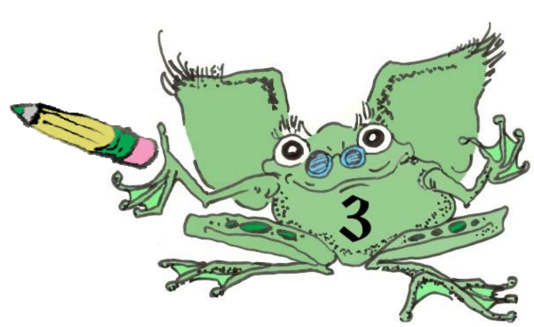
- Mechanical waves, such as sound waves, must transfer energy through a substance or medium.
- Electromagnetic waves—such as light waves, radio frequency waves, X-rays, and microwaves—can transfer energy in a vacuum, without a medium.
- Electromagnetic waves are created by electrically charged particles that move.
- All types of electromagnetic waves travel at the same speed.
- Both types of waves are initiated by something that vibrates.

Today you will calculate the speed of radio frequency waves, a type of electromagnetic wave. You will then compare this value to the value you calculated yesterday for the speed of sound.

Speed of Radio Frequency Waves in Space:

The table below shows the distance of representative planets from Earth and the calculated time it would take for a radio frequency wave to travel from Earth to that planet.

Planet	Distance from Earth in km	Seconds needed for radio frequency wave to travel between planet and Earth
Mercury	92,000,000	306
Jupiter	629,000,000	2096
Saturn	1,277,000,000	4256
Uranus	2,721,000,000	9070

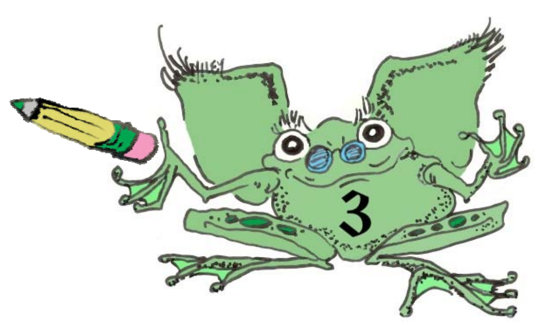


Graph the data. First convert the distance in km to a number that is easier to work with. Convert each distance into millions of km (distance in km given in table/1,000,000).
Convert the time in seconds to time in minutes: time (minutes) = time (seconds) ÷ 60.

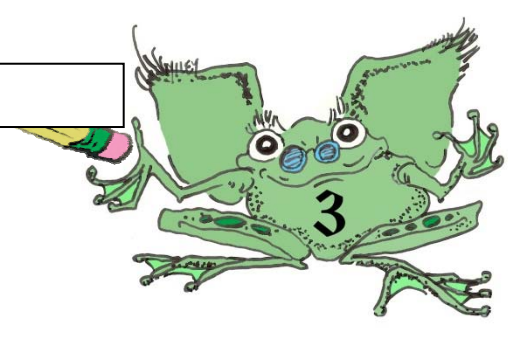
Planet	Distance from Earth in km	Distance from Earth in 1,000,000 km	Seconds needed for radio frequency waves to travel between planet and Earth	Minutes needed for radio frequency waves to travel between planet and Earth
Mercury	92,000,000		306	
Jupiter	629,000,000		2096	
Saturn	1,277,000,000		4256	
Uranus	2,721,000,000		9070	

Graph the data: (on the next page)

- Label the *x*-axis "time in minutes" and the *y*-axis "distance in millions of km." Which is the
    - Manipulated/independent variable: ______________________
    - Responding/dependent variable: _________________________
- Decide on an appropriate interval for both the *x*- and *y*-axes.
- Plot the data.
- Draw a line connecting the points on your graph.



Analysis:



1. On your graph, what two ordered pairs represent Mercury and Jupiter?
   Mercury (____ min, _____ millions of km)
   Jupiter (____ min, _____ millions of km)

2. On your graph, what two ordered pairs represent Saturn and Uranus?
   Saturn (____ min, _____ millions of km)
   Uranus (____ min, _____ millions of km)

3. Determine the unit rate of change (slope) along the line on your graph.

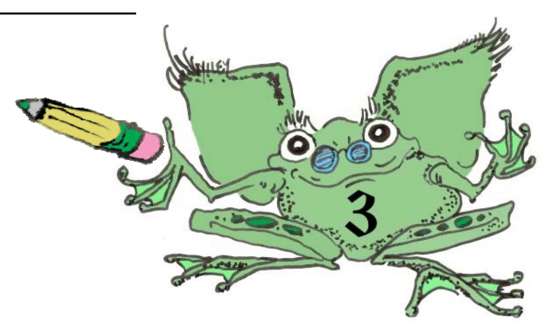
   Unit rate of change = $\frac{\Delta y}{\Delta x} = \frac{(y_2 - y_1)}{(x_2 - x_1)} = \frac{\Delta \text{ distance}}{\Delta \text{ time}}$

Ordered Pair used for calculation (x_1, y_1) (x_2, y_2)	Δ Distance (millions of km) Δy	Δ Time (min) Δx	**Unit Rate of Change (slope)** $\Delta y/\Delta x$
Mercury and Jupiter			
Saturn and Uranus			

4. Is change in distance divided by the change in time different for the two sets of points?

   ____

5. What does the unit rate of change represent? _______________________



6. Convert your calculated value to a value in km/second.

$$\frac{\_\_\_\_\_\_\_\_\_\_ \text{ millions of km}}{\_\_\_\_ \text{ minutes}} \times \frac{1 \text{ minute}}{60 \text{ seconds}} \times \frac{1{,}000{,}000 \text{ km}}{1 \text{ million of km}} =$$

_________________ km/second

7. The speed of light is about 300,000 km/second. How does your value for the speed of radio frequency waves compare with this?

____

8. Calculate the percent error.

$$\frac{(300{,}000 \text{ km/sec} - \text{your calculated value})}{300{,}000 \text{ km/second}} = \frac{\_\_\_\_\_\_\_\_\_\_\_\_}{300{,}000 \text{ km/second}} =$$

______________ x 100 = ___________ %

9. Compare the speed of radio frequency (or light) waves to that of sound.

Speed of radio frequency waves and light waves: ___________________

Speed of sound (calculated yesterday): _________________________

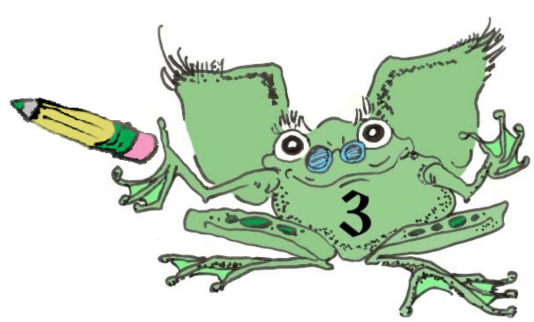
Comparison: ____

____

10. The general equation for a line is ***y = mx + b*** where *m* represents the constant rate of change and *b* represents the value of *y* when *x* = 0 (also called the *y*-intercept). If time = 0 minute, what is the distance that radio frequency waves have traveled? ________________

11. What is the *y*-intercept? _______________________

12. Write the equation for the line that you drew on the graph.



13. How long would it take for a radio frequency wave to reach Mars (78,000,000 km from Earth) and Neptune (4,347,000,000 km from Earth)?

   a. Use the graph to estimate the time.

      Earth to Mars estimate: ________________________

      Earth to Neptune estimate: _____________________

   b. Use the equation for the line to calculate the time.

      Earth to Mars calculation:

      Earth to Neptune calculation:

Question of the Day:

Why is it that you see lightning before you hear the thunder associated with it?

*The idea for this activity was adapted from "How Long Does It Take to Say Hello?" in *Out of This World*, AIMS Education Foundation, 2007, p. 122.