STUDENT WORKSHEETS

DIFFERENTIATED

ELECTROMAGNETIC SPECTRUM

Physics for Senior High School Grade 12 (Phase F)

Guided Inquiry Model

For Senior High School or Equivalent

Prepared by :
Firna Agustin
(2280230004)

2026

STUDENT WORKSHEETS

ELECTROMAGNETIC SPECTRUM

Group Identity

Group

Members

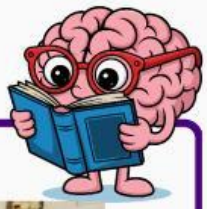
Learning Outcomes

Students are able to apply the concepts and principles of vectors, the kinematics and dynamics of motion, fluids, and the phenomena of sound and light waves to solve problems, as well as apply the principles and concepts of heat and thermodynamics, including their various transformations in heat engines. Students are able to apply the concepts and principles of electricity (both static and dynamic) and magnetism in various problem-solving scenarios and technological products, and **apply the concepts and principles of electromagnetic waves in solving problems**. Students are able to understand the principles of logic gates and their application in computer systems and other digital computations. Students are able to analyze the relationships between various physical quantities in the theory of special relativity and quantum phenomena, and demonstrate the application of concepts in nuclear physics and radioactivity in everyday life and technology.

Experiment Objectives

After completing this worksheet, students are expected to be able to:

1. Analyze the relationship between wavelength, frequency, and energy in the electromagnetic wave spectrum based on observations and discussions using the Javalab Electromagnetic Waves simulation.
2. Relate the characteristics of each electromagnetic wave spectrum to their applications in daily life, accompanied by sound scientific reasoning.



Problem Orientation

Figure 1. Remote control usage for operating a television from a distance

Figure 2. X-ray imaging used to examine internal bone structures

Have you ever used a television remote control to change channels from a distance without touching the television? Or have you ever seen an X-ray image that reveals the condition of the bones inside the human body without any surgical procedure? Despite having completely different functions, both technologies utilize electromagnetic waves. Why is one type of wave used to transmit remote control signals, while another type can penetrate the human body? As it turns out, this difference is related to the characteristics of each electromagnetic wave, which possesses a distinct wavelength, frequency, and energy. The arrangement of these various types of waves is known as the **electromagnetic spectrum**. Let's investigate together!

After reading the phenomenon above, answer the following questions before proceeding:

1. Why do you think each type of electromagnetic wave is utilized for different technologies? Connect your answer to what you know about the characteristics of electromagnetic waves!

2. Based on your prior knowledge, which electromagnetic wave do you think has the highest energy and which has the lowest energy? Explain your initial prediction!

Phase 2: Formulating the Problem (Guided Inquiry Model)

Formulating the Problem

Based on the observed phenomena, now it is time to formulate the scientific questions to be investigated. Write down your problem statement in the box provided!

1. The relationship between wavelength, frequency, and energy in the electromagnetic spectrum.

2. The correlation between the characteristics of each electromagnetic spectrum and its applications in daily life.

Phase 3: Formulating Hypotheses (Guided Inquiry Model)

Formulating Hypotheses

Before conducting the observation, you are asked to make a prediction or hypothesis. Complete the sentences below based on your initial expectations!

Instructions: Choose one of the words in the parentheses, or fill in the blanks based on your prediction

Hypothesis 1

The higher the frequency of an electromagnetic wave, the _____ (longer / shorter) its wavelength. This means that frequency and wavelength are _____ (directly / inversely) proportional.

Hypothesis 2

The higher the frequency of an electromagnetic wave, the _____ (greater / smaller) its energy. This means that frequency and energy are _____ (directly / inversely) proportional.

Hypothesis 3

High-energy electromagnetic waves such as X-rays tend to be used for applications requiring _____ (high / low) penetrating power, while low-energy waves such as radio waves are used for _____ (long-distance communication / medical imaging) because of their _____ (long / short) wavelength.

Phase 4: Data Collection (Guided Inquiry Model)

Data Collection

Experimental Variables

Independent Variable	:	Type/position of electromagnetic waves on the spectrum
Dependent Variable	:	Wavelength (m) and frequency (Hz)
Control Variable	:	Speed of light in a vacuum ($c=3\times10^8$ m/s)

Tools and Materials

1. Javalab simulation (https://javalab.org/en/electromagnetic_waves_en/)

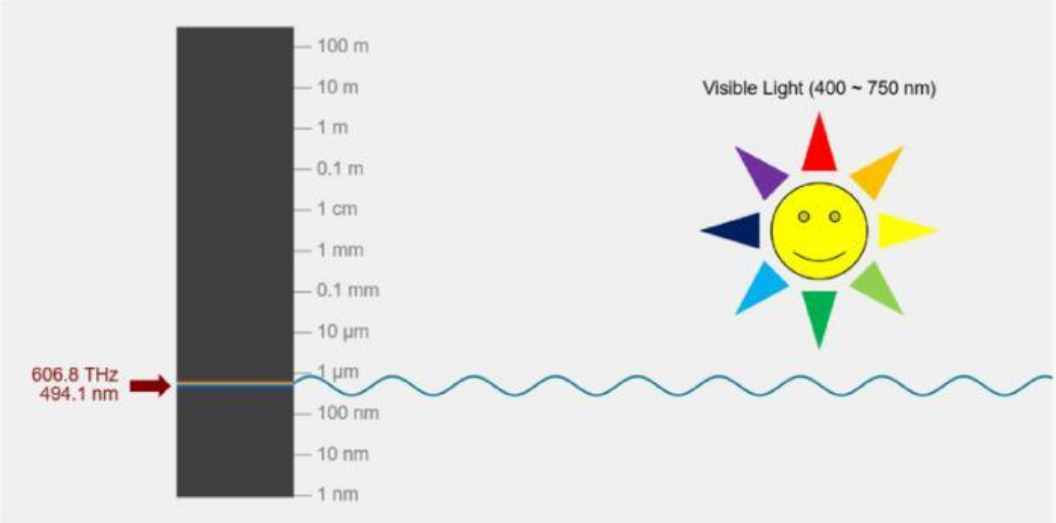
SCAN HERE

2. Mobile phone / Laptop / Other electronic devices with internet access.

Experimental Procedure

Follow these steps carefully. Make sure all requested options are enabled before you start recording data!

1. Prepare a device (mobile phone/laptop) that has internet access.
2. Open the Javalab electromagnetic wave simulation using the link above.
3. Observe the spectrum scale display that spans from radio waves to gamma rays.
4. Click/slide the pointer to the radio wave position, observe and record the wavelength and frequency values.



5. Continue the exploration sequentially to microwaves, infrared, visible light, ultraviolet, X-rays, and up to gamma rays.
6. Record the wavelength, frequency, and at least two examples of technology applications for each type of wave into the available observation table.
7. Observe how the position on the spectrum scale changes as the wavelength and frequency change.
8. Discuss with your group the patterns you found in the data.
9. Analyze the obtained data to answer the questions in the Hypothesis Testing section.

Observation Data

Table 1. Results of electromagnetic spectrum data and observations

No.	Type of EM	Wavelength (m)	Frequency (Hz)	Application Examples
1	Gamma rays			
2	X-rays			
3	Ultraviolet rays			
4	Visible light			
5	Infrared			
6	Microwaves			
7	Radio waves			

Draw a graph of the relationship between wavelength and frequency! What is the relationship between these two variables?

Phase 5: Testing the Hypothesis (Guided Inquiry Model)

Testing the Hypothesis

The students have collected the data in Table 1. Now, use that data to answer the following questions. Each answer must be supported by the recorded data!

Profile A

1. Observe the "Wavelength" and "Frequency" columns in Table 1. What is the pattern of the relationship between wavelength and frequency based on the data you obtained? Is the relationship linear or nonlinear? Explain using data evidence and physical concepts.

2. Based on the frequency data in Table 1 for radio waves and X-rays, use the equation $c = f\lambda$ to mathematically prove how many times shorter the X-ray wavelength is compared to the radio wave.

3. Evaluate how the position of a wave on the spectrum affects its energy, based on the utilization data in Table 1. Which types of waves are low-energy and safe for daily use? Which types of waves are high-energy and require special protection? Use both sets of data to explain why X-rays are able to penetrate the body while radio waves are not.

Phase 5: Testing the Hypothesis (Guided Inquiry Model)

Profile A

4. Evaluate the consistency of your hypothesis with the data obtained. Is your hypothesis accepted, partially accepted, or rejected? If there are discrepancies, explain the possible causes based on physics concepts.

☐ ***Accepted*** ☐ ***Rejected*** ☐ ***Partially accepted***

Profile B

1. Observe the 'Frequency' column in Table 1. Analyze the relationship between wavelength and frequency based on the data you obtained.

2. Based on the application example data in Table 1, explain the relationship between the type of electromagnetic wave and its utilization in technology.

Phase 5: Testing the Hypothesis (Guided Inquiry Model)

Profile B

3. Based on the results of your research, explain why gamma rays have much greater penetrating power and are much more dangerous than radio waves.

4. Evaluate the consistency of your hypothesis with the data obtained. Is your hypothesis accepted or rejected? Explain using data evidence.

☐ ***Accepted*** ☐ ***Rejected***

Profile C

1. Observe the "Wavelength" column in Table 1. What happens to the wavelength as the frequency of the electromagnetic wave increases?

Phase 5: Testing the Hypothesis (Guided Inquiry Model)

Profile C

2. Based on the data in Table 1, mention two examples of electromagnetic waves that have high energy and two examples that have low energy.

3. According to the data obtained, does frequency affect the energy of electromagnetic waves? Explain briefly.

4. Does your hypothesis match the observation results? If it matches or does not match, explain the reasons!

☐ ***Appropriate*** ☐ ***Inappropriate***

Phase 6: Drawing Conclusions (Guided Inquiry Model)

Drawing Conclusions

Write the conclusion you obtained based on all the observation and analysis results!

1. The relationship between wavelength and frequency in the electromagnetic wave spectrum

2. The relationship between the position on the spectrum and the energy of electromagnetic waves

3. Connection to everyday technology applications

Reflection

After conducting observations using the simulation, analyzing the data, and discussing the results, reflect on your understanding of the Electromagnetic Spectrum!

The concept I understood best today is:

The concept that is still confusing for me is:

The question I still want to know is:

"The structures of the heavens can only be viewed in detail when we examine them part by part."

- William Herschel

"Struktur alam semesta hanya dapat dilihat secara detail ketika kita memeriksanya bagian demi bagian."

- William Herschel