What I Need to Know

When you were in Grade 7, you were able to demonstrate understanding of the characteristics of light by explaining color and intensity of light in terms of its wave characteristics. In Grade 8, you grasped the knowledge about some of properties and characteristics of light by explaining the hierarchy of colors in relation to the energy of visible light. This time, it will be all about comparing the relative wavelengths of different forms of electromagnetic waves.

Have you ever tried sending messages, cooking in a microwave, listening radio or watching TV today? Have you ever tried to ask yourself “What makes this possible?”. As you go along this module, you will able to answer that BIG question.

Content Standard

The different regions of electromagnetic Spectrum

Most Essential Learning Competency (MELC)

Compare the relative wavelengths of different forms of electromagnetic wave

(S10FE 11a-b-470)

Specific Objectives:

a. Trace the development of the electromagnetic wave theory
b. Describe how electromagnetic wave is produced and propagated.
Let us recall the dispersion of light that you learned in Grade 8. This is when white light splits into many colors as it passes through a prism, thus creating a rainbow.

Trivia: A rainbow is caused by sunlight and atmospheric conditions. Light enters a water droplet, slowing down and bending as it goes from air to denser water. The light reflects off the inside of the droplet, separating into its component wavelengths—or colors. When light exits the droplet, it makes a rainbow.

(Source: https://scijinks.gov/rainbow/#:~:text=A%20rainbow%20is%20caused%20by,droplet%2C%20it%20makes%20a%20rainbow.)

ACTIVITY 1: SHINE LIKE RAINBOW!

Directions: In the left box below, write the 7 colors of the rainbow arranged from top to bottom in the space provided (0.5 point each). In the right box below, write T if the statement about energy, frequency and wavelength is true and F if the statement is false (1 point each).

1. RED
2. __________
3. YELLOW
4. __________
5. __________
6. INDIGO
7. __________

___1. Red light has the highest frequency.
___2. Violet has the highest energy.
___3. Violet has the longest wavelength.
___4. The higher the frequency of light, the greater the energy.
___5. The longer the wavelength, the lesser the frequency of light.
___6. Wavelength is directly proportional to frequency.
___7. Frequency is inversely proportional to energy.
___8. Wavelength is inversely proportional to energy.
**ACTIVITY 2A: MATCH ME!**

**Directions:** Match the scientists given below with their contributions. Write the letter of the correct answer in the space provided before each number.

<table>
<thead>
<tr>
<th>Scientists</th>
<th>Contributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>____1. Ampere</td>
<td>a. Contributed in developing equations that showed the relationship of electricity and magnetism</td>
</tr>
<tr>
<td>____2. Faraday</td>
<td>b. Showed experimental evidence of electromagnetic waves and their link to light</td>
</tr>
<tr>
<td>____3. Hertz</td>
<td>c. Demonstrated the magnetic effect based on the direction of current</td>
</tr>
<tr>
<td>____4. Maxwell</td>
<td>d. Formulated the principle behind electromagnetic induction</td>
</tr>
<tr>
<td>____5. Oersted</td>
<td>e. Showed how a current-carrying wire behaves like a magnet</td>
</tr>
</tbody>
</table>

**ACTIVITY 2B. LET’S TALK ABOUT EM!**

**Directions:** Write T if the statement is True, F if the statement is false. (1 point each)

| ______ 1. Electromagnetic waves transfer energy through vacuum. |
| ______ 2. A wave is a disturbance that transfers energy |
| ______ 3. Most EM waves are invisible and undetectable. |
| ______ 4. The electric field and the magnetic field oscillate parallel to each other |
| ______ 5. As wavelength increases, the frequency of wave also increases. |

Score: ___/5
What Is It

In the previous activity, you matched the scientists with their contributions on the discoveries of electricity and magnetism and the development of Electromagnetic wave theory. Hoping that you got them right. Take a look at this.

- **Hans Christian Oersted**
  - 1777–1851
  - Showed how a current carrying wire behaves like a magnet.
  - Contributed in developing equations that showed the relationship of electricity and magnetism.

- **James Clerk Maxwell**
  - 1831–1879
  - Formulated the principle behind electromagnetic induction.

- **Michael Faraday**
  - 1791–1867
  - Contributed in developing equations that showed the relationship of electricity and magnetism.

- **Heinrich Hertz**
  - 1857–1894
  - Showed experimental evidence of electromagnetic waves and their link to light.
  - Demonstrated the magnetic effect based on the direction of current.

- **Andre-Marie Ampere**
  - 1775–1836
**Electromagnetic Waves**

Accelerating electrons produce **electromagnetic (EM) waves**. These waves are a combination of **electric** and **magnetic** fields. A changing magnetic field produces an electric field and a changing electric field produces a magnetic field. As accelerated electrons produce an electric field of a wave, the varying electric field produces the wave’s magnetic field. Both the electric field and the magnetic field oscillate perpendicular to each other and to the direction of the propagating wave. Therefore, electromagnetic waves are transverse waves, as shown in Figure 1.

![Figure 1. Electromagnetic Wave Propagation](image)

Among the examples of EM waves are radiowaves, microwaves, infrared, visible light, ultraviolet, x-rays and gamma rays. All EM waves travel at a speed of $3 \times 10^8 \text{ m/s}$ in a vacuum and denoted as $c$, the speed of light.

Since all the electromagnetic waves have the same speed, as wavelength decreases, the frequency of the wave increases as expressed in the equation

$$v = \lambda f$$

where: $v$ is the wave speed, or $c$ (speed of light) expressed in meter per second,

$f$ is the frequency expressed in Hertz

$\lambda$ is the wavelength expressed in meters

**Speed**

All electromagnetic waves travel at a **speed** of 300,000 km/s ($3 \times 10^6 \text{ m/s}$) in a vacuum of space. However, when electromagnetic waves travel through matter, they slow down. The speed of the wave depends upon the material they travel through.
Electromagnetic waves usually travel the slowest in solids and the fastest in gases, as shown in Table 1 below.

<table>
<thead>
<tr>
<th>Material</th>
<th>Speed (Km/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum</td>
<td>300,000</td>
</tr>
<tr>
<td>Air</td>
<td>Slightly less than 300,000</td>
</tr>
<tr>
<td>Water</td>
<td>226,000</td>
</tr>
<tr>
<td>Glass</td>
<td>200,000</td>
</tr>
<tr>
<td>Diamond</td>
<td>124,000</td>
</tr>
</tbody>
</table>

Table 1. Speed of Visible Light

**Frequency**

The **frequency**, represented by the Greek letter nu (ν), is the number of waves that pass a certain point in a specified amount of time. Typically, frequency is measured in units of cycles per second or waves per second. One wave per second is also called a Hertz (Hz) and in SI units is a reciprocal second (s⁻¹).

Example Problem 1: (Assume that the waves propagate in a vacuum.)

1. What is the frequency of radio waves with wavelength of 20 m?
   
   Given: \( v = c = 3 \times 10^8 \text{ m/s} \)
   \( \lambda = 20 \text{ m} \)
   \( f = ? \)
   
   **Equation:**
   \[ v = c = \lambda f \]
   
   **Solution:**
   \[ f = \frac{c}{\lambda} = 3 \times 10^8 \text{ m/s} \]
   \[ \frac{20 \text{ m}}{} = 1.5 \times 10^7 \text{ Hz} \]

**Wavelength**

Wavelength is defined as the distance measured from one crest of a wave to the next crest or from one trough to the second trough.

A wave cycle consists of one complete wave—starting at the zero point, going up to a wave crest, going back down to a wave trough, and back to the zero point again. The wavelength of a wave is the...
distance between any two corresponding points on adjacent waves. It is easiest to visualize the wavelength of a wave as the distance from one wave crest to the next. In an equation, wavelength is represented by the Greek letter lambda (\( \lambda \)). Depending on the type of wave, wavelength can be measured in meters, centimeters, or nanometers (1 m = 10\(^9\) nm). To find wavelength (\( \lambda \)), use this equation \( v = \lambda f \)

Example Problem 2:

1. What is the wavelength of an electromagnetic wave that has a frequency of \( 4.95 \times 10^{14} \) Hz?

Given : \( f = 4.95 \times 10^{14} \) Hz  
\( v = c = 3.00 \times 10^8 \) m/s  
\( \lambda = ? \)

Equation: \( v = \lambda f \)

Solution:  
\( \lambda = \frac{v}{f} = \frac{3.00 \times 10^8 \text{ m/s}}{4.95 \times 10^{14} \text{ Hz}} = 6.06 \times 10^{-7} \) m

**What’s More**

**ACTIVITY 3: SOLVE ME!**

**Directions**: Solve the problem. Write all your solutions and answers on the space provided after the question.

1. Calculate the wavelength of a photon that has a frequency of \( 2.5 \times 10^{12} \) Hz. (5 points)

\[ \lambda = \frac{v}{f} = \frac{3.00 \times 10^8 \text{ m/s}}{2.5 \times 10^{12} \text{ Hz}} = 1.2 \times 10^{-4} \text{ m} \]

2. What is the frequency of an electromagnetic wave having a wavelength of 300,000 km? (5 points)

\[ f = \frac{v}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{300,000 \text{ km}} = 1.0 \times 10^6 \text{ Hz} \]
ACTIVITY 4: FILL ME!

Direction: Complete the statements below by filling in with correct word(s) found in the box. (1 point each)

<table>
<thead>
<tr>
<th>magnetic field</th>
<th>Maxwell</th>
<th>perpendicular</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric field</td>
<td>Faraday</td>
<td>transverse</td>
</tr>
<tr>
<td>electromagnetic wave theory</td>
<td>vacuum</td>
<td></td>
</tr>
<tr>
<td>electromagnetic waves</td>
<td>3x10^8 m/s</td>
<td></td>
</tr>
</tbody>
</table>

1. A changing magnetic field produces an ____________.

2. A changing electric field produces a ____________

3. The successive production of electric and magnetic field results to the creation of _________________ wave.

4-5. The electric and magnetic fields vibrate _______________ to each other to the direction the wave travels so it is a _________________ wave.

6. James Clerk Maxwell formulated the _________________- which says that an oscillating electric current should be capable of radiating energy in the form of electromagnetic waves.

7. The one who formulated the principle behind electromagnetic induction was ________________.

8. ________________ contributed in developing equations showing the relationship of electricity and magnetism.

9-10. EM waves can travel through a ______________ with a speed value of ________________.
**ACTIVITY 5: COMPLETE ME!**

**Directions:** Complete the concept map (1 point each)

- **Distance between wave crests**
- **SI unit**
- **Defined as**
- **Have properties of**
- **SI unit**
- **Hertz**
- **Range is called**
- **Defined as**
- **Can travel through**
- **Transfers kinetic energy in form of**
- **Spectrum which includes**
- **Electromagnetic radiation**
- **X-rays**
MULTIPLE CHOICE

Directions: Identify the letter of the choice that best completes the statement or answers the question. Write the letter on the space provided before each number.

1. Who formulated the principle behind electromagnetic induction?
   a. Faraday
   b. Hertz
   c. Ampere
   d. Maxwell

2. In the electromagnetic wave, the direction of the propagation of the wave is_____.
   a. always to the right
   b. always to the left
   c. parallel to electric and magnetic field directions
   d. perpendicular to the electric and magnetic field directions

3. Which of the following is the contribution of Oersted in the development of Electromagnetic Wave Theory?
   a. demonstrated the magnetic effect based on the direction of current
   b. showed how a current carrying wire behaves like a magnet
   c. showed how experimental evidence of electromagnetic waves and their link to light
   d. contributed in developing equations that showed the relationship of electricity and magnetism.

4. The following are the properties of Electromagnetic waves EXCEPT_______.
   a. EM waves can travel through a vacuum
   b. EM waves travel at the speed of $3 \times 10^8$ m/s
   c. EM waves have an electric field and magnetic field which vibrate parallel to each other
   d. As wavelength of EM wave decreases, its frequency increases.
5. The source of all electromagnetic wave is
   a. magnetic fields
   b. heat
   c. electric fields
   d. vibrating charges

6. Which of the following is NOT an electromagnetic wave?
   a. Sound
   b. Radio
   c. Light
   d. Infrared

7. How far is a light-second?.
   a. 5000 km
   b. 300,000 km
   c. 4,000,000 km
   d. 50,000,000 km

8. What is the wavelength of an electromagnetic wave that has a frequency of 1 Hz?
   a. More than 1 m
   b. Less than 1 m
   c. 1 m
   d. Cannot be determined

9. What is the frequency of an electromagnetic wave having a wavelength of 300,000 km?
   a. More than 1 Hz
   b. Less than 1 Hz
   c. 1 Hz
   d. Cannot be determined
10. What is the wavelength of the wave with a frequency of $3 \times 10^9$ Hz?

a. $1.0 \times 10^{-1}$ m  

b. $1.0 \times 10^1$ m  

c. $1.0 \times 10^{-2}$ m  

d. $1.0 \times 10^2$ m

**Additional Activity**

**Directions:** Make a Comic Strip about the scientist contributions on the development of electromagnetic wave theory. Refer to the rubric below for your guidance in making your output.

Remember:

A comic strip is a sequence of drawings in boxes that tell an amusing story, or a form of story-telling, which uses drawings or cartoon characters to tell a story.

<table>
<thead>
<tr>
<th></th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
<td>Concept is clearly evident.</td>
<td>Concept is evident;</td>
<td>Concept is acceptable;</td>
<td>Concept is limited;</td>
</tr>
<tr>
<td><strong>Spelling and Grammar</strong></td>
<td>There are no spelling, punctuation or grammar errors</td>
<td>There are 1-3 spelling, punctuation or grammar errors</td>
<td>There are 4-5 spelling, punctuation or grammar errors</td>
<td>There are more than 5 spelling, punctuation, and grammar errors</td>
</tr>
<tr>
<td><strong>Visual Effect</strong></td>
<td>Comic strip is incredibly exciting and interesting</td>
<td>Comic strip is very exciting and interesting</td>
<td>Comic strip is quite exciting and interesting</td>
<td>Comic strip is not interesting and exciting</td>
</tr>
</tbody>
</table>

**Table 2. Rubric for Comic Strip**
**Key to Answers**

*Grade 10Q2W1 Science*

**Pre-test**

1. A
2. D
3. B
4. C
5. D
6. A
7. B
8. C
9. C
10. A

**Activity 1: Shine Like Rainbow**

1. Red
2. Orange
3. Yellow
4. Green
5. Blue
6. Indigo
7. Violet
8. T

**Activity 2A: MATCH ME!**

1. C
2. D
3. B
4. A
5. E

**Activity 2B: LET'S TALK ABOUT**

1. T
2. T
3. F
4. F
5. F

**Activity 3: Solve Me!**

1. $1.2 \times 10^{14}$ Hz
2. $1.3 \times 10^8$ m/s

**Assessment**

1. A
2. D
3. B
4. C
5. D
6. A
7. B
8. C
9. C
10. A

**Theory**

4. Perpendicular
3. Electromagnetic Wave
2. Magnetic Field
1. Electric Field

**Vacuum**

8. James Clerk Maxwell
7. Faraday
6. Electromagnetic Wave
5. Transverse
Activity 5: COMPLETE ME!

Electromagnetic Waves

Distance between wave crests

Wavelength

Frequency

Number of waves per second

SI unit

Defined as

Have properties of

Can travel through

Range is called the

ELECTROMAGNETIC SPECTRUM

which includes

Radiowaves

Infrared

Ultraviolet

Gamma Rays

Microwaves

Visible Light

X-Rays

SI unit

Defined as

Vibrating electric and magnetic field moving through space that carries energy

Vacuum

Hertz

Electromagnetic Radiation

Meter
References

Books

Publications
Anjaylo B. Pascua. Gotta Catch ‘EM All. A strategic IMs for Grade-10 Science. 2nd quarter.

Websites
https://www.britannica.com/science/electromagnetic-spectrum
https://www.teachengineering.org/lessons/view/clem_waves_lesson04
https://sciijnks.gov/rainbow/#:--.text=A%20rainbow%20is%20caused%20by,droplet%2C%20it%20makes%20a%20rainbow.)

Images
https://en.wikipedia.org/wiki/Heinrich_Hertz
https://www.britannica.com/biography/Andre-Marie-Ampere/media/1/21416/8352
https://www.researchgate.net

Development Team

<table>
<thead>
<tr>
<th>Writer:</th>
<th>Ruby V. Caperida</th>
</tr>
</thead>
<tbody>
<tr>
<td>Editors:</td>
<td>Margie Lou C. Jacob, Laarni A. Adonis, Kathleen Joy B. Padilla, Joly C. Baradero</td>
</tr>
<tr>
<td>Reviewer:</td>
<td>Sandy R. Albarico</td>
</tr>
<tr>
<td>Illustrator:</td>
<td>Sandy R. Albarico</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mi Ultimo Adios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deja que el sol, ardiente, las lluvias evapore y al cielo tomen puras, con mi clamar en pos;</td>
</tr>
<tr>
<td>Deja que un ser amigo mi fin temprano llore y en las serenas tardes cuando por mi alguien ore,</td>
</tr>
<tr>
<td>Ora también, oh Patria, por mi descanso a Dios</td>
</tr>
<tr>
<td>Y cuando en noche oscura se envuelve el cementerio Y solos sólo muertos queden velando su hábito,</td>
</tr>
<tr>
<td>No turbes su reposo, no turbes el misterio,</td>
</tr>
<tr>
<td>Y solos sólo muertos queden velando allí,</td>
</tr>
<tr>
<td>No tenga cruz ni piedra que marquen su lugar,</td>
</tr>
<tr>
<td>Entonces nada importa me libere, me diera por tu bien.</td>
</tr>
<tr>
<td>Deja que el sol, ardiente, las lluvias evapore y al cielo tomen puras, con mi clamar en pos;</td>
</tr>
<tr>
<td>Deja que un ser amigo mi fin temprano llore y en las serenas tardes cuando por mi alguien ore,</td>
</tr>
<tr>
<td>Ora también, oh Patria, por mi descanso a Dios</td>
</tr>
<tr>
<td>Y cuando en noche oscura se envuelve el cementerio Y solos sólo muertos queden velando su hábito,</td>
</tr>
<tr>
<td>No turbes su reposo, no turbes el misterio,</td>
</tr>
<tr>
<td>Y solos sólo muertos queden velando allí,</td>
</tr>
<tr>
<td>No tenga cruz ni piedra que marquen su lugar,</td>
</tr>
<tr>
<td>Entonces nada importa me libere, me diera por tu bien.</td>
</tr>
</tbody>
</table>

Dr. Jose Rizal