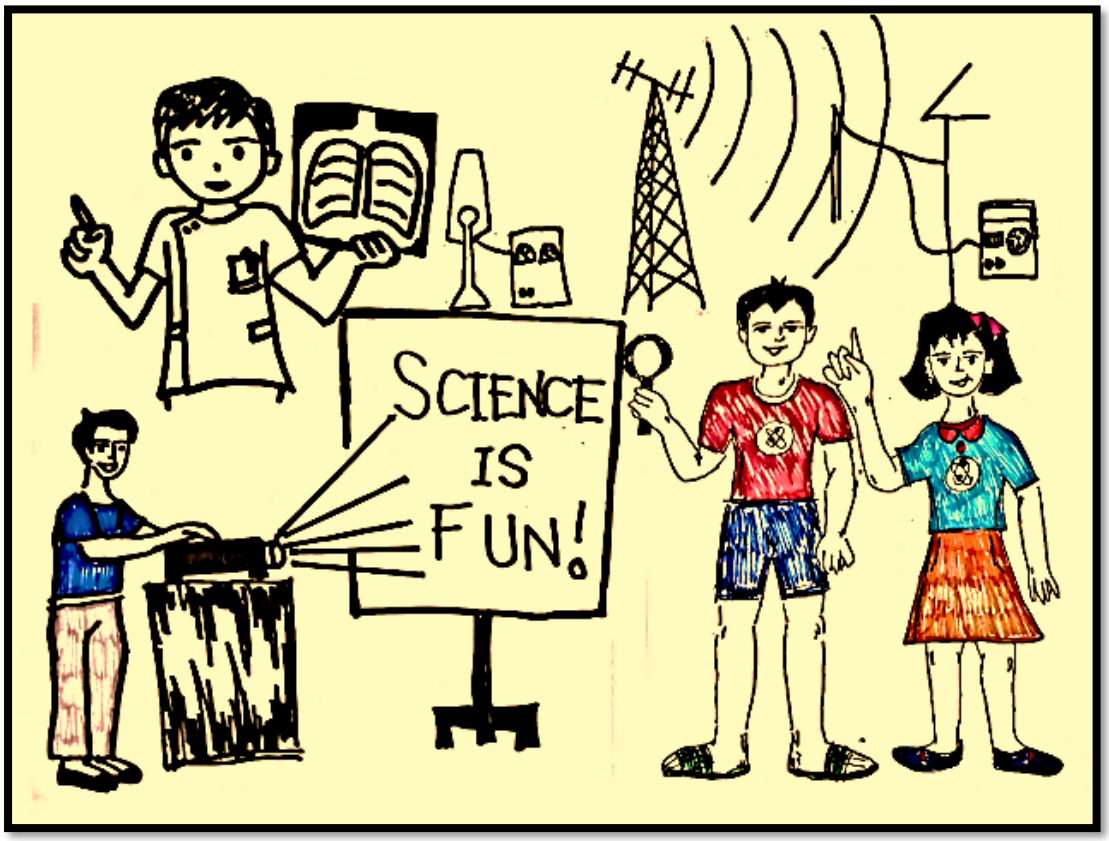
SELF- LEARNING KIT IN SCIENCE 10

THE ELECTRIC AND MAGNETIC FIELDS TOGETHER



MARIO JAMES S. DELA CRUZ
Santiago City National High School

SCIENCE 10
Self- Learning Kit
Quarter 2 Module 2: THE ELECTRIC AND MAGNETIC FIELDS TOGETHER
First Edition, 2024

Department of Education
Secretary: **SARA Z. DUTERTE**

Development Team

Writer: **MARIO JAMES S. DELA CRUZ**, Master Teacher I

Reviewers: **CLARISSA F. SOLIVEN-** EPS- Science; **PERFECTA M. BAUSTISTA PhD**- EPS-English;
MARIVEL G. MORALES- EPS- LRMDS; **JENELYN B. BUTAC**- Division Librarian;
JAY LORD B. GALLARDE- PDO II

Illustrator/ Layout Artist: **MARIO JAMES S. DELA CRUZ**, Master Teacher I

Management Team: **CLARISSA F. SOLIVEN**, EPS- Science; **JANETTE V. BAUTISTA EdD**, CID- Chief;
JACQUELINE S. RAMOS PhD, CESE, OIC-Assistant Schools Division Superintendent;
FLORDELIZA C. GECOBE PhD, CESO V, Schools Division Superintendent

Printed in the Philippines
Department of Education-Region II
Schools Division of Santiago City
Telephone Nos.: (078) 682-0151; (078) 682-0156
Email Address: santiago.city@deped.gov.ph

FOREWORD

This Self-Learning Kit aims to guide Grade 10 students on explaining the formation of electromagnetic wave, discussing the properties of an electromagnetic wave and calculating problems about the wave equation.

Electromagnetic energy travels in waves and spans a broad spectrum from very long radio waves to very short gamma rays. The human eye can only detect only a small portion called visible light. A radio detects a different portion of the spectrum, and an x-ray machine uses yet another portion. NASA's scientific instruments use the full range of the electromagnetic spectrum to study the Earth, the solar system, and the universe beyond.

The different activities in this kit will enable students to explore the comparison of the relative wavelengths of different forms of electromagnetic waves. The activities also provide students analytical thinking while doing their given tasks.

SCIENCE 10
PIONEERS OF ELECTROMAGNETIC THEORY

CONTENT STANDARD

The learners demonstrate an understanding of the different regions of the electromagnetic spectrum.

PERFORMANCE STANDARD

The learners should be able to perform differentiated activities on electromagnetic waves.

MOST ESSENTIAL LEARNING COMPETENCY

Compare the relative wavelengths of different forms of electromagnetic waves.
Code: (S10FE-IIa-b-47)

SPECIFIC OBJECTIVES

1. Explain the formation of electromagnetic wave;
2. Discuss the properties of an electromagnetic wave; and
3. Calculate problems about the wave equation.

WHAT HAPPENED?

LET'S HUNT ELECTROMAGNETIC WORDS

DIRECTIONS: The **ELECTROMAGNETIC SPECTRUM** is the collective name of all the different frequencies and types of light or electromagnetic radiation. Search for the hidden words by looking vertically, horizontally, and diagonally.

M	**I**	**B**	**H**	**T**	**I**	**D**	**A**	**M**	**L**	**Y**	**O**	**W**	**C**	**T**
U	**E**	**N**	**T**	**L**	**N**	**R**	**I**	**I**	**B**	**E**	**A**	**O**	**V**	**M**
R	**Y**	**O**	**G**	**O**	**D**	**L**	**W**	**C**	**E**	**B**	**L**	**U**	**I**	**E**
T	**L**	**I**	**N**	**V**	**I**	**A**	**T**	**R**	**V**	**O**	**L**	**I**	**O**	**A**
C	**I**	**T**	**E**	**N**	**G**	**A**	**M**	**O**	**R**	**T**	**C**	**E**	**L**	**E**
E	**G**	**A**	**L**	**O**	**O**	**L**	**Y**	**W**	**R**	**L**	**S**	**E**	**E**	**Z**
P	**H**	**I**	**E**	**R**	**D**	**E**	**R**	**A**	**R**	**F**	**N**	**I**	**T**	**R**
S	**T**	**D**	**V**	**T**	**R**	**G**	**V**	**V**	**R**	**E**	**R**	**R**	**W**	**R**
Y	**E**	**A**	**A**	**C**	**R**	**I**	**E**	**E**	**U**	**A**	**E**	**I**	**U**	**G**
E	**G**	**R**	**W**	**E**	**O**	**A**	**Q**	**L**	**D**	**H**	**M**	**W**	**Z**	**E**
T	**G**	**R**	**E**	**L**	**A**	**U**	**B**	**I**	**B**	**D**	**X**	**M**	**T**	**C**
V	**I**	**N**	**E**	**E**	**E**	**W**	**O**	**B**	**N**	**I**	**A**	**R**	**A**	**R**
N	**R**	**T**	**A**	**N**	**G**	**S**	**T**	**R**	**O**	**M**	**S**	**P**	**A**	**G**
V	**V**	**D**	**C**	**R**	**E**	**D**	**R**	**O**	**Y**	**G**	**B**	**I**	**V**	**Y**
T	**T**	**Y**	**O**	**W**	**O**	**L**	**L**	**E**	**Y**	**T**	**O**	**V**	**V**	**S**

Angstrom
Blue
Color
Electromagnetic
Electron volt
Energy
Frequency
Gamma ray
Green
Hertz
Indigo
Infrared
Light
Microwave
Orange
Radiation
Radio
Rainbow
Red
Roy G Biv
Spectrum
Ultraviolet
Violet
Visible
Wavelength
Xray
Yellow

**Adopted:*
https://sciencenotes.org/electromagnetic-spectrum-word-search/

PRE- TEST

DIRECTIONS: Write the letter of your answer on the space provided before the number.

____1. How are Electromagnetic Waves produced?
a. by static electricity
b. by accelerating electrons
c. by constant magnetism
d. by gravitational force

____2. EM Waves are combination of what physical quantities?
I. Gravitational III. Magnetic
II. Electric IV. Inertial
a. I and II
b. II and III
c. III and IV
d. II,III,IV

____3. Which of the following is a wave equation?
a. **F=ma** b. **v=λf** c. **I=V/R** d. **d=vt**

____4. What is the speed of light or speed of EM waves?
a. **3x10^{5}** m/s b. **3x10^{6}** m/s
c. **3x10^{7}** m/s d. **3x10^{8}** m/s

____5. Which is true about mechanical and EM waves?
a. Sound is an EM Wave and radio wave is a mechanical wave
b. Both waves can travel in space and vacuum
c. Mechanical wave requires medium to propagate while EM wave do not.
d. Mechanical waves can travel in space and vacuum.

____6. Which of the following is an Electromagnetic Wave?
I. Microwave II. Infrared III. Surface IV. Sound
a. I and II
b. I,II and III
c. II and III
d. III and IV

____7. This type of wave was discovered by famous astronomer Sir Frederick William Herschel and has a range of 7x10-7 m – 1x10-5 m.
a. infrared b. microwave c. radio wave d. visible light

____8. Which of the following electromagnetic waves has the least wavelength range?
a. infrared (7x10-7 m – 1x10-3 m) b. x-ray (1 x10-11 m – 1 x10-8 m)
c. visible light (6.22 x10-7 m – 4.55 x10-7 m) d. ultraviolet (1x10-8 m – 4x10-7 m)

____9. Which among the following EM waves has the longest wavelength?
a. infrared b. ultraviolet c. visible light d. x-ray

____10. Which electromagnetic wave can travel the farthest distances because it has a wavelength range of greater than 1x10-1 m?
a. gamma ray b. microwave c. radio wave d. x-ray

WHAT TO LEARN?

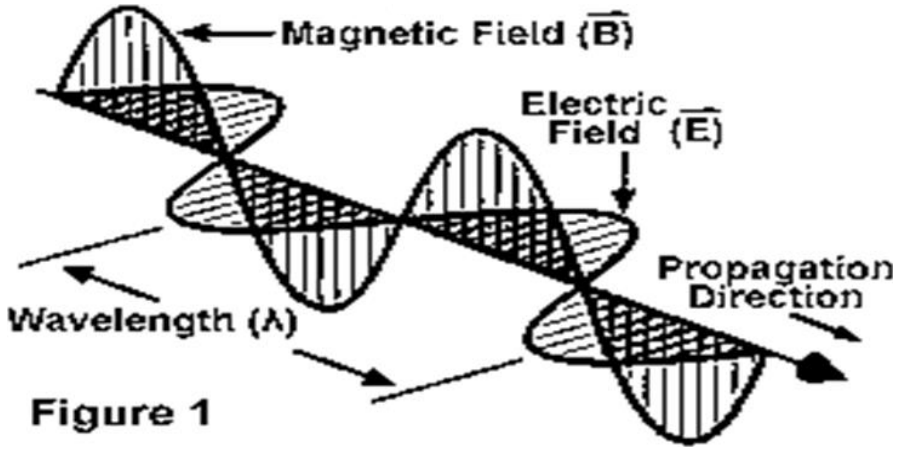
DEVELOPMENT OF ELECTROMAGNETIC WAVE

Accelerating electrons produce electromagnetic 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.

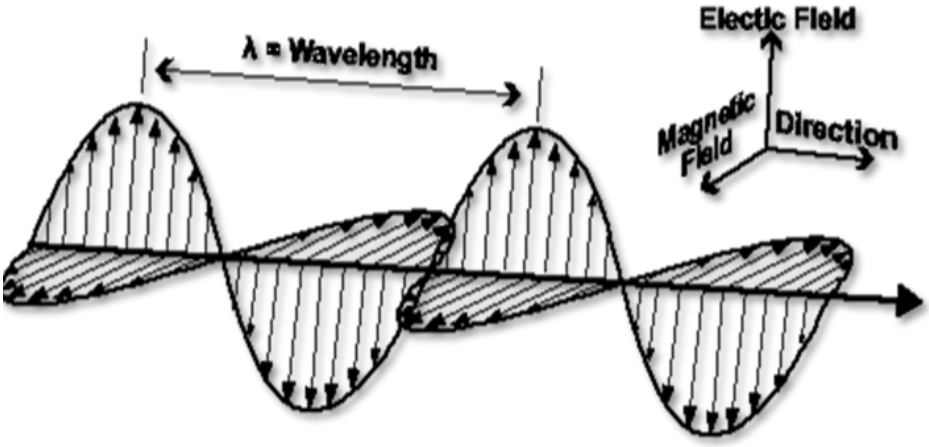
Whenever a current varies, associated electric and magnetic fields vary, moving out from the source like waves. The electric and magnetic fields are closely related and propagate as an electromagnetic wave. This is what happens in broadcast antennae such as those in radio and TV stations.

Figure 1. Electromagnetic Wave



https://www.chemistryviews.org/details/ezine/5283841/The_Electro magnetic_Spectrum.html

Figure 2. Direction of Magnetic and Electric Fields



https://www.rfcafe.com/references/electrical/electromagnetic-wave-physics.htm

Electromagnetic waves consist of both electric and magnetic field waves. These waves oscillate in perpendicular planes with respect to each other (refer to Figure 2) and are in phase. The creation of all electromagnetic waves begins with an oscillating charged particle, which creates oscillating electric and magnetic fields.

Electromagnetic radiation is a form of energy emitted by moving charged particles. As it travels through space it behaves like a wave and has an oscillating electric field component and an oscillating magnetic field. These waves oscillate perpendicularly to and in phase with one another.

PROPERTIES OF ELECTROMAGNETIC WAVE

All electromagnetic waves can travel through a medium but unlike other types of waves, they can also travel in vacuum. They travel in vacuum at a speed of **3 x 10^8 or 300,000,000 m/s** and denoted as c, the speed of light. The wave speed, frequency, and wavelength are related by the following equation:

$$v=\lambda f$$

v is the wave speed, or c (speed of light) in meters per second (m/s), frequency f in Hertz (Hz) or per second (/s) and wavelength λ in meters.

Since all the EM waves have the same speed and that is equal to the speed of light, as **wavelength decreases, the frequency of the wave increases.** Electromagnetic waves exhibit reflection, refraction, diffraction and interference. These waves can also transfer energy.

SAMPLE PROBLEMS ON WAVE EQUATION:

1. What is the frequency of radio waves with wavelength of 20 m? (Assume that the waves propagate in a vacuum)

Given: v = c = $3x10^8$ m/sλ = 20 m f = ?
Solution: v = c = λf
Formula: **f = c / λ**
= $3x10^8$ m/s / 20 m (cancel m)
Answer: = 1.5 x 10^7 / sec or 1.5 x10^7 Hz

2. What is the frequency of light waves with wavelength of 5×10^{-7} m? (Assume that the waves propagate in a vacuum)

Given: $v = c = 3 \times 10^8$ m/s $\lambda = 5 \times 10^{-7}$ m $f = ?$
Solution: $v = c = \lambda f$
Formula: **$f = c / \lambda$**
$= 3 \times 10^8$ ~~m~~/~~s~~ / 5×10^{-7} ~~m~~
Answer: $= 6 \times 10^{14}$ / sec or 6×10^{14} Hz

3. Calculate the wavelength of a light wave if it moves at the speed of light (300,000,000 m/s) with a frequency of 4×10^6 Hz. (Assume that the waves propagate in a vacuum)

Given: $v = c = 3 \times 10^8$ m/s$f = 4 \times 10^6$ Hz $\lambda = ?$
Solution: $v = c = \lambda f$
Formula: **$\lambda = c / f$**
$= 300{,}000{,}000$ m/s / 4×10^6 Hz
or $= 3 \times 10^8$ m / ~~s~~ / 4×10^6 / ~~s~~
Answer: $= 75$ m

WHAT ARE ELECTROMAGNETIC AND MECHANICAL WAVES?

Mechanical waves and electromagnetic waves are two important ways that energy is transported in the world around us. Waves in water and sound waves in air are two examples of **mechanical waves**.

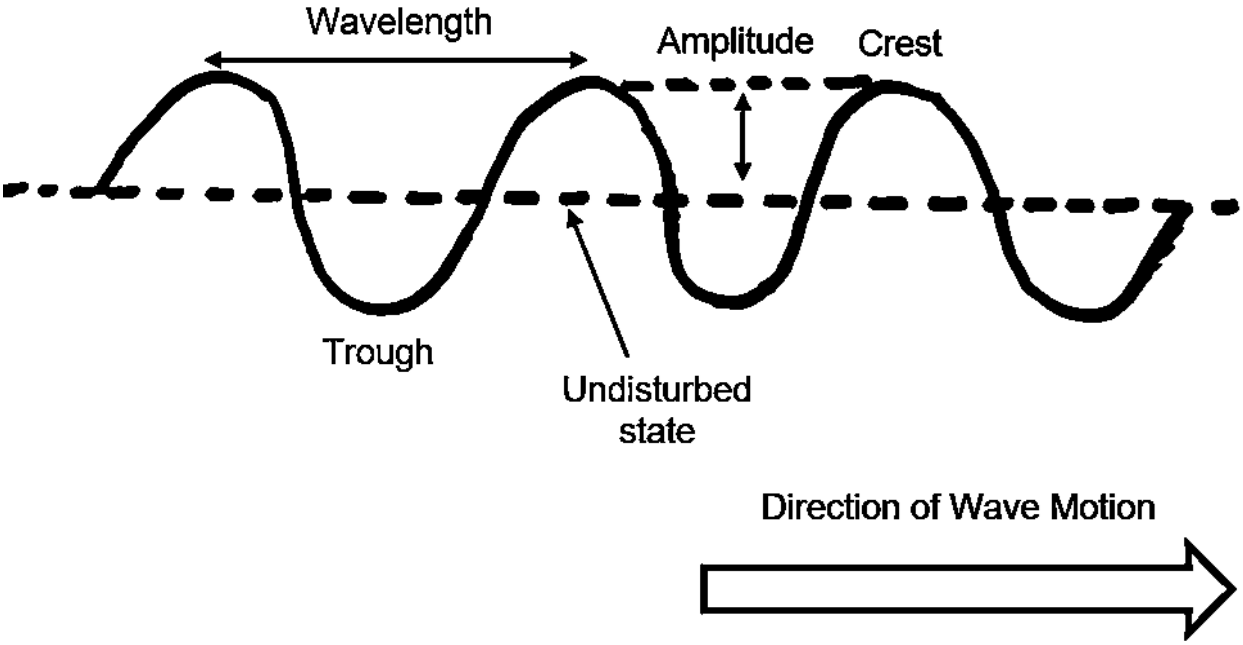
Mechanical waves are caused by a disturbance or vibration in matter, whether solid, gas, liquid, or plasma. Sound waves cannot travel in the vacuum of space because there is no medium to transmit these mechanical waves.

Electromagnetic waves differ from mechanical waves in that they do not require a medium to propagate. This means that electromagnetic waves can travel not only through air and solid materials, but also through the vacuum of space.

Examples of EM Waves are:

1. Radio Wave
2. Microwave
3. Infrared
4. Visible light
5. Ultraviolet
5. X-Ray
6. Gamma

Electromagnetic waves have crests and troughs similar to those of ocean waves. The distance between crests is the wavelength. The shortest wavelengths are just fractions of the size of an atom, while the longest wavelengths scientists currently study can be larger than the diameter of our planet!



WHAT HAVE YOU LEARNED?

ACTIVITY 1
LET'S HUNT ELECTROMAGNETIC WORDS

DIRECTIONS: Read the given statements below. If the statement is correct, write ***EM WAVE***. If not, correct them by writing your answers.

_____1. Electromagnetic waves transfer energy through a vacuum.

_____2. There is indirect relation between electric and magnetic field in the formation of EM waves.

_____3. Most EM waves are invisible and undetectable.

_____4. Static electrons can produce EM waves.

_____5. A wave is a disturbance that transfer energy.

_____6. Sound waves can propagate in a vacuum.

_____7. Electromagnetic wave is the same as mechanical wave in terms of propagation or generation.

ACTIVITY 2
QUESTION AND ANSWER PORTION

DIRECTIONS: Answer briefly but substantially. Write your answer on a separate sheet of paper.

1. What comprises an EM wave?

2. If the wavelength increases, what happens to the frequency of the wave?

3. What is the relationship of electric and magnetic fields in the formation of EM wave?

4. Explain why an EM wave is an energy carrier.

5. What is the main difference between mechanical wave and electromagnetic wave?

ACTIVITY 3
WHAT'S YOUR PROBLEM?

TASK: Solve the given problems about the wave equation. Show your complete solution and encircle your final answer.
* Assume that the waves propagate in a vacuum/ speed of light = 300,000,000 m/s

1. What is the frequency of microwaves with a wavelength of 35 m?

2. Calculate the wavelength of an infrared wave if it moves at the speed of light with a frequency of 5,000,000 Hz.

3. What is the frequency of an infrared wave if it has a wavelength of 16 m?

4. What is the wavelength of a certain EM wave who's moving at a speed of light with a wave frequency of 2,000,000 Hz?

POST- TEST

DIRECTIONS: Write the letter of your answer on the space before the number.

____1. Which of the following is an Electromagnetic Wave?
I. Microwave II. Infrared III. Surface IV. Sound
a. I and II
b. I,II and III
c. II and III
d. III and IV

____2. EM Waves are combination of what physical quantities?
I. Gravitational II. Electric III. Magnetic IV. Inertial
a. I and II
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d. II,III,IV

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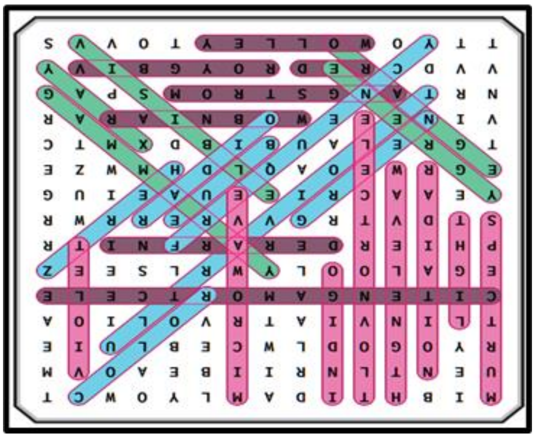
Illustrations

https://www.chemistryviews.org/details/ezine/5283841/The_Electromagnetic_Spectrum.html

https://www.rfcafe.com/references/electrical/electromagnetic-wave-physics.htm

ANSWER KEY

What Happened?



Pre-Test

1. b, 2. b, 3. b, 4. d, 5. c, 6. a, 7. a, 8. b 9,. a 10. c

Post- Test

1. a, 2. b, 3. b, 4. d, 5. d, 6. b 7. a, 8. b 9,. a 10. c

Activity 1

1. EM WAVE 2. Direct 3. EM WAVE

4. Cannot 5. EM WAVE 6. Cannot 7. Not the same

Activity 2

Answers may vary

Activity 3

1. 8,571,428.57 hz 2. 60 m.

3. 18,750,000/s or 18,750,000 hz

4. 150 m.

SYNOPSIS

A wave is a disturbance that transfers energy. Electromagnetic Waves have unique properties: can travel through a vacuum, travel at the speed which is constant in a given medium and has a value of $c=3x10^8$ m/s in vacuum and are disturbances in a field rather than a medium.

EM Waves have an electric field that travels perpendicular with the magnetic field. When moving charged particles transfer energy through a field, EM Waves are produced.

ABOUT THE AUTHOR

MARIO JAMES S. DELA CRUZ, Master Teacher I, is an Advanced Physics and Science 10 teacher at Santiago City NHS. In 2020, he was awarded Most Outstanding Secondary Teacher in the Schools Division of Santiago City and a Finalist during the 2020 Regional STARS Awards.

In 2021, he received an international recognition as Luminary Excellence in Education and Research Award- Outstanding Educator in Science.

His work as Science teacher also appreciated in Region 02 and gave him the award Most Outstanding Secondary Teacher and Outstanding Employee Award.

He was awarded as the Grand National Champion in SIM Making at the National Science and Technology Fair in 2020. Recently, he was awarded Grand National Champion in SIM Making spearheaded by the Salindunong Review and Research Center.

He is a Regional Learning Activity Sheet writer and Content Editor. He is a Strategic Intervention Material (SIM) and Self- Learning Kit (SLK) writer.

He continues to contribute to Science Education as a Science Club adviser, academic coach, resource person, lecturer and evaluator at various seminars, conferences and Science fairs.