12

General Physics 1

Quarter 1 – Module 1

Measurement

General Physics 1 – Grade 12
Self-Learning Module (SLM)
Quarter 1 – Module 1: Measurement
First Edition, 2020

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Printed in the Philippines by Department of Education – SOCCSKSARGENRegion

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Introductory Message

For the facilitator:

Welcome to the **General Physics 1 – Grade 12 STEM** Self-Learning Module (SLM) on **Measurement!**

This module was collaboratively designed, developed and reviewed by educators both from public and private institutions to assist you, the teacher or facilitator in helping the learners meet the standards set by the K to 12 Curriculum while overcoming their personal, social, and economic constraints in schooling.

This learning resource hopes to engage the learners into guided and independent learning activities at their own pace and time. Furthermore, this also aims to help learners acquire the needed 21st century skills while taking into consideration their needs and circumstances.

In addition to the material in the main text, you will also see this box in the body of the module:

Notes to the Teacher

This contains helpful tips or strategies that will help you in guiding the learners.

As a facilitator you are expected to orient the learners on how to use this module. You also need to keep track of the learners' progress while allowing them to manage their own learning. Furthermore, you are expected to encourage and assist the learners as they do the tasks included in the module.

For the learner:

Welcome to the **General Physics 1 – Grade 12 STEM** Self-Learning Module (SLM) on **Measurement!**

The hand is one of the most symbolized part of the human body. It is often used to depict skill, action and purpose. Through our hands we may learn, create and accomplish. Hence, the hand in this learning resource signifies that you as a learner is capable and empowered to successfully achieve the relevant competencies and skills at your own pace and time. Your academic success lies in your own hands!

This module was designed to provide you with fun and meaningful opportunities for guided and independent learning at your own pace and time. You will be enabled to process the contents of the learning resource while being an active learner.

This module has the following parts and corresponding icons:

 ***What I Need to Know***	This will give you an idea of the skills or competencies you are expected to learn in the module.
 ***What I Know***	This part includes an activity that aims to check what you already know about the lesson to take. If you get all the answers correct (100%), you may decide to skip this module.
 ***What's In***	This is a brief drill or review to help you link the current lesson with the previous one.
 ***What's New***	In this portion, the new lesson will be introduced to you in various ways such as a story, a song, a poem, a problem opener, an activity or a situation.
 ***What is It***	This section provides a brief discussion of the lesson. This aims to help you discover and understand new concepts and skills.
 ***What's More***	This comprises activities for independent practice to solidify your understanding and skills of the topic. You may check the answers to the exercises using the Answer Key at the end of the module.
 ***What I Have Learned***	This includes questions or blank sentence/paragraph to be filled in to process what you learned from the lesson.
 ***What I Can Do***	This section provides an activity which will help you transfer your new knowledge or skill into real life situations or concerns.

	***Assessment***	This is a task which aims to evaluate your level of mastery in achieving the learning competency.
	***Additional Activities***	In this portion, another activity will be given to you to enrich your knowledge or skill of the lesson learned. This also tends retention of learned concepts.
	***Answer Key***	This contains answers to all activities in the module.

At the end of this module you will also find:

References	This is a list of all sources used in developing this module.

The following are some reminders in using this module:

1. Use the module with care. Do not put unnecessary mark/s on any part of the module. Use a separate sheet of paper in answering the exercises.
2. Don't forget to answer *What I Know* before moving on to the other activities included in the module.
3. Read the instruction carefully before doing each task.
4. Observe honesty and integrity in doing the tasks and checking your answers.
5. Finish the task at hand before proceeding to the next.
6. Return this module to your teacher/facilitator once you are through with it.

If you encounter any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator. Always bear in mind that you are not alone.

We hope that through this material, you will experience meaningful learning and gain deep understanding of the relevant competencies. You can do it!

What I Need to Know

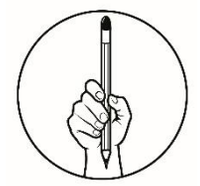
This module was designed and written with you in mind. It is here to help you master the Measurement!. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the textbook you are now using.

After going through this module, you are expected to:

1. Solve measurement problems involving conversion of units, expression of measurements in scientific notation; **STEM_GP12EU-Ia-1**
2. Differentiate accuracy from precision; **STEM_GP12EU-Ia-2**
3. Differentiate random errors from systematic errors; **STEM_GP12EU-Ia-3**
4. Estimate errors from multiple measurements of physical quantity using variance. **STEM_GP12EU-Ia-4**

The module is divided into three lessons, namely:

- Lesson 1 – Measurement: Units, Conversion and Scientific Notation
- Lesson 2 – Accuracy, Precision and Errors in Measurement
- Lesson 3 – Measurement Data Presentation



What I Know

Choose the letter of the answer. Write the chosen letter on a separate sheet of paper.

1. Which of the following is a measurement unit?
   a. Meter
   b. Yard
   c. Inch
   d. All are correct
2. Measurement is _____ something to a standard and accepted value.
   a. comparing
   b. describing
   c. quantifying
   d. all are correct
3. Which of the following is an English System Unit?
   a. Kilogram
   b. Kilometer
   c. Liter
   d. Mile
4. How many inches are there in one foot?
   a. 6 b. 12 c. 14 d. 16
5. Which of the following can be a source of a measurement error?
   a. Uncalibrated instrument
   b. Wrong observation
   c. Mechanical defects
   d. All are correct
6. The following are systematic error except:
   a. instrumental error
   b. loading effect
   c. misuse of instrument
   d. carelessness in measuring
7. Which of the following measurements indicates the mass of the objects?
   a. 1 square inch
   b. 3 pounds
   c. 2 cubic meters
   d. 4 seconds
8. Which of the following metric prefixes can be used to measure the mass of our planet Earth?
   a. Kilo b. Nano c. Micro d. Milli
9. For a measurement to be accurate, it should be based with the _____ used to take the actual measurement of the material.
   a. same parts of the body
   b. same objects
   c. same time
   d. same standards of measure
10. Using scientific notation, decimal places are expressed as powers of _____.
    a. 6 b. 8 c. 10 d. 12
11. The statement 1 L = 1000 m^3 is _____.
    a. True b. False c. Not sure d. all are correct
12. The S. I unit for mass is_____.
    a. Kilograms b. Pounds c. Inches d. Seconds
13. A measuring tape can measure length more than a/an_____.
    a. inch but less than a foot
    b. foot but less a meter
    c. meter
    d. inch
14. The difference between the measured value of a quantity from its exact value is a/an_____.
    a. error
    b. mistake
    c. measurement
    d. absolute value
15. The following are systematic error except:
    a. instrumental error
    b. loading effect
    c. misuse of instrument
    d. carelessness in measuring

Lesson 1 Measurement: Units, Conversion and Scientific Notation

Learning Objective:

1. Solve measurement problems involving conversion of units, expression of measurements in scientific notation; **STEM_GP12EU-Ia-1**

A nice day ahead... Today we will learn about measurement which you are familiar with and you had been using in your everyday life. Are you aware of your height and weight? Well you must be, because annually you are required to have your Body Mass Index (BMI) recorded and analyzed to indicate your Nutritional Status for the year since your elementary years. This and more are just few things which apply measurement, in real situations. Matter around us needs to be described through measuring.

What's In

Activity 1: It's My Unit!

Direction: Given the material or event, select a unit of measurement that can be used to describe it. Write your answer on a separate sheet of paper.

1. Distance of a town to another = kilometers, centimeters, meters
2. Average height of a human = kilometers, centimeters, meters
3. Weight of a full grown chicken = kilograms, grams, milligrams
4. Thickness of a hardbound 300 pages book = kilometers, centimeters, meters
5. Collision impact on objects = years , hours, seconds
6. Medicinal dosage = kilograms , grams , milligrams
7. Time of a space travel = years , hours , seconds
8. Charging a cell phone = years , hours , seconds
9. Information response through the use of internet = years , hours , seconds
10. Weight of an insect = kilograms , grams , milligrams

What's New

Activity 1.1. Express Me Scientifically!

Procedure:

1. Move the decimal point in the following measurements below to arrive at a single non-zero digit.
2. Take note that the number of times you move the decimal point becomes the exponent of your power of ten.
3. Remember that if the movement is to the left the exponent is positive while towards the right is negative.

a. Size of a cell is 0.00001 m_____
b. A 8,500 m high elevation mountain_____
c. A mosquito weighs 0.00002 kg _____
d. A 50- ton truck _____
e. The size of dust particleis about 0.000002 m _____

Guide Questions:

Q1. Which of the given have negative exponent? Which have the positive exponent?

Q2. What can you say with the measurement when the exponent is positive? Negative?

Activity 1.2. Convert Me!

Materials :	Footrule	Bond Paper (Long)
	Egg (medium)	Slipper
	Pingpong ball	Softdrink Bottle (1 L)

Procedures:

1. Using a ruler, take the length of each specified objects below. Use centimeters as a unit of measurement.

   A) Soft drink bottle (1 L)
   B) A sheet of bond paper (long)
   C) A slipper (size 10)
   D) An egg (medium size)
   E) A pingpong ball

2. Using the other side of the ruler which uses inch as its unit, record the measurement of each of the above objects.

3. Record your answers on the table below:

Object/Thing	Metric Unit (cm)	English Unit (in)
1. Softdrink Bottle (1L)		
2. A sheet of bond paper (long)		
3. A slipper(size 10)		
4. An egg (medium size)		
5. A pingpong ball		

Guide Questions:

Q1. Which of the objects listed is the shortest? The longest? What is their dimension?

Q2. As what you can see on the ruler, how many centimetres is equivalent to an inch?

Q3. Do you think that each measurement expressed in different units for the same material is equal? Why?

What is It!

Measurement Defined

Measurement is the act of determining matter's size, length, weight, capacity or other aspect. In general, measurement can be understood as one action within the term instrumentation. When we measure we compare the material's basic properties with the accepted international standards for its accuracy and precision.

A **measurement unit** is a standard quantity used to express a physical quantity. Whatever is chosen as a standard must be readily accessible and possess some property that can be measured reliably—measurements taken by different people in different places must yield the same result.

In measuring physical quantities, there are two systems of measurement commonly used by different countries all over the world, these are **Metric Units and the US Standard Unit (English Unit). Length** describes how long a thing is from one end to another. **Mass** is the amount of matter a thing consists of. **Time** is the ongoing sequence of events. Below are the common units of measurement in the basic physical quantities:

Physical Quantity	Metric System	English System
Length	Meters + Prefixes	Mile, Yard, Foot, Inches
Mass	Grams + Prefixes	Pounds, Tons
Time	seconds	Seconds

How do we express measurement into standard scientific notation? We simply move the decimal point either left or right to attain a single non-zero digit which is the significant digit. The number of times you move the decimal point either to the left or right becomes the exponent, moving it to the left makes the exponent positive while moving this to right is negative.

Let's say that you have a 50,000 kg of rice as your yield in the farm, how much is this amount in unit kg and grams respectively? To do this, you move the decimal point four times to the left to reach a single non-zero digit which is five, hence in unit kg this is 5×10^4 kg while in unit g this is 5×10^7 g .

Indeed, both measurements represent the same amount. These quantities are called **equivalent units.** Furthermore, we can determine the equivalent amount of a single measurement by using the equivalent amount of unit called the **conversion factor.**

Conversion factors between the SI units and conventional units of length are as follows:

1 m = 39.37 in. = 3.281 ft 1 in. = 0.025 4 m = 2.54 cm (exactly)

1 mi = 1 609 m = 1.609 km 1 ft = 0.304 8 m = 30.48 cm

Units can be treated as algebraic quantities that can cancel each other. For example, suppose we wish to convert 15.0 in. to centimeters. One (1) inch is defined as exactly 2.54 cm, because it is the same as multiplying by 1, since the numerator and denominator describe identical things. (2.54 cm 1 in) 15.0 in. = (15.0 in.)(2.54 cm/in.) = 38.1 cm

What's More!

Activity 1.3. That is My Equivalent

Direction: In each of the following statements below, evaluate whether it is **TRUE** or **FALSE** and write your answer on a separate sheet of paper.

_____ 1. A mile is shorter than a kilometer.
_____2. An inch is equal to 2.54 cm.
_____3. A 6 foot person is taller than 3.1 m object.
_____4. Earth 's diameter is longer than the diameter of its orbit .
_____5. The diameter of a Hydrogen atom is larger than a millimeter.

_____6. A 7.5 x 10^{-6} ions of Hydrogen are more than 1.5 x 10^{-3} molecules of Helium.
_____7. A 1 square mile stadium can contain a 1 square kilometer football field.
_____8. A 3.2 x 10^{-2} mm bacterium is as large as 0.032 mm fungi.
_____9. The diameter of an atomic nucleus which is 1 x 10^{-14} mis longer than the diameter of a proton 1 x10^{-15} m.
_____10. One thousand kilograms 1,000 x 10^{3} kg is as heavy as one Mega gram 1 x 10^{6} Mg.

What I Have Learned

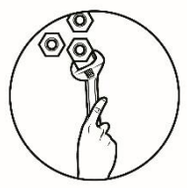
Activity 1.4. I Fill You

Direction: Fill in the blanks to complete the paragraph.

The act of determining the object's size, and or dimension is called (1)_____. For a measurement to be accurate, and precise it must use the standard (2) _____ of Measurement. One measurement system can be converted with another system by using (3) _____, which states the equality of different measurement units. In writing these measurements, scientist uses the method of using the powers of ten this is called the scientific (4) _____.

The number of times the decimal is moved to reach the single non-zero digit is termed as the (5) _____. When the decimal point is moved to the left the exponent is (6) _____ this means that the measurement is greater than its base unit, while when the decimal point was moved to the right, the exponent is (7) _____ which means that the measurement is smaller than its base unit.

When (8)_____ yourself on a scale, you position yourself slightly differently each time. When taking a (9) _____in a flask, you may read the value from a different angle each time. Measuring your (10) _____is affected by minor posture changes.



What I Can Do

Activity 1.5. Let's Solve It!

Direction: Solve what are asked below:

1. A rectangular building lot is 100 ft by 150 ft. Determine the area of this lot in m^2.

2. The mass of the Sun is 1.99×10^{30} kg, and the mass of an atom of hydrogen, of which the Sun is mostly composed, is 1.67×10^{27} kg. How many atoms are there in the Sun?

3. Walt grew 10 centimeters in 1 year. He is now 1.6 m tall. How tall was he 1 year ago?

4. Chase measured a line for his art project. It is 200 millimeters long. How many centimeters is the line?

5. John wanted to impress his friends by winning the 200 yard dash at the track meet. If he runs 8.2 feet per second, how long will it take him to complete the dash? (round to the nearest tenth)

Lesson 2 Accuracy, Precision and Errors in Measurement

Learning Objectives:

2. Differentiate accuracy from precision. **STEM_GP12EU-Ia-2**
3. Differentiate random errors from systematic errors. **STEM_GP12EU-Ia-3**

Hi! Today, we will learn about precision and accuracy in a measurement which you are familiar with and you had been using in your everyday life. Did you experience difficulty in measuring because the equipment is new to you? This and more are just few things which could hinder accuracy and precision in measurement, in real situations. Matter around us needs to be measured accurately and precisely.

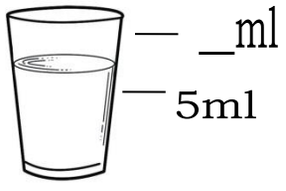
What's In

Activity 2.1. How accurate am I!

Procedures:

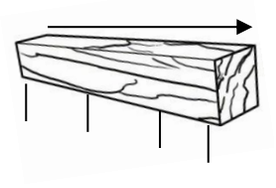
A. Given the following objects, find the volume and length that is accurately expressed.

1.

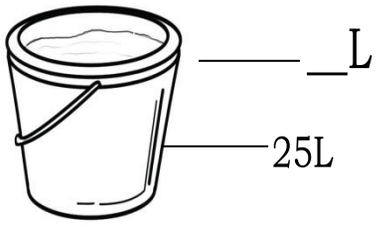


a. 8ml
b. 9ml
c. 10ml
d. 15 ml

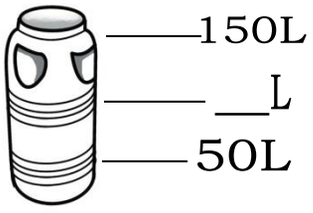
2.



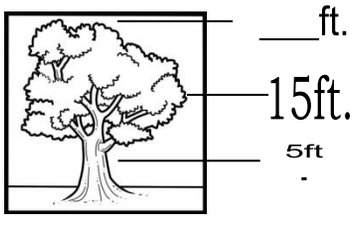
a. 3.5cm
b. 4cm
c. 3.0cm
d. 3.8cm

3. 

a. 30L
b. 45L
c. 50L
d. 40L

4. 

a. 25L
b. 125L
c. 75L
d. 100 L

5. 

a. 20ft.
b. 15ft.
c. 15.5ft.
d. 18ft.

Guide Questions:

1. What is/are your bases to make it accurate?

2. What have you noticed with the unit in problem number 1,3 and 4? Are they related to each other? How?

What's New

Activity 2.2. Error, Error It's My Call

Procedure:

1. The following are the measurements of the waistline of a family member taken by 3 different persons using a tape measure.

Table 1. Measurements Taken by 3 Persons

PERSON	MEASUREMENT (cm)
1	15
2	13
3	12.5

2. The mass of a small stone using different scales- the spring balance, double beam balance and the digital weighing scale are shown below:

Table 2. Measurements Taken by Different Scales

Mass of Stone	Spring balance.	Double Beam Balance	Digital Weighing Scale
120 g	115 g	119 g	118 g

Guide Questions:

1. Looking into the table 1, are the measurements the same?
2. What could be the source of these differences?
3. In Table 2, are the measurements the same?
4. What do you think could be the source of these differences?

What is It

Accuracy and Precision Defined

In a measurement of anything, **accuracy** is the closeness of the measurements to a specific value, while **precision** is the closeness of the measurements to each other. Alternatively, ISO definesaccuracy as describing a combination of both types of Observational error above (random and systematic), so high accuracy requires both high precision and high trueness.

In simpler terms, given a set of data points from repeated measurements of the same quantity, the set can be said to be *accurate* if their average is close to the *true value* of the quantity being measured, while the set can be said to be *precise* if the values are close to each other. In the first, more common definition of "accuracy" above, the two concepts are independent of each other, so a particular set of data can be said to be either accurate, or precise, or both, or neither.

The main difference between systematic and random errors is that **random errors** lead to fluctuations around the true value as a result of difficulty taking measurements, whereas **systematic errors** lead to predictable and consistent departures from the true value due to problems with the calibration of your equipment. This leads to two extra differences that are worth noting.

Activity 2.3. Am I Accurate or Precise?

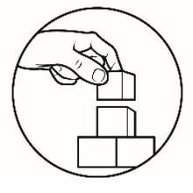
A scientist weighed a set of standard masses in grams on four different balances. Assume each standard mass is the true value with no error.

Table 1. Different Masses Measured in Different Balances

Standards (g)	Balance 1	Balance 2	Balance 3	Balance 4
12.5	12.4	11.0	12.6	15.1
8.2	8.1	6.5	8.3	9.4
6.3	6.2	7. 2	6.3	8.1
3.5	3.4	1.9	3.6	4.2
10.7	10.6	12.2	10.7	11.3

Q1. Based on the table above,which among the balances is precise and accurate?

PRECISE	ACCURATE



What's More

Activity 2.4. True or False!

Direction: Read the statement carefully and write **TRUE**if the statement is correct and **FALSE** if not. Write your answers on a separate sheet of paper.

_____1. Accuracy represents how closely the results agree with the standard value.

_____2. Eliminating the systematic error improves accuracy but does not change precision.

_____ 3. In numerical analysis, accuracy is also the nearness of a calculation to the true measurement.

_____ 4. The term accuracy is interchangeably used with validity and constant error.

_____5. Accuracy is obtained by taking small readings.

_____6. Accuracy represents how closely results agree with one another.

_____7. The closeness of two or more measurements to each other is known as the accuracy of a measurement.

_____8. Accuracy is the measure of correctness of the value in correlation with the information.

_____9. Accuracy is the amount of information that is conveyed by a value.

_____10. Accuracy is a description of systematic error.

What I Have Learned

Activity 2.5. You Made Me Complete

Direction: Fill in the blanks to complete the paragraph.

The act of determining the object's size, and or dimension is called (1)_____. For a measurement to be accurate, and precise it must use the standard (2)_____ of Measurement. One measurement system can be converted with another system by using (3)_____, which states the equality of different measurement units. In writing these measurements, scientist uses the method of using the powers of ten this is called the scientific (4)_____.

The number of times the decimal is moved to reach the single non-zero digit is termed as the (5)_____. When the decimal point is moved to the left the exponent is (6)_____ this means that the measurement is greater than its base unit, while when the decimal point was moved to the right, the exponent is (7))_____ which means that the measurement is smaller than its base unit.

When (8)_____ yourself on a scale, you position yourself slightly differently each time. When taking a (9)_____ in a flask, you may read the value from a different angel each time. Measuring your (10) _____ is affected by minor posture changes.

What I Can Do

Activity 2.6. Let's Think of It!

Direction: Solve and analyze the problems and choose the letter of the correct answer. Write in another sheet of paper.

1. Martin is conducting an experiment. His first test gives him a yield of 5.2 grams. His second test gives him a yield of 1.3 grams. His third test gives him a yield of 8.5 grams. On average, his yield is 5.0 grams, which is close to the known yield of 5.1 grams of substance. Which of the following are true?
   a. His results are accurate but not precise
   b. His results are precise but not accurate
   c. His results are both accurate and precise.
   d. His results are neither accurate nor precise.

2. Jared is practicing for a golf tournament. His normal driver distance is 250 yards. He hits three balls with his driver, and they travel a distance of 190 yards, 195 yards, and 187 yards. Which of the following is true?
   a. His drives are accurate but not precise.
   b. His drives are precise but not accurate.
   c. His drives are both accurate and precise.
   d. His drives are neither accurate nor precise.

3. Susan conducts an experiment five times and gets a solution concentration of 1.9M, 2.1M, 1.8M, 1.9M, and 2.2M. The known concentration of the solution is 2.0M. Which of the following are true about Susan's results?
   a. They are precise, but not accurate
   b. They are both accurate and precise
   c. They are accurate, but not precise.
   d. They are neither accurate nor precise

4. Precision pertains to all of the following except:
   a. Reproducibility of measurements
   b. Agreement among numerical value
   c. Sameness of measurements
   d. Closeness of a measurements to an accepted value

5. Systematic errors lead to a lack of:
   a. Accuracy in measurement
   b. Significant digits in the measurements
   c. Precision in the measurements
   d. Gradation of the measuring instruments

Lesson 3 Measurement Data Presentation

Learning Objective:

4. Estimate errors from multiple measurements of a physical quantity using variance **STEM_GP12EU-Ia-4**

Good day! Today, we will learn about graphical presentation of data from multiple measurements of a physical quantity. In most of your previous experiments in science, you may have noticed that any concept, material or physical quantity under study is measured several times, why is this so? This will give you an average value of a measurement under study.

What's In

Activity 3.1. I Will Do It Again!

Materials: Small stone or any material that can be dropped at a distance
a meter stick, stop watch

Procedures:

1. From the floor level measure a height of 2 meters.
2. At the tip of your measurement, position the object and release it at once.
3. Record the time it takes the object to hit the floor.
4. Repeat steps 2-3 four times more.
5. Solve for the average.
6. Prepare a tabular data using the measured values

Notes to the Teacher
Remind the learners not to climb up to a highly elevated place just to have a height of 2 meters.

Guide Questions:

1. Did the object hit the floor at the same time?

2. What could be the reason having the same or different time of hitting the floor?

What's New

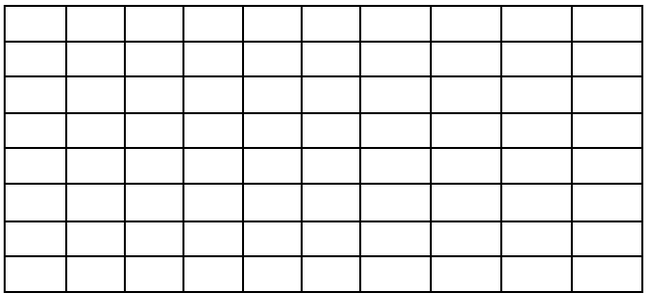
Activity 3.2. The Story of a Line

Procedures:

1. An experiment was conducted to find out if the amount of fertilizer can affect the growth of a plant. All the other factors that is necessary for nourishment are given uniform amount. Every 2 weeks the number of full grown leaves are counted to be deemed as the growth of each plant.

Amount of Fertilizer Applied (grams)	Number of Leaves Grown
25 g	10
20 g	8
15 g	6
10 g	4
5 g	2

1. Plot the graph of the variables by placing the dependent variable on y axis, while the independent variable on the x axis.



Guide Questions:

1. How does the line graph looks like?

2. What is the dependent variable? the independent variable?

Data Presentation

The disparity between the calculated value and the measured value is defined as a **measurement error.** No matter how careful we are in taking measurements, errors can still exists as we measure things. So, where does this error come from and how do we represent this phenomenon visually? After taking measure into account, data presentation can be done in different ways. The most common ways are **tabular and graphical representation of data.**

Tabular representation is done by placing variables in lines and in columns. **Graphs** provide a visual representation of data and provide a faster form of communication than tables of data. Graphs may also be used as an analytical tool to determine the value of some quantity. The independent variable (the variable that you are changing in the experiment) is plotted on the horizontal or x-axis. The dependent variable (the variable that you are measuring and that changes in response to manipulation of the independent variable) should be plotted on the vertical or y-axis.

What is It

You have just learned how to plot measurements using a graph. How do we represent a measurement error using linear presentation? This time you are to describe **an error in measurement and will figure out how to estimate it.**

Activity 3.3. It Might Be Your Error

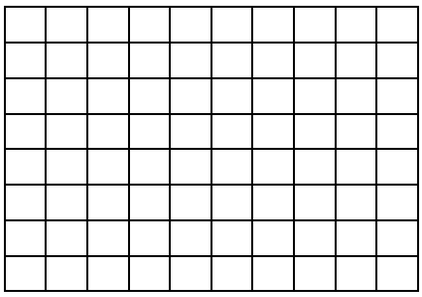
Procedure:

1. The table below is a data set of an experiment. This is the time it takes a marble to roll down an inclined plane 3 meter long.

Distance	Time 1(s)	Time 2 (s)	Time 3(s)	Time 4 (s)	Time 4 (s)
3m	1.5	1.6	1.4	1.7	1.3

2. Plot the graph of these values.

Distance (m)



Time (s)

3. Find the average of the time you have in your data.

4. The mean or the average of the time is the measured value.

Guide Questions:

Q1. Did your time value follows a straight line when plotted? Why not?

Q2. Why is there a need to get the average of these time values?

The observations we make are never exactly representative of the process we think we are observing.

measured value = true value ± error

The error is a combined measure of the inherent variation in the phenomenon we are observing and the numerous factors that interfere with the measurement.

A better way of obtaining a better estimate of something you are trying to measure, is to take repeated measurements and calculate the **average or mean** of these measurements. **Variance** is the measure of how far each value in the data set is from the mean. Here it is defined as:

1. Subtract the mean from each value in the data
2. Square each of these distances
3. Divide the sum of the squares by the number of values in the data set.

Let's have this as an e*xample:* Given that the accepted distance from Chattanooga to Knoxville = 125 miles, but values of 151, 152, 148, and 149 miles were determined experimentally, estimate the error..

Solution:

Values	Residuals	Residual square
148	= |148-150| = 2	= 2^2 = 4
149	= |149-150| = 1	= 1^2 = 1
151	= |151-150| = 1	= 1^2 = 1
152	= |152-150| = 2	= 2^2 = 4
Average=150		Sum=4+1+1+4 = 10

So the variance = $\sqrt{10}/3$ = 1.82

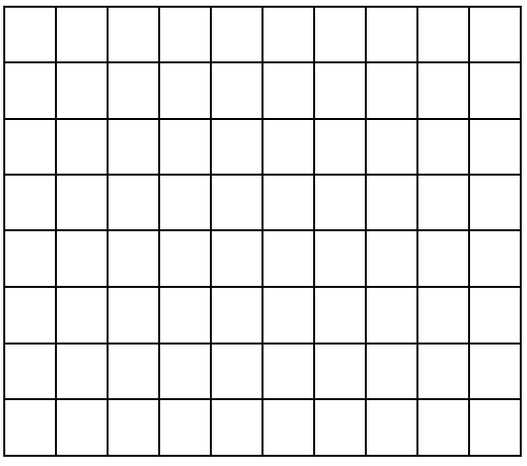
Thus, the result would be reported as **150 ± 2 miles**.

What's More

Activity 3.4. I Will Estimate You!

Procedures:

1. A student collects a series of six groundwater samples from a well. She measures the dissolved oxygen concentration in six of these. Her observations in mg/L are: 8.8, 7.1, 7.2, 8.2, 7.6, 8.6.
2. Plot a graph based on the given values above.



3. Find the mean of the different samples collected.
4. Find the variance.

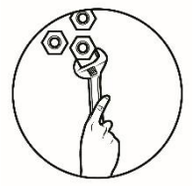
What I Have Learned

Activity 3.5. My Total Recall

Direction: Fill in the blanks with the correct word. Write you answer on a Separate sheet of paper.

The disparity between the calculated value and the measured value is defined as a (1)_____. After taking measure into account, data presentation canbe done in different ways. (2) _____representation is done by placing variables in lines and in columns. (3) _____provide a visual representation of data and provide a faster form of communication than tables of data. . The independent variable (the variable that you are changing in the experiment) is plotted on the (4) _____or x-axis. The dependent variable (the variable that you are

measuring and that changes in response to manipulation of the independent variable) should be plotted on the vertical or (5) _____. A better way of obtaining a better estimate of something you are trying to measure, is to take (6) _____ measurements. Standard (7)_____is a valid result for error, and tells about the precision of your experiment. (8) _____is the measure of how far each value in the data set is from the mean. All types of error imply precision andaccuracy. (9) _____is a measure of the closeness of separate determinations of a value. (10) _____refers to how close the average of the determinations is to the accepted value.



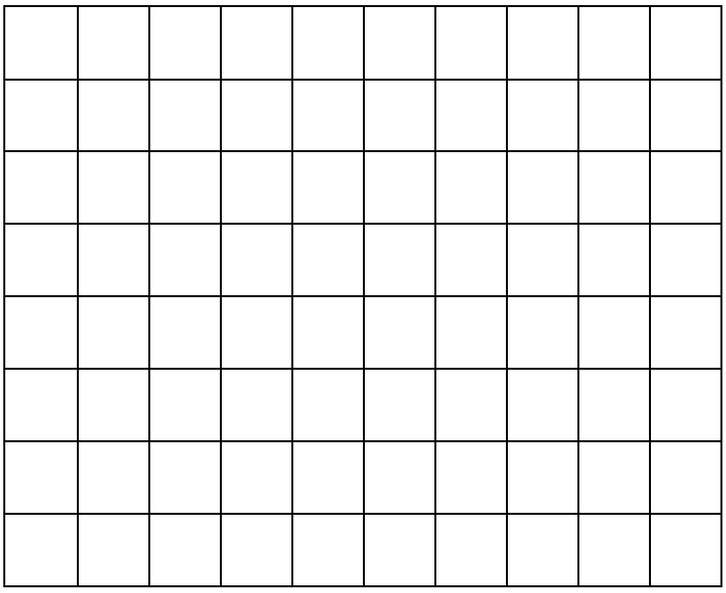
What I Can Do

Activity 3.6. Plot Me and My Family

Procedures:
1. Have 10 members of the family as participants.
2. Take their individual height and age.
3. Tabulate the measured data like the one below.

Name	Height (m)	Weight (kg)

4. Plot the graph of height against the age of each family member.



Guide Questions:

Q1 How does your graph looks like?

Q2 Do you see any relationship between the height and age among your family members?

Assessment

Multiple Choice. Choose the letter of the answer. Write the chosen letter on a separate sheet of paper.

1. Which of the following statements about systematic errors is false?
   a. Poorly calibrated instruments may be a cause of systematic errors.
   b. Repeating an experiment many times and averaging the result minimizes systematic error and increases accuracy.
   c. Systematic errors always bias the result in the same direction.
   d. Systematic errors may be associated with technique or equipment.
2. How can the effect of random errors be reduced?
   a. Repeating the measurement numerous times and averaging the result.
   b. Calibrating instruments correctly.
   c. Perfecting experimental technique.
   d. Always taking measurements under standard conditions.
3. A group of measurements for which there is insignificant random error but significant systematic error is
   a. imprecise and unbiased. b. imprecise and biased.
   c. precise and biased. d. precise and unbiased.
4. The difference between random and systematic errors is
   a. Systematic errors are always larger than random errors.
   b.Random errors are subject to probability laws,while systematic errors are not.
   c. Systematic errors can be eliminated by taking repeated measurements.
5. A micro scale measures the mass of a certain bacteria to be 15 nanogram . What is this measure when expressed in unit grams?
   a. 1.5×10^{-10} g b. 1.5×10^{10} g
   c. 1.5×10^{-8} g d. 1.5×10^{8} g
6. Writing a measurement in scientific notation, when the exponent is negative, the measurement is _____ compared with its base unit.
   a. larger b. smaller c. equal to d. cannot be determined
7. The size of the smallest dust particle is approximately 1×10^{-4} m, when written in a decimal form ,this measurement is equal to:
   a. 0.1 m b. 0.01 m c. 0.001 m d. 0.0001 m
8. A commercial drone usually flies at a height of 10 ft, this is equivalent to 120 inches, hence conversion factor between ft. to inches is _____.
   a. 10 b. 11 c. 12 d. 13
9. A bonsai plant stands at 2 feet long, if translated into cm, this plant's height is____
   a . 48 cm b. 60 cm c. 78 cm d. 90 cm
10. A biggest whale weighs at an approximate mass of 1,000 kg, which unit of measure is its counterpart in English System of measurement?
    a. Inches b. Yards c. Feet d. Pounds
11. The ability of the instrument to measure the accurate value is known as _____.
    a. Measurement c. Accuracy
    b. Unit d. Precision

12. These terms are often used to describe the reliability of measurements.
    a. Measurement and unit
    b. Length and Height
    c. Accuracy and Precision
    d. All are correct
13. When we plot the graph of a data, the dependent variable is placed n the
    a. horizontal
    b. vertical
    c. both horizontal and vertical
    d. none of the above
14. Which of the following methods of data presentation is best suited fortrend analysis?
    a. table data
    b. line graph
    c. histogram
    d. pie graph
15. The closeness of two or more measurements to each other is known as the _____ of these measurements.
    a. Measurement
    b. Accuracy
    c. Unit
    d. Precision

Additional Activities

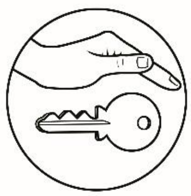
Activity 3.7. PAG-ASA - Lend Me Your Data

Procedures:

1. Search through the web site of Philippine Atmospheric Geophysical and Astronomical Services Administration the data on the different typhoons which hit the country in the previous year and the month it occurred.
2. Have your data tabulated and graphed applying the knowledge that you already had.
3. Label and put a title on it.

Guide Questions:

1. Based from your data which month/s is/ are most number of typhoons hit the country? Which month/s has the least number of typhoons?
2. What do you think is the significance of these data?



Answer Key

Activity 1
1. kilometer
2. meter
3. kilogram
4. centimeter
5. seconds
6. milligrams
7. years
8. hours
9. seconds
10. grams

Activity 1.1
a. $1.o\times10^{-5}$m
b. 8.5×10^{3}m
c. 2×10^{-5} kg
d. 5×10^{4} kg
e. 2×10^{-6} m
Q1. Negative - a, c, e
Positive- b , d
Q2. Positive
Exponents-large measurement
Negative exponent- small measurement

Activity 1.2

Answers will depend on the materials used by the students.

Activity 1.3
1. False
2. True
3. False
4. False
5. False
6. False
7. True
8. True
9. True
10. True

Activity 1.4
1. Measurement
2. Units
3. Conversion Factors
4. Notation
5. Exponent
6. Positive
7. Negative
8.
10. True

Activity 1.5
1. 1,393.85 m
2. 1.00×10^{54} atoms H
3. 1.5m or 150 cm
4. 20 cm
5. 73.17 seconds

Activity 2.1
1. C
2. A
3. C
4. D
5. A

*Guide Questions:
1. Labels & scales in pictures
2. All are volume measurements

Activity 2.2
*Guide Questions:
1. Measurements are different.
2. Skill of the person measuring
3. Measurements are different
4. Calibration of instrument.

Activity 2.3
<u>Precise</u> (2 & 4)

<u>Accurate</u> (1 & 3)

Activity 2.4
1. True
2. False
3. True
4. True
5. True
6. False
7. False
8. True
9. True
10. True

Activity 3.5
1. Error
2. Tabular
3. Graphs
4. horizontal
5. Y -axis
6. several/many
7. deviation
8. error
9. precision
10. accuracy

What I Know
1. D
2. D
3. D
4. B
5. D
6. D
7. B
8. A
9. D
10. C
11. B
12. A
13. B
14. A
15. D

Assessment
1. B
2. D
3. C
4. B
5. C
6. B
7. D
8. C
9. B
10. D
11. D
12. C
13. B
14. B
15. D

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DISCLAIMER

This Self-learning Module (SLM) was developed by DepEd SOCCSKSARGEN with the primary objective of preparing for and addressing the new normal. Contents of this module were based on DepEd's Most Essential Learning Competencies (MELC). This is a supplementary material to be used by all learners of region XII in all public schools beginning SY 2020-2021. The process of LR development was observed in the production of this module. This is version 1.0. We highly encourage feedback, comments, and recommendation.

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