Republic of the Philippines
Department of Education
Region V (Bicol)
Ligao City, Division
LIGAO NATIONAL HIGH SCHOOL
SY 2022-2023

Precise Resource Device Optimized for Real-Life Calculations, Learning and Utilized System in Trigonometry (PROCLUS)

ACADEMIC TRACK

Science, Technology, Engineering, and Mathematics Strand

Submitted by

Calwit, John Mel

Dayandante, Benedict A.

Geronimo, Roger Steven V.

Martinez, Manuela

Pocua, Melissa

Poja, Matthew

11-STEM 1

TABLE OF CONTENTS

INTRODUCTION

Trigonometry is a branch of mathematics that deals with the study of triangles and their relationship with angles and sides. Typically introduced to students in junior high school. However, many students struggle to apply and comprehend trigonometry effectively.

Finding the distance from one object to another or solving for the height given an angle, questions like these continue to intimidate students hence the difficulty in comprehending and using trigonometric ratios. The link between the angles and sides of a right-angled triangle and how to apply trigonometric ratios to solve issues involving angles and sides may be difficult concepts for students to grasp. Trigonometric functions like sine, cosine, and tangent can be challenging to visualize and explain. It could be challenging for students to comprehend how these functions apply to angles and triangles.

Another challenge is using trigonometric identities to resolve trigonometry problems. The multiple trigonometric identities and formulas necessary to solve problems may be difficult for students to recall and put into practice. Trigonometric issues' complexity could also present a challenge. Students often encounter challenges in solving trigonometry problems due to various factors such as insufficient understanding of trigonometry concepts, inability to apply the formulas correctly, and lack of practice. These challenges can lead to poor academic performance, frustration, and even discouragement among students.

Over time, extensive attempts have been undertaken to tackle the ongoing challenge. With the objective of enhancing comprehension, creative teaching methods and technological advancements have been employed. This paper shares the same goal by presenting a guide to simplify the complexities of Trigonometry using technology.

Technology such as robotics can assist in solving trigonometric functions by providing precise and automated measurements. Robots equipped with sensors and mathematical algorithms can accurately determine angles and distances, enabling efficient calculations of sine, cosine, and tangent values. With the help of this device, the field of robotics will be utilized to help students in understanding the concepts of trigonometry. It will also include an easy to understand interface showing the sides of a triangle corresponding to its angle in a real world basis. A measuring device that converts and solves in real time, making understanding Trigonometry easier and fun.

Objectives

The objective of this study is to be able to create a mathematical device capable of guiding students in understanding Trigonometric identities and inverse trigonometric functions *(**STEM_PC11T-IIe-2**)*. A device that is able to derive the corresponding sides of a triangle using the principles of trigonometry and angles, hence helping students learn and apply appropriate trigonometric identities in solving situational problems *(**STEM_PC11T-IIg-2**)*.

This is especially beneficial to junior high school students who are near the path of tackling the aforementioned topics. This device would be able to help them comprehend and visualize the given situational problems more easily.

This research aims to build a simple mathematical device using an Arduino Uno microcontroller utilized trigonometry and other topics in geometry that will help students and teachers in:

a) finding the length of the sides and hypotenuse of right triangles through pythagorean theorem
b) calculating the trigonometric ratios using the measurements measured by the device;
c) computing the angle of elevation and depression;
d) learning tool for trigonometry and geometry;
e) guiding for easy and scaled triangle drawing; and
f) converting the answers from degree to radian and vice versa

Scope and Limitations

This device focuses on solving trigonometric problems that are incorporated in the real world. In other words, this device is mostly capable of solving trigonometry in real life applications. Our device also include the calculation for the sides and the hypotenuse of a right triangle (Pythagorean Theorem), degree and radian unit converter, finding the distance, height, angle, learning tool for trigonometry and geometry, and a guide for scaled

triangle drawing. It also aims to bridge the gap between theory and practical application, highlighting the relevance of trigonometry in real-world scenarios such as astronomy, construction, and aviation.

Even with technology on our side, the device is still only limited to a few things, such as being only focused on the device's functionality in solving trigonometric problems. It does not explore advanced mathematical concepts beyond trigonometry, and the device's functionality is limited to trigonometric calculations and visual display. Due to the large structure of the device, it cannot fit on small spaces. Our lack of knowledge in calibrating the sensors also affects the functionality of the device since it cannot measure large measurements and the fluctuation of values caused by the code in the system. This device is only restricted in solving right triangles since it has no capability in determining if the triangle is a right triangle or not .Lastly, the study does not delve into the technical specifications or programming details of the device, but rather focuses on its application and benefits in trigonometry education.

Device Features

Pythagorean Theorem Solver

This device uses robotics to measure and calculate for the basic sides of a triangle, ie. the side, base and the hypotenuse. Coded in it is the formula $a^2 + b^2 = c^2$ (the pythagorean theorem). Using this, it can solve for the hypotenuse given the sides, and vice versa.

Trigonometric Ratios Calculator

PROCLUS can be used to solve for the basic trigonometric ratios such as the sine, cosine and tangent. It has the built-in function of measuring for the angle in either degree or in radian form, as well as the distance, using those inputs to solve for the corresponding trigonometric ratio.

Radian and Degree Unit Converter

As mentioned above, PROCLUS is capable of converting an angle into its radian form and vice versa. Coded into it is the formula $\theta * \frac{\pi}{180}$ for converting degrees to radian, and $x * \frac{180}{\pi}$ for converting radian to degrees. This will allow users to easily know their corresponding value.

Angle of Elevation and Depression Computer

Already mentioned are its functions to be able to measure for the distance. Its angles, using either degrees or its radian form. As well as its capability of performing trigonometric calculations. The aforementioned functions will allow PROCLUS to be able to measure either the angle of elevation, or the angle of depression, depending on what is needed.

Guide for Scaled Triangle Drawing

As this is a device that performs measurements and calculations in real time, it allows users to assimilate scaled drawings. PROCLUS can determine the needed measurements making it easy for students to draw it in scale.

Visual and Learning Tool for Trigonometry and Geometry

Geometry and trigonometry are some of the topics students find challenging. Hence why we invented PROCLUS. Given its precise calculations and measurements of the mentioned topics, as well as its ability to visualize it, learning will not only be easy, but also fun.

Its functions can be associated with the name of the device

P - Pythagorean theorem solver

R - Radian and degree converter

O - Optimal angle of elevation and depression Solver

C - Calculator for trigonometric functions

L - Learning tool for trigonometry and geometry

U - Ultimate guide for scaled triangle drawing

S - Solving for the distance, height, and angle

Furthermore, by enabling quick and precise calculations of triangle side lengths and trigonometric ratios, the device enhances problem-solving efficiency, reducing errors, and saving time. With the visual guide representing the triangles, the device aids comprehension of geometric concepts. It assists students in drawing scaled triangles, facilitating visualization of angle-side relationships and promoting better understanding.

The device also incorporates a feature that converts degrees to radians that helps in mastering the two units. This functionality allows seamless transitions between different mathematical contexts and enhances problem-solving skills.

In conclusion, developing a consistent mathematical device for trigonometry and geometry education offers numerous benefits. By integrating technology, it enhances the learning experience, promotes efficient problem-solving, aids visual understanding and comprehension, and facilitates unit conversions. This device empowers students and teachers to dive deeper into trigonometry and geometry, promoting to have a stronger grasp and mastery of these mathematical concepts.

Significance of the Device

The device's significance lies in creating a precise mathematical tool. This device aids students and teachers in trigonometry and geometry education by enhancing the learning experience, promoting efficient problem-solving, and facilitating conversions between degrees and radians. The device provides hands-on learning, enabling students to automatically solve problems related to triangle measurements and the Pythagorean theorem. This practical application bridges theory and real-world scenarios, highlighting the relevance of trigonometry and geometry in various fields.

This device will be beneficial to people who are getting involved in trigonometry and geometry, especially for the following;

*a) **Students** - students, especially those who find it difficult to understand trigonometry would be the first to benefit from the device. Enabling them to easily visualize and solve for the answer.*

*b) **Teachers** - teachers who aim to easily teach trigonometric identities and solving situational problems involving it would also benefit greatly from the device. PROCLUS is a measuring device that solves for the distance of one point to the next using the principles of triangles and trigonometric identities. This in turn would easily allow them to demonstrate situational problems when teaching.*

*b) **Engineering Fields and Professionals**- with this simple device, professionals can maximize its features with on the go calculations and applications of trigonometry which is widely used in this field.*

*b) **Future Researchers**- future researchers can improve this study and can be a basis to develop an improved version of it that bridges the gaps and find an alternative solution to the limitations of the device*

*c) **Community and Others** - PROCLUS is a device intended not only on educational grounds. As it is first and foremost a measuring device, almost anyone can use it. Decorating the house, scaling a structure, as long as it*

involves the principles of a triangle such as finding the height, the distance and the shortest possible path (hypotenuse) PROCLUS can be of use.

Definition of Terms

1. **Angle of Depression**: The angle of depression is the angle formed between the horizontal line of sight and a downwardly directed line of sight. It is typically used to describe the angle from a point on a higher elevation to an object located at a lower elevation.

2. **Angle of Elevation**: The angle of elevation is the angle formed between the horizontal line of sight and an upwardly directed line of sight. It is typically used to describe the angle from a point on the ground to an object located above the ground level.

3. **Degree**: Degree is a unit of angular measurement commonly used in mathematics and everyday life. It divides a full circle into 360 equal parts, with each part representing one degree.

4. **Optimization**: Optimization refers to the process of making something as effective, efficient, or useful as possible.

5. **PROCLUS**: PROCLUS refers to the precise mathematical resource device optimized for real-life calculations and learning in trigonometry. It incorporates various features, such as a Pythagorean theorem solver, radian and degree

converter, optimal angle of elevation and depression solver, calculator for trigonometric functions, learning tool for trigonometry and geometry, ultimate guide for scaled triangle drawing, and solver for finding distance, height, and angle.

6. **Pythagorean Theorem**: The Pythagorean theorem is a fundamental principle in geometry that states that in a right-angled triangle, the square of the hypotenuse (the side opposite the right angle) is equal to the sum of the squares of the other two sides. It is represented by the equation $a^2 + b^2 = c^2$, where c represents the hypotenuse, and a and b represent the other two sides.

7. **Radian**: Radian is a unit of angular measurement commonly used in mathematics and physics. It is defined as the angle subtended by an arc of a circle that is equal in length to the radius of the circle. There are 2π radians in a full circle.

8. **Robotics**: refers to the interdisciplinary field that combines engineering, computer science, and mathematics to design, create, and operate robots.

9. **Trigonometry**: Trigonometry is a branch of mathematics that focuses on the study of triangles and their relationships, particularly the angles and sides. It involves the measurement and interpretation of geometric properties and angles of triangles, including the calculation of trigonometric functions such as sine, cosine, and tangent.

10. **Trigonometric Ratios**: Trigonometric ratios are mathematical functions that relate the angles of a right-angled triangle to the ratios of the lengths of its sides. The main trigonometric ratios are sine (sin), cosine (cos), and tangent (tan), which are defined as the ratios of the lengths of the opposite, adjacent, and hypotenuse sides, respectively.

11. **Scaled Triangle Drawing**: Scaled triangle drawing refers to the process of creating a representation of a triangle using proportional measurements. It involves accurately scaling down the dimensions of a triangle to fit within a given space or on a piece of paper while maintaining the relative proportions between its angles and sides.

MATERIALS

Materials

Materials	Quantity	Cost per Quantity (Php)	Total Cost (Php)
Arduino Uno Microcontroller	2	275.00	550.00
Ultrasonic Sensor	1	75.00	75.00
SG90 Servo Motor	1	90.00	90.00
Potentiometer	1	25.00	25.00
60 nm Laser Diode	3	89.00	267.00
16x2 LCD I2C	1	100.00	100.00
20X4 LCD I2C	1	199.00	199.00

Leveling System

Accelerometer	1	84.00	84.00
Piezo Electric Buzzer	1	5.00	5.00
LED	1	10.00	10.00

Power Supply and Others

Jumper Wires	37	5.00	185.00
9V Battery	4	40.00	160.00
ON-OFF Way Switch	2	15.00	30.00
9V Battery Holder	2	25.00	75.00
Foam Board	1	150.00	150.00

	Total Amount	**Php 2, 005**

Procedures

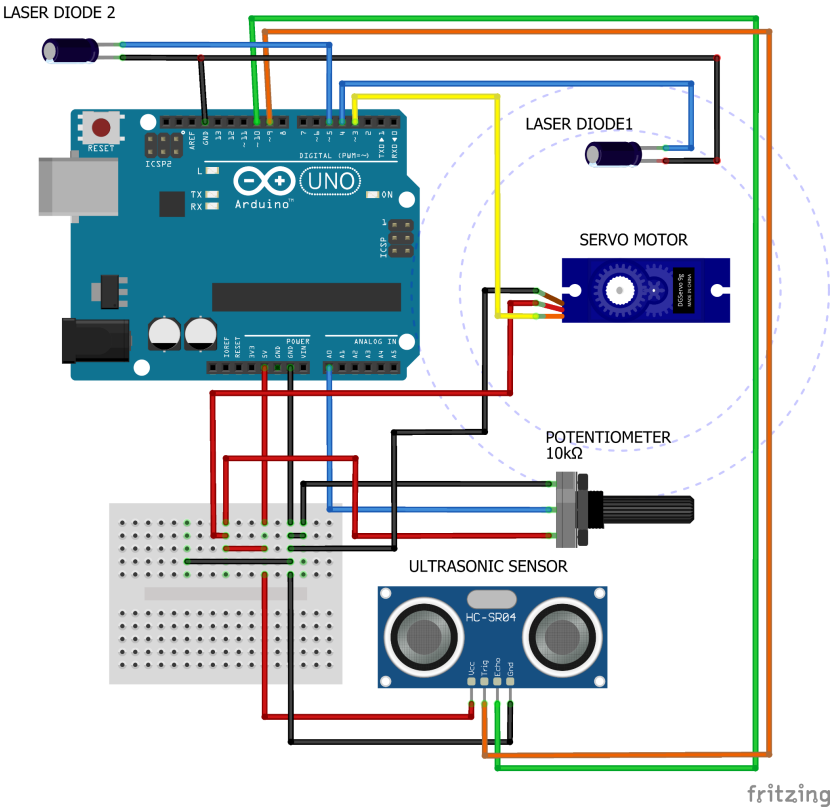
Creating the Device Structure

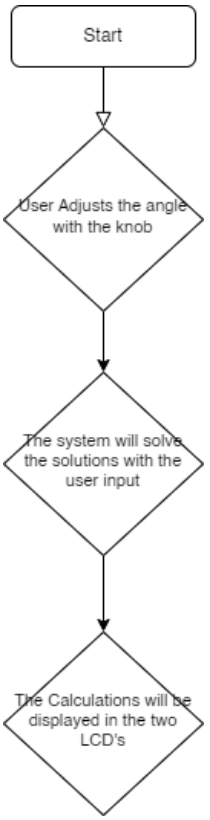
1. First get the measurements of the main components of the device, to maximize the portability of the structure.
2. Cut out the styrofoam boards based off the acquired measurements and the practicality of the device
3. Make proper and fitted cutouts based on where you want the components (ie. LCD's, Switch, UltraSonic Sensor and Adjustment Knob), making sure placement efficiency is observed
4. Assemble the styrofoam boards and the wirings of the main system circuit. Ensure that everything is fitted into place.
5. Design the device to your liking.

Working Principles

Main System and Circuit

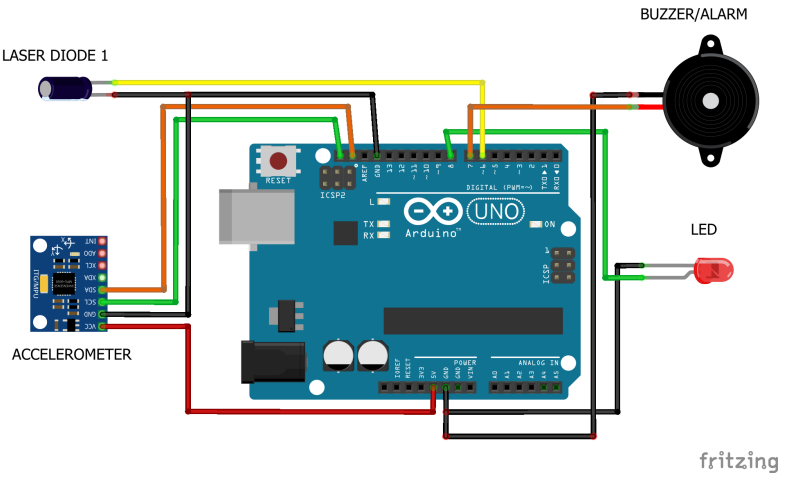
The main system is composed of an arduino microcontroller, servo motor, ultrasonic sensor, adjustment knob, and two LCDs. This system is powered with three 9 volt batteries and controlled with a two-way switch.The function of the main system is to calculate and display the answers solved by the device based on the concept solutions.

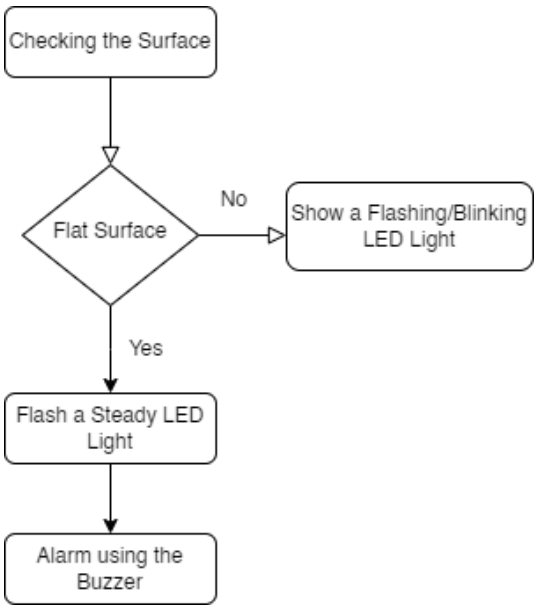




Leveling System and Circuit

The accelerometer is a sensor that will determine if the surface is even or not. If the surface is even, the LED will flash a steady red light and the buzzer will beep. This is both a visual and auditory tool that will guide the user in measuring. Though, even if the surface is uneven, solving it would still be possible because the device can measure tilted angles and the LED light will flash a blinking light to indicate that the surface is uneven.

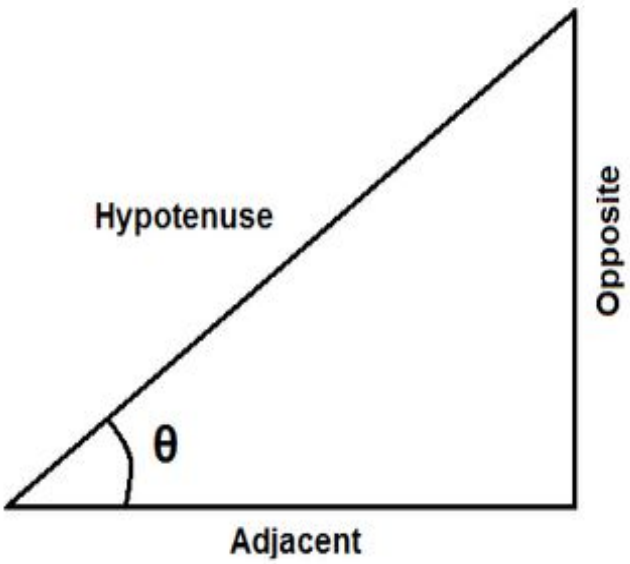




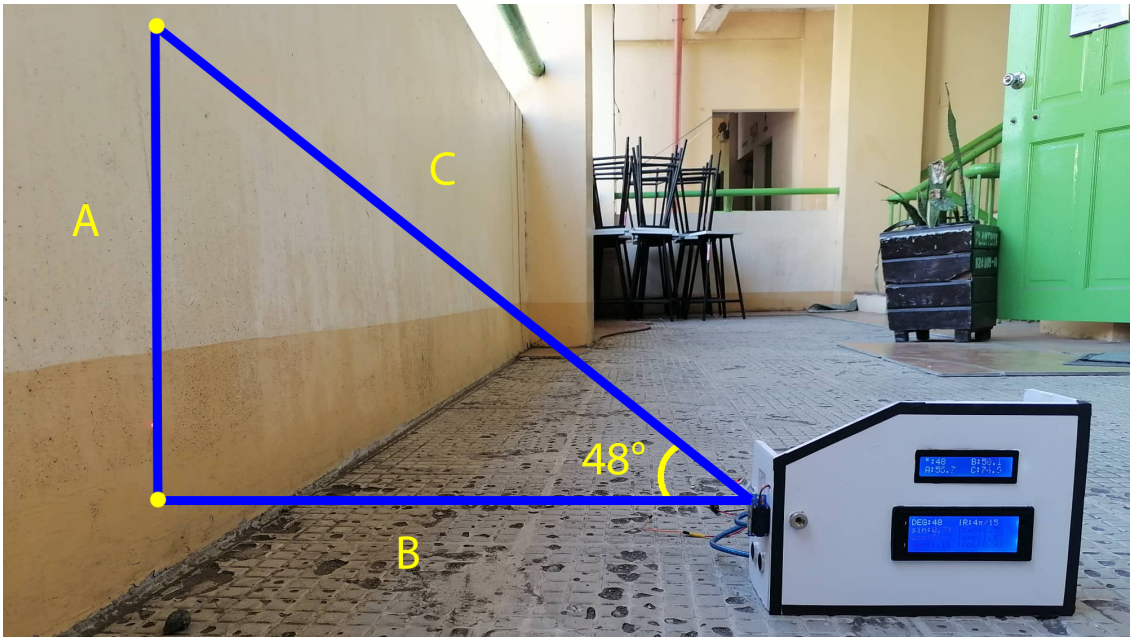
Calculation System

First and foremost, you need to define the six trigonometric functions: sine, cosine, tangent, cosecant, secant, and cotangent. Since the angle units used in the code to calculate is radian, we need to convert the angle entered by the user, solve it and convert it again in degrees.

1. $\text{Sin}\,\theta = \frac{\text{Opposite side of } \theta}{\text{Hypotenuse}}$
2. $\text{Cos}\,\theta = \frac{\text{Adjacent side of } \theta}{\text{Hypotenuse}}$
3. $\text{Tan}\,\theta = \frac{\text{Opposite side of } \theta}{\text{Adjacent side of } \theta}$
4. $\text{Cot}\,\theta = \frac{\text{Adjacent side of } \theta}{\text{Opposite side of } \theta}$
5. $\text{Sec}\,\theta = \frac{\text{Hypotenuse}}{\text{Adjacent side of } \theta}$
6. $\text{Cosec}\,\theta = \frac{\text{Hypotenuse}}{\text{Opposite side of } \theta}$



These functions relate the ratios of sides in a right triangle to its angles. Implementing these functions using codes or mathematical formulas (as shown above) provide us precise and near point accurate results. Ensure that it supports both degree and radian units for an additional function. Lastly, implement input validation to check for valid range and format, and handle any errors or exceptions that may arise.



Display System

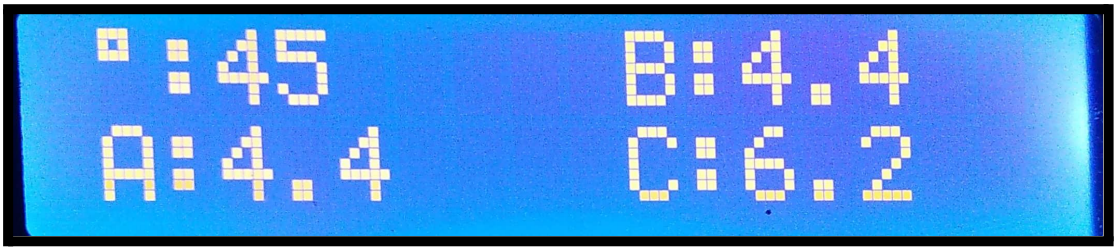
The Display system is the output of all the calculations made. Using two I2C Liquid Crystal Display (LCD) we can display all the solutions made by the device. We used 2 LCDs (1 large 20x4 and 1 small 16x2).

In the small LCD, the values of the sides in a right triangle were displayed with the angle (the symbol '°' denotes angle; A is for the height or

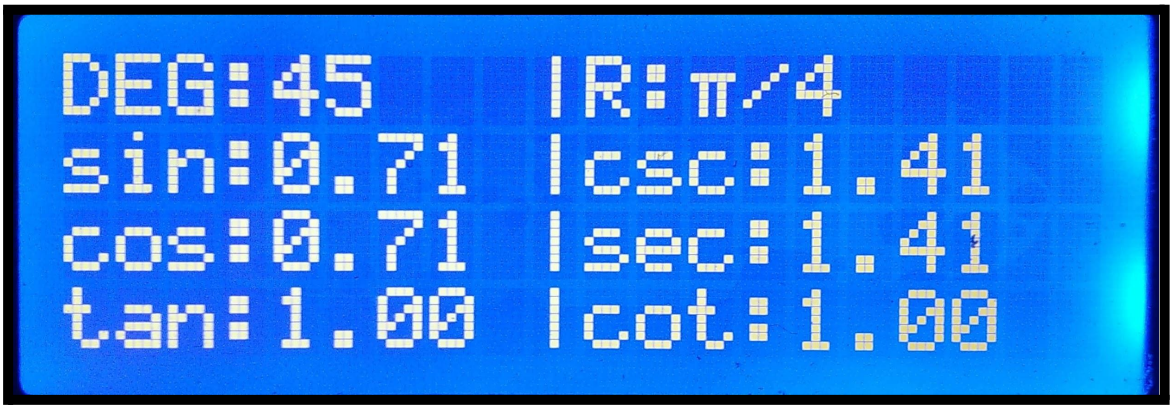
opposite side; B is the base or the adjacent side; and the hypotenuse side which is represented by C).

The large LCD contains 4 rows and 20 columns. The six trigonometric ratios were displayed here together with the angle in degree and in radian unit on top. This will help the user to easily compare and convert the unit and help their mastery in both units of measure.

Small LCD for displaying the Angle (°), Opposite Side (A), Adjacent Side (B), Hypotenuse Side (C).



Large LCD for displaying Trigonometric Ratios with the Angle in Degree and Radian Unit.

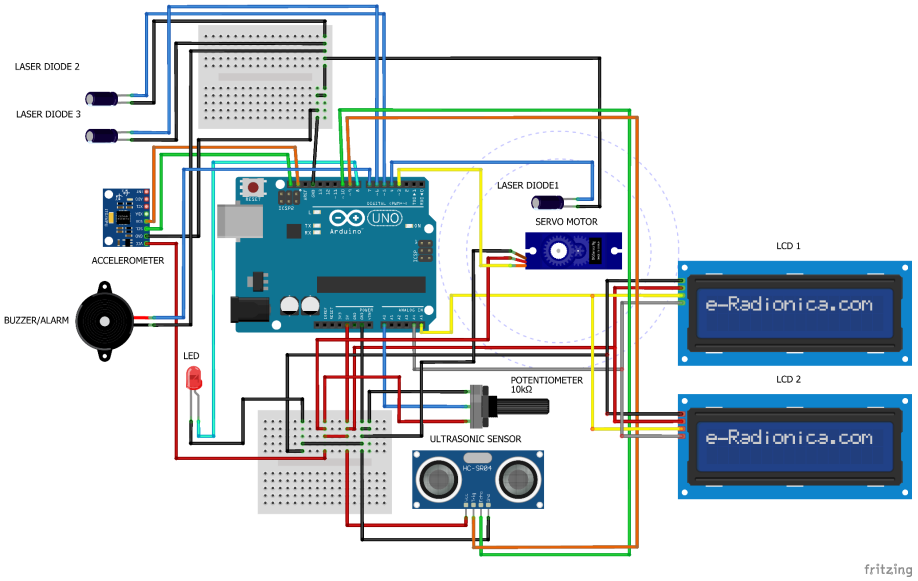


Laser/Scaled Drawing System

The laser/scaled drawing system is another feature of our system that will help to draw a scaled drawing or the right triangle with the measures that the user inputs. With the help of three lasers on each side, you can easily draw a right triangle with its corresponding measurements.

Overall Circuit

Main System and Display System



Utilization of the Device

To use this device it is very simple and user friendly

1. To open the systems of the devices, turn on the on/off switch. There are two switches (The one that powers the main system and the other one for the leveling and drawing system).

2. Using the Adjustment knob, you can adjust the angle input from 0-180 degrees. We divided it into two 90 degree angles (positive for the angle of elevation or angle greater than 0 degrees, negative for the angle of depression or angle that is less than 0). We use 0 degrees as the normal level and reference for the angle of elevation or depression.
3. While adjusting the knob, the servo motor is moving and so the laser that is attached to it. As you input and adjust the angle, calculations were made.
4. The angle, opposite side, adjacent side and the hypotenuse is displayed in real time in the small lcd (in centimeter). Meanwhile, the angle in degree and radian unit of measure is displayed in the larger lcd together with the computed trigonometric ratios which are the following: sin, cos, tan, cosecant, secant and cotangent.
5. The Automatic Leveling System doesn't require any input from the user. The system will flash a blinking LED light if the surface is uneven and if the surface is flat and ready for computing, the system will alarm or beep and the LED light will light steadily. This system can be turned on or off when the user wants to compute tilted angles and complicated measurements.
6. There are 3 lasers that will visually guide you on the angle or triangle that will be formed with the exact measurements.
7. That's how easy it is for you to use this device. If you want to compute another measurement, just repeat the process of using the knob and the calculation will be displayed for you in real time.

Test Run and Results

Since the device is composed of various systems, it needs to be tested before implementing it. We did a total of five tests, one for each system of the device to ensure that we will fulfill the objectives and the functionality of the device that we've built.

The main components and functionality of the device depends on the main system which all of its functions are included here. The adjustment knob was working properly after we soldered it with a solid wire. The servo motor is one of the biggest problems that took up so much time for us to fix since it is difficult to determine what is the root cause of the problem. The ultrasonic sensor which is capable of measuring the distance from one place to another had some discrepancy on the measurements that barely affects the calculated measurements. But after the test runs and prototyping, we manage to resolve these problems on the device.

For the calculation system, the calculations were accurately displayed in the display system. The code and the formula we used were the same when we tested it and we solved it manually on our own. The code works best in solving since computers have a less chance of making mistakes in calculations. However, the sensors do affect the readings of the data that will be used in the calculation. As we mentioned earlier, we don't have that much experience in calibrating sensors but based on the results, it has some little discrepancy on the measurements.

The display system is one of the trickiest parts that we've experienced. Since we have to display the six trigonometric ratios and the degree and radian unit in addition to it in one LCD, we need to find a way to fit it there. Furthermore, the display system works as it is intended to be with some error that we've fixed caused by the power supply.

For the laser and scaled drawing system, the laser is working perfectly fine after some tests because at first, we are having some difficulty on placing the laser on the correct placement since it has to complement with the moving laser attached to the servo motor to perfectly guide the user. We did some testing and calibration of the whole drawing and laser system and turns out we managed to draw a scaled right triangle with the measurement that we want it to be.

An additional feature of our device is the leveling system which will guide the user to know if the surface is flat or not. It can also determine the placement of the device if it is perfectly leveled even if you are just holding it and not placed on a surface. We have no problems with the LED and Buzzer for the visual and auditory tool but the accelerometer sensor which was responsible for determining the axis was very difficult to utilize since we are not familiar with that sensor. We did some test runs and did our best to calibrate it until it works perfectly together with the LED and Buzzer.

In conclusion, testing this device is a long process and a lot of patience is required in order to achieve the desired results. We cannot just build it and sacrifice the accuracy of the device but we need to undergo many tests to ensure its functionality. What we've realized in making this device is that exploring isn't just going to lead you to discovery but the process while exploring will shape your character and help you learn step by step. Realizing the problems, applying what you already know, and gaining new knowledge that you can use to explore many things. PROCLUS isn't just a device for calculation itself but a device that teaches us how to cope up with life's real world problems and challenges.

References

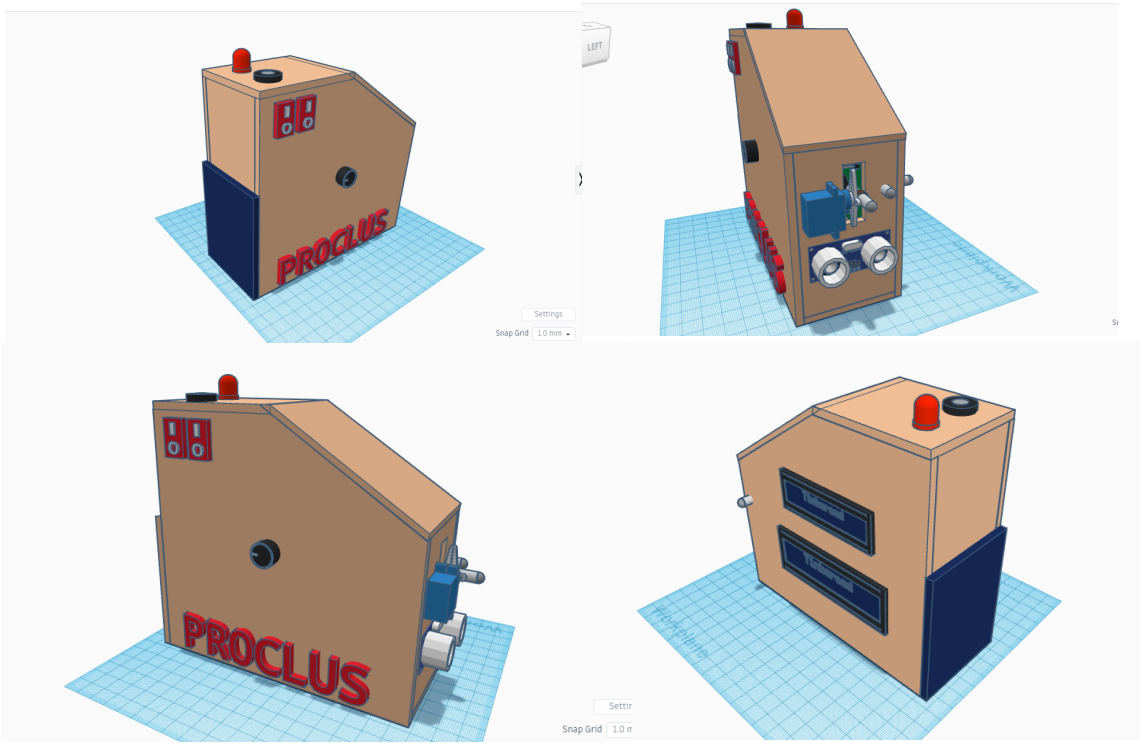
Algebra and Trigonometry, E. Young, C. Bivens (1997). Trigonometric Applications. Retrieved from https://www.youngmath.net/algebra-and-trigonometry/onlinetext/fractions/chapter05/chapter05.html#S051

Deferio, R. (2016). APPLICATION OF TRIGONOMETRY IN ENGINEERING FIELD. Retrieved from https://practicalmathematics.weebly.com/trigonometry-engineering-blog/applications-of-trigonometry-in-engineering-field

Weisstein, E. W. (2021). Trigonometry. Retrieved from https://mathworld.wolfram.com/Trigonometry.html

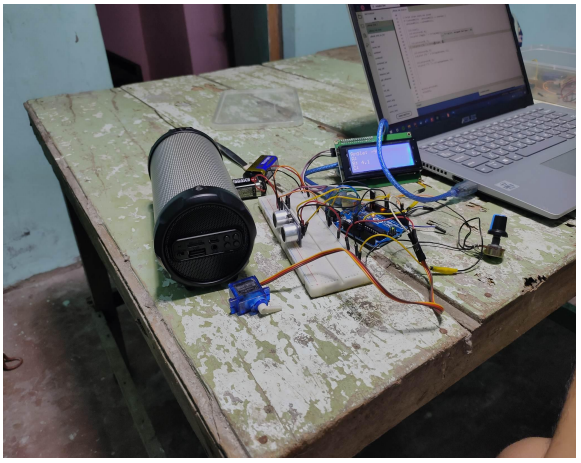
Appendix

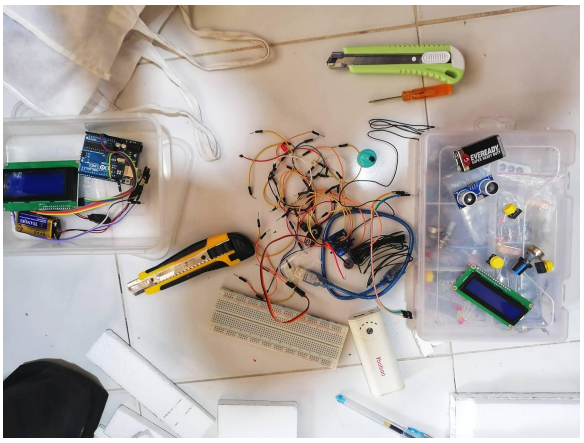
A. Sketch of the Device

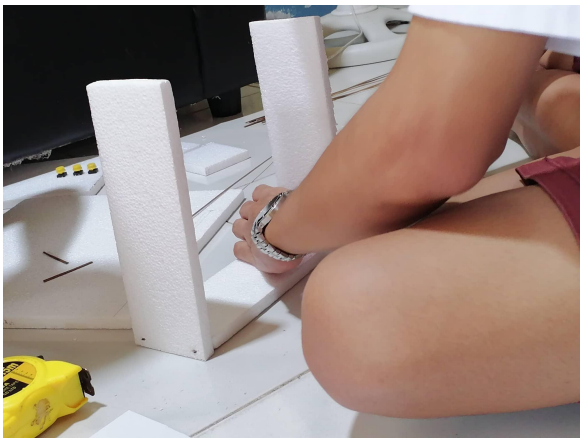


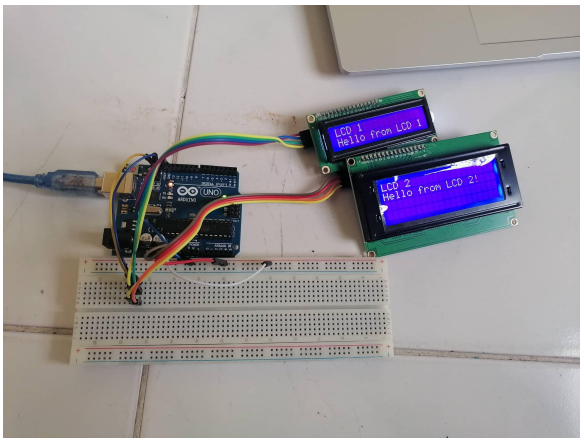
B. Documentation

Making the Structure and Prototype

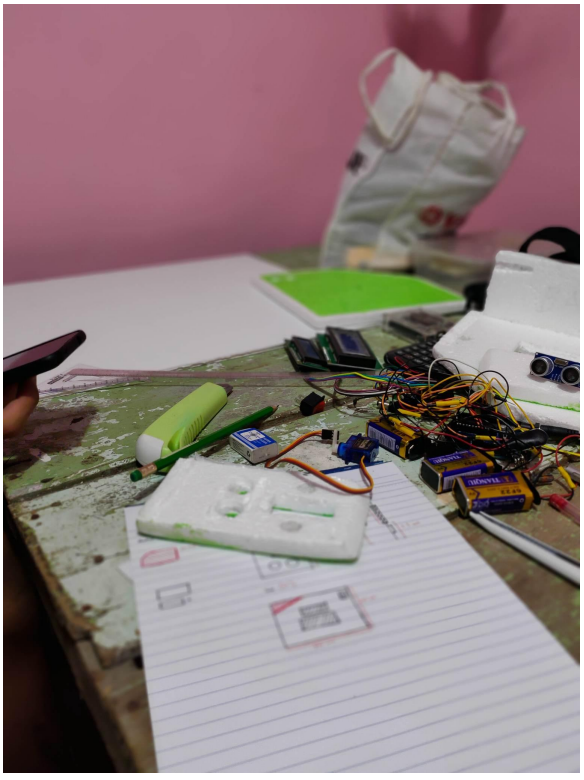


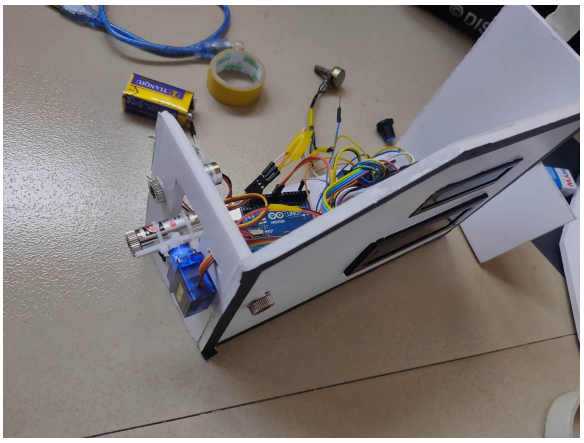


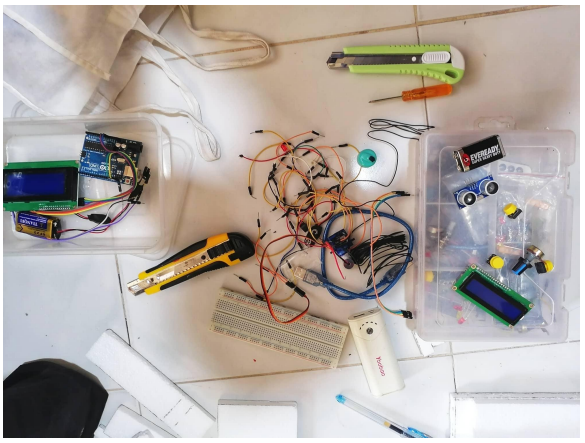




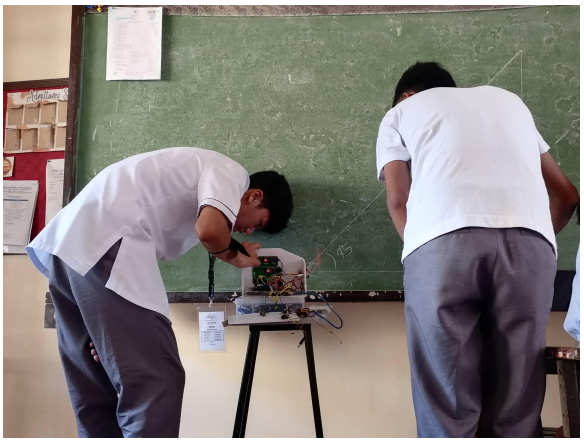
Finalization of Circuit and Structure

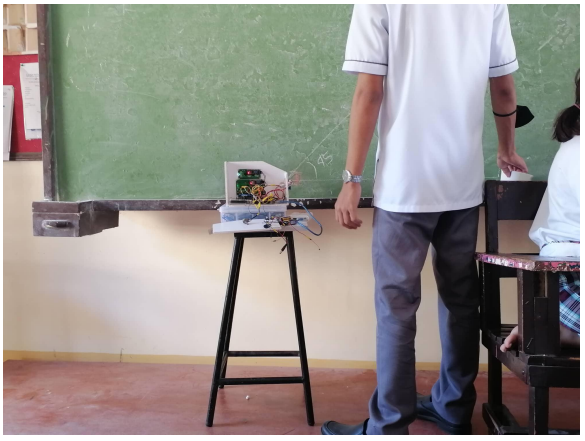


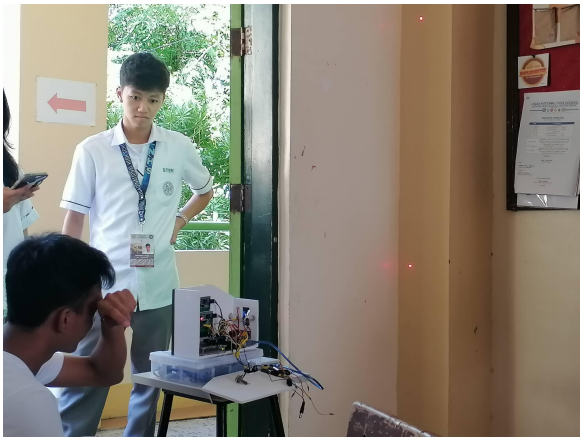


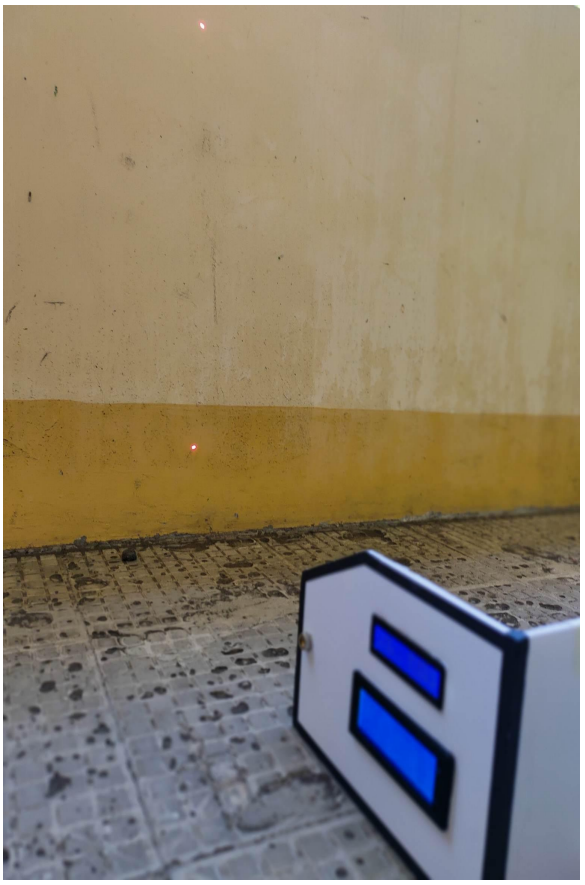


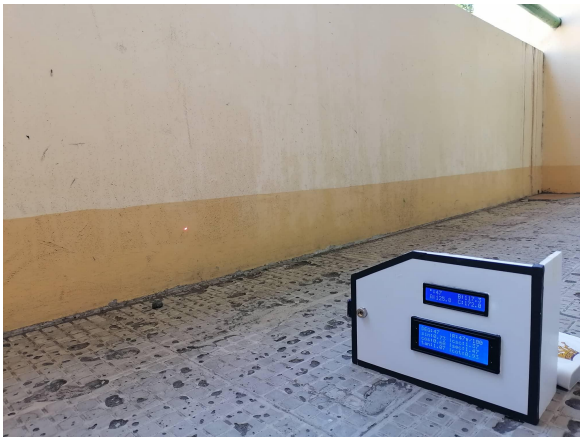
C. Test Run











About the Proponents

Name: John Mel J. Calwit

Birthdate: January 6, 2006

Age: 17

Address: Mahaba, Ligao City

About you/ Interests: I love indulging in my interests of gaming and watching movies to unwind and escape into exciting and immersive worlds.

Name: Benedict A. Dayandante

Birthdate: December 26, 2005

Age: 17

Address: Guilid, Ligao City

About you/ Interests: I find happiness and tranquility in tending to my garden while also taking good care of my pets.

Name: Roger Steven Geronimo

Birthdate: March 08, 2006

Age: 17

Address: Binatagan, Ligao City

About you/ Interests: I have a passion for a variety of interests, like coding, playing instruments, athletics, and exploring different stuff, which always annoys my mother^^.

Name: Matthew Poja

Birthdate: November 08, 2005

Age: 17

Address: Tuburan Ligao City, Albay

About you/ Interests: I find solace and tranquility in the simple pleasures of sleeping and reading. And maybe sports.

Name: Manuela P. Martinez

Birthdate: March 30,2006

Age: 17

Address: Tomolin Ligao City

About you/ Interests: I like how my interests in reading and handicrafts match as it enables me to express my creativity through handicrafts while at the same time immersing myself in fascinating worlds through literature.

Name: Melissa Pocua

Birthdate: December 07, 2004

Age:17

Address:Bay, Ligao City

About you/ Interests: I find immense joy and fulfillment in expressing my creativity through the medium of painting