POLITEKNIK BANTING SELANGOR

GYROSCOPIC INSTRUMENT TRAINER KIT

NAME	MATRIC NO.
AMIR BIN AZNAN	24DAM22F1031
CINTA BINTI ZAINURI	24DAM22F1003
NUR WASILAH BIN JANURI	24DAM22F1039
HILMI JABBARUN NA'IEM BIN MUHAMMAD NABIH	24DAM22F1060

DEPARTMENT OF AIRCRAFT MAINTENANCE ENGINEERING

SESSION I 2024/2025

POLITEKNIK BANTING SELANGOR

GYROSCOPIC INSTRUMENT TRAINER KIT

NAME	MATRIC NO.
AMIR BIN AZNAN	**24DAM22F1031**
CINTA BINTI ZAINURI	**24DAM22F1003**
NUR WASILAH BIN JANURI	**24DAM22F1039**
HILMI JABBARUN NA'IEM BIN MUHAMMAD NABIH	**24DAM22F1060**

A REPORT SUBMITTED TO THE DEPARTMENT OF AIRCRAFT MAINTENANCE IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR A DIPLOMA ENGINEERING IN AIRCRAFT MAINTENANCE

SUPERVISOR:

MOHD ASWAD BIN OTHMAN

REPORT ENDORSEMENT

This report entitled **"Gyroscopic Instrument Trainer Kit"** is being submitted, reviewed, and endorsed to fulfill the condition and requirements of report writing as specified.

Checked By:

Supervisor's Signature:

Supervisor's Stamp:

MOHD ASWAD BIN OTHMAN
Pensyarah
Jabatan Penyenggaraan Pesawat
Politeknik Banting Selangor

Date: 2/12/2024

Endorsed by:

Project Coordinator's Signature:

Project Coordinator's Stamp:

KHAIRUL IZWAN BIN ISMAIL
Pensyarah
Jabatan Penyenggaraan Pesawat
Politeknik Banting Selangor

Date: 3rd December 2024

CERTIFICATE OF PROJECT ORIGINALITY & OWNERSHIP

GYROSCOPIC INSTRUMENT TRAINER KIT

SESSION: 2 2024/2025

NAME	MATRIC NO.
AMIR BIN AZNAN	**24DAM22F1031**
CINTA BINTI ZAINURI	**24DAM22F1003**
NUR WASILAH BIN JANURI	**24DAM22F1039**
HILMI JABBARUN NA'IEM BIN MUHAMMAD NABIH	**24DAM22F1060**

"We hereby declare that this report is the result of our own work, except excerpts That we have outlined its sources and this project will be the ownership of polytechnic."

SIGNATURE: WRITER 1

(AMIR BIN AZNAN)

SIGNATURE: WRITER 2

(CINTA BINTI ZAINURI)

SIGNATURE: WRITER 3

(NUR WASILAH BINTI JANURI)

SIGNATURE: WRITER 4

(HILMI JABBARUN NA'IEM BIN MUHAMMAD NABIH)

Endorsed by,

(SUPERVISOR'S SIGNATURE)

MOHD ASWAD BIN OTHMAN
Pensyarah
Jabatan Penyenggaraan Pesawat
Politeknik Banting Selangor

SUPERVISOR'S STAMP

DATE: 2/12/2024

ACKNOWLEDGEMENT

First and foremost, we would like to take this golden opportunity to thank our parents profoundly for the great support, encouragement, and sacrifices they made to help us complete this final year project, the Gyroscopic Instrument Trainer Kit here at Polytechnic Banting Selangor.

We would also like to express our deepest gratitude to our supervisor, Sir Mohd Aswad bin Othman, for his continued support, the invaluable guidance, and encouragement he has accorded us throughout the development of our project. His insightful comments and knowledge have formed a backbone that guided the success of this project. Moreover, we would like to give thanks for his financial support in providing what was necessary to realize this project.

We would also like to express our deep appreciation to our colleagues and friends for their continued support and enlightening discussions, which helped bring great results to the GITK project. Their commitment towards the advancement of this cause, either by putting time, energy, or resources into it, has motivated us to excellence. We value all types of support, direct or indirect, that we received from everyone involved.

Finally, many thanks to Polytechnic Banting Selangor for providing the enabling environment and relevant facilities that have enabled us to accomplish this project successfully. Thank you all for your invaluable contributions and support which are proving so vital in carrying through the GITK project.

ABSTRACT

The following abstract describes the design and development of the Gyroscopic Instrument Trainer Kit, a novel training aid for the better understanding of gyroscopic aircraft instruments. The project addresses the need for an interactive and practical training system with which to expose aviation students and maintenance personnel to the principles and application of the instruments concerned, such as the artificial horizon. The GITK integrates a functional demonstration system that realistically simulates the behavior of gyroscopic instruments as would be seen in the primary flight displays of modern aircraft. With its integration of precise mechanical components and an intuitive interface, this trainer kit allows users to observe and understand the internal operation and behavior of gyroscopic instruments under various conditions throughout simulated flight. The following report describes the planning, fabrication, and testing of the GITK. This system is designed to be real-to-life, accurate, yet easy to use for training purposes. The design considerations were targeting the robustness and portability of the structure to be appropriate for educational use. Extensive testing of gyroscopic simulations for accuracy and reliability, as well as endurance of the kit for normal use, was performed. The findings indicate that the GITK represents the missing link between theoretical-based knowledge and practical understanding while assisting in an interactive manner. Responses from instructors and students indicate there may be an improved understanding of gyroscopic principles using this trainer kit, thus proving to be an essential addition to aviation education and training. Conclusively, GITK is a fundamental development in aviation training technology: an effective and efficient way to improve both the understanding and operational awareness of gyroscopic instruments. This report discusses the design methodology of this unique educational tool, the technical challenges experienced during its development, and possible future enhancements.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABREVIATIONS

SHORT FORM	MEANING
PFD	Primary Flight Display
IMC	Instrument Meteorological Conditions
CAAM	Civil Aviation Authority of Malaysia
ICAO	International Civil Aviation Organization
UV	UltraViolet
GITK	Gyroscopic Instrument Trainer Kit

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

In the cockpit, especially for the older aircraft that use analogue primary flight display (PFD) or also known as six-pack instruments which is functioned to provide information about direction, altitude, and airspeed of an aircraft while in flight. These ‘six- pack' instruments are divided into two which are gyroscopic and pitot static flight instruments. Plus, for the gyroscopic instruments there are attitude indicators, turn indicators and heading indicators while for the pitot static instruments have altimeter, airspeed indicators and vertical speed indicators.

Our project is to develop a trainer kit based on one of the gyroscopic flight instruments from primary flight display in the cockpit to be displayed for others to learn and more understand about its operation in flight. It is because these analogue primary flight display instruments system is very rare to be found nowadays in the older aircraft because of new technology of modern aircraft that upgraded to digital flight display.

Figure 1.1: Airplane Standard Flight Instrument (istockphoto.com Dec. 29 2009)

Figure 1.1 above shows that the example of analogue primary flight display (PFD) in the cockpit of older aircraft. Due to technological advances nowadays, modern aircraft have been upgraded into digital primary flight display in the cockpit that automatically shows the data to the pilot unlikely the older version.

Furthermore, for the students of aircraft maintenance it is mandatory to know all the functions of the primary flight display system and how it operates in flight. Plus, I also have knowledge of how to do maintenance on these instruments. But the limited accessibility and real experience to students in process of learning the system is few of the problem have been identified despite just getting knowledge from theory classes and not real-life experience.

1.2 PROBLEM STATEMENTS

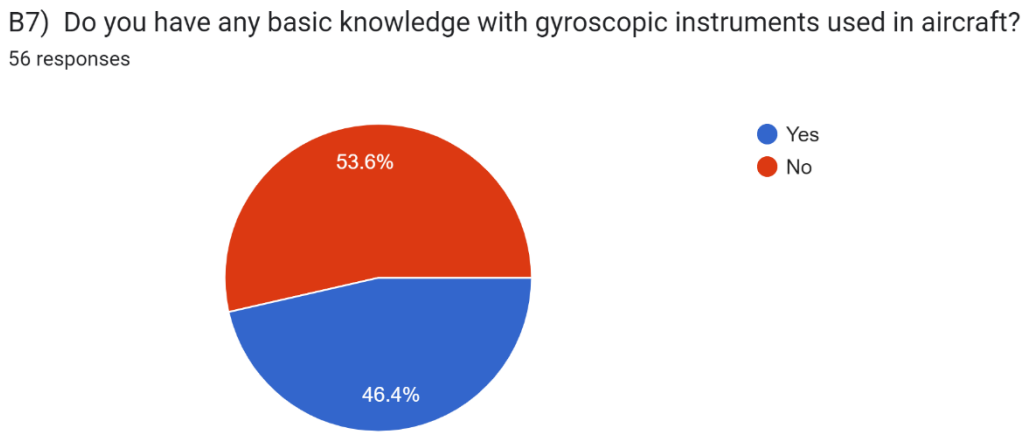


Figure 1.2: Example of Question from the Survey

Based on the data from the survey, figure 2 shows one example question being asked in the survey. The question asked about respondent basic knowledges related to gyroscopic instrument system and the percentages that answer 'NO' is more than 'YES'. This data has already shown that there are few groups of students who still do not know or are familiar with gyroscopic instrument systems.

From the explanation above, it indicates that more than half of respondents does not know about gyroscopic instrument system in the cockpit and could be labeled as 'lack of knowledge'. These issues should not arise for students that studied on aircraft maintenance courses but here we are, and this problem needs to be settled.

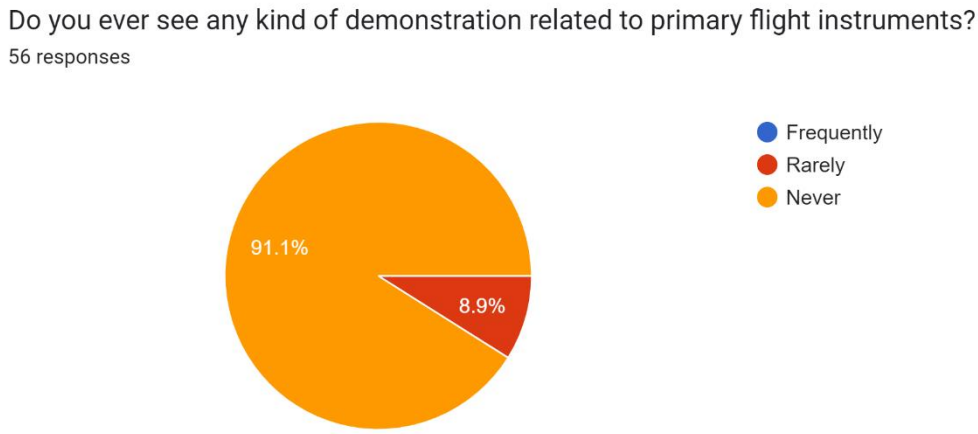


Figure 1.3: Example Question from the Survey

From Figure 3 above, the question asked about the familiarity of the respondents related to the primary flight instruments demonstration or any gyroscopic training kit. The respondent's answer has stated 'never' and 'rarely' as their only answers.

Based on the data above, it indicates that most of the respondents are not familiar with any kind of live demonstration related to primary flight instruments or gyroscopic training kit.

As the result, this data shows that the respondents never having a chance to experience the live demonstration and resulting in the lack of resources as the issue. This issue This problem can be expected because not all places have equipment facilities to demonstrate, and our polytechnic encounters the same problem.

1.3 PROJECT OBJECTIVES

1.3.1 General Project Objectives

The project objectives are:

- To design a Gyroscopic Training Kit that is portable as for aids for teaching.
- To develop a gyroscopic instrument as a Gyroscopic Training Kit.
- To demonstrate Gyroscopic Training Kit as aids of teaching.

1.3.2 Specific Individual Project Objectives

1.3.2.1 Project Structure

This project target:

- To design a better facility for learning.
- To develop and deliver a Gyroscopic Training Kit that offers practical aids of teaching and in general of gyroscopic instrument purposes.
- To differentiate between theoretical knowledge and practical skills.

1.3.2.2 Product Mechanism

This project target:

- To design a switch button for product to operate.
- To develop a mechanism of movement by using lever actuator that connected by Arduino outside the device as for operating switch.
- To show the functionality of a transport mechanism without exceeding its capacity.

1.3.2.3 Product Software/Electronic

This project target:

- To design a program that can help in reading situation for Gyroscopic Training Kit.
- To develop software that uses complete coding on Arduino.
- To demonstrate a system that can decrease human intervention as much as possible.

1.3.2.4 Accessories & Finishing

This project target:

- To design Gyroscopic Training Kit with attractive looks and finishing without affecting the functionality of the product.
- To Equip the Gyroscopic Training Kit with compatible and advantageous accessories to enhance its capabilities.
- To make the Gyroscopic Training Kit accessible to all aircraft maintenance institutes by using budget-friendly materials/coatings.

1.4 SCOPE OF PROJECT

1.4.1 General Project Scopes

Gyroscopic Training Kit is a simple instrument kit that contains a straightforward product structure designed to ensure how precise the functionality and reliability of the aircraft's instrument system. The product structure is designed to meet exact aviation standards, focusing durability, accuracy, and ideal combination with the instrument system for students. Even through this simple but well-defined structure, the gyroscopic training kit plays a crucial role in improving the overall safety, efficiency, and operational capabilities of the aircraft.

1.4.2 Specific Individual Scopes

1.4.2.1 Product Structure

The Gyroscopic Training Kit features a simple structure for strength, meeting the standards in aviation, yet easy for students to operate. The framework is light yet strong to ensure that it survives through multiple uses during training sessions. At its heart is a high-precision gyroscope with smooth rotors and a transparent protective casing, through which students can see its workings. The kit also comes equipped with a user-friendly front panel that allows the adjustment of the gyroscope's rotational speed and direction to simulate, within a real aircraft, certain roll, pitch, and yaw aircraft movements. It can work in conjunction with other general aviation instruments, such as an attitude indicator and turn coordinator through standard connection points.

1.4.2.2 Product Mechanism

The gyroscopic training kit is equipped with a compact design product mechanism for efficient and reliable functionality that indicates the real situation within the aircraft's instrument system. This compact system is designed with a focus on essential components, featuring platform to act as the moving mechanism to move the gyroscopic and will indicate the reading or measurement such as altitudes of the aircraft.

1.4.2.3 Product Software/Programming

This gyroscopic training kit is equipped with the Arduino as its control movement, translating the data from the Arduino's coding to actionable insights for the lever actuator function. The software's algorithmic capabilities contribute to automated adjustments, enhancing the overall efficiency of the gyroscopic training kit operation.

Furthermore, the simplicity of the electronic system ensures user-friendly interactions, making it an accessible solution for a wide range of pilots. As aviation technology, the role of electronic software in gyroscopic instrument kits remains necessary for ensuring safe, reliable, and efficient aircraft operations.

1.4.2.4 Accessories & Finishing

The gyroscopic training kit is designed with various features that assist the product towards its main core which is functionality and precision. The accessories in this training kit act as main components to make the system function smoothly. Also, for the finishing part, the gyroscopic training kit is equipped with extra features such as transparent resin material as its protector and to make the product looks attractive for exhibition display.

1.5 PURPOSE OF PRODUCT

The gyroscopic training kit is designed to be a simple, portable, and precise system kit to teach people about the real-life situation of gyroscopic instrument system in the cockpit. This product is also simple in structural and usage to easy the use for people. It is because the gyroscopic training kit is designed to be user-friendliness.

Next, this product is portable within its operation for easy to bring anywhere such as classes or for demonstration or display. It is easy to handle because it is light in weight and ergonomic design.

After that, the gyroscopic training kit is designed to be precise within the operation like in the real-life situation on the cockpit itself. All the movement is controlled by Arduino as the main system to move the gyroscope and shows the reading from it. Plus, all the air inlet and outlet are set to be rigid same as applied in real-life situation.

In conclusion, the gyroscopic training kit functions as trainer to shows real-life operation of one of the flight instruments in the cockpit to people for their exposures and knowledges of flight instruments that are rarely to be found unless in the cockpit.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

2.1.1 Aviation Industry in Malaysia

The relationship between gyroscopic instrument trainer kits and the aviation industry in Malaysia is essential, particularly in the contexts of training and education. Gyroscopic instrument training kits are essential to pilot training programs, helping pilots understand the principles of gyroscopic instruments, which are fundamental in navigating an aircraft. Aviation schools and pilot training academies in Malaysia rely heavily on these kits to ensure that students are proficient in instrument flying. Plus, these kits are crucial in the training of aviation technicians and engineers, equipping them with the skills needed for aircraft maintenance and repair.

Next, the use of gyroscopic instrument trainer kits directly contributes to flight safety and proficiency. Gyroscopic instruments like the attitude indicator, heading indicator, and turn coordinator are crucial for safe flight operations, especially in instrument meteorological conditions (IMC). By training with these kits, pilots gain the necessary proficiency in using these instruments, which enhances overall flight safety. This training also prepares pilots to handle emergencies where reliance on instruments is critical, particularly in situations involving poor visibility or adverse weather conditions.

Besides that, in terms of regulatory compliance, the use of gyroscopic instrument trainer kits ensures comply to the standards set by the Civil Aviation Authority of Malaysia (CAAM) and international bodies like their (ICAO). Proper training using these kits helps aviation professionals meet the regulatory standards required for safe and efficient flight operations.

Finally, the economic impact of gyroscopic instrument trainer kits on the Malaysian aviation industry is essential. By providing comprehensive training, these kits help produce a skilled workforce capable of supporting and sustaining the industry. A well-trained workforce is essential for the growth and competitiveness of the aviation sector. In conclusion, the proficiency gained using these kits can enhance the overall efficiency and safety of aviation operations, contributing to the industry's growth and development.

Figure 2.1: Civil Aviation of Malaysia

Figure 2.2: International Civil Aviation Organization (ICAO)

2.1.2 Demand for Gyroscopic Training Kit

The future of aviation industry is growing constantly and always advancing. As the aviation institution expands, the demand for qualified personnel and especially pilots will increase. To deal with this demand, the aviation institution is required to produce innovative and effective methods. This is where the Gyroscopic Training Kit appears to be one of the important equipment, offering **a** cost-effective and accessible solution for introducing students to the complexities of gyroscopic instruments, a main root of safe and efficient flight.

There are various feature and benefit about the Gyroscopic Training Kit, including:

Realistic Simulation:

The training kits represent the maneuvering characteristics and display of actual gyroscopic instruments. They demonstrate to students how these instruments react to movements in the direction or location of the aircraft. The kits also have a simulation feature that lets students experience instrument malfunctions and learn how to deal with them. Students learn considerably from this realistic practice since it gets them ready for emergencies and real-world flying situations. A pilot can, for instance, practice handling rapid changes in direction or lack of view to the horizon to see how the instruments respond and learn how to correct the path safely.

Hands-On Learning: Because they may engage with the instruments directly, students can learn more about gyroscopic principles. Practicing with the instruments directly is considerably more beneficial than reading about them in a book. Using the instruments in various simulated situations, students improve their memory and understanding of the subject matter. They get experience and confidence while using these important instruments. For example, a student can develop the physical and mental flexibility required for actual flying by practicing maneuvers like turns and climbs while keeping an eye on the attitude and heading indicators.

Cost-Effective:

For aviation educational institutions and schools, trainer kits can save costs. Since real flying instruction requires using planes, fuel, and several other resources, it is quite costly. Students may complete almost all their training on the job with these kits, which lowers the overall cost of their education. Training facilities can more easily provide more students with excellent education because to its affordability. For example, a flying school does not have to worry about fuel prices or aircraft availability when conducting many training sessions in a single day. In the end, this lowers fees and increases accessibility for pilot training by enabling them to train more students more effectively.

Furthermore, using actual aircraft has far greater maintenance expenses than using trainer kits. The operational costs of a real aircraft are increased by the need for routine inspections, repairs, and part replacements. Trainer kits may be used again without experiencing the same wear and tear because they are simulators with less maintenance requirements. Due to this financial benefit, educational institutions are able to make larger investments in other training-related areas, such recruiting skilled instructors or replacing outdated equipment.

Additionally, using trainer kits reduces the environmental effect of normal flying instruction. Releases of greenhouse gases and fuel consumption are greatly reduced by reducing the requirement for real flying hours. This is in line with global efforts to lower aviation sector environmental impact, which makes the training procedure both economical and environmentally friendly.

2.1.3 Type of Gyroscopic Training Kit in Market

Gyroscopic instrument trainer kits are essential tools used in the education and training of students and professionals in fields especially in aviation. These kits help users understand the principles of gyroscopes, their applications, and their behavior under various conditions.

Among the available types, physical model kits stand out for their hands-on approach, offering users the opportunity to engage directly with gyroscopes. These kits range from basic models, which illustrate fundamental concepts such as precession and angular momentum, to advanced models that include high-precision gyroscopes and comprehensive data logging capabilities, suitable for university-level courses and research.

Next, Integrated training systems, on the other hand, provide a more immersive experience, combining physical gyroscopes with digital simulations and interactive software. These systems are particularly valuable in specialized training contexts, such as aviation, where they replicate the behavior of aircraft gyroscopic instruments like attitude indicators and heading indicators.

By blending physical manipulation with virtual experimentation, integrated training systems offer a robust platform for both theoretical learning and practical skill development, making them ideal for professional training programs and advanced educational institutions.

Physical Model Kits

Physical model kits are a very significant facility in gyroscopic training in aviation. In this respect, they provide students with certain hands-on experience that makes aircraft direction and control understandable. Such kits are designed in a way to simulate real flying conditions and allow students to engage directly with gyroscopic forces and the aircraft's control systems. Using these physical models, students can understand flight dynamics by learning how gyroscopic precession and complex forces affect aircraft control. Unlike theory lessons, which may sometimes be confusing, kits provide a clear and interactive way of learning for the students. The students can carry out practical tasks of simulating changes in pitch, roll, and yaw and maintain the aircraft orientation in various conditions. In this way, students will more easily learn and remember abstract concepts of gyroscopic forces.

Model kits are equally cheaper to acquire compared to full-flight simulators. Whereas simulators might be the epitome of advanced training, they are awfully expensive for many small-scale training institutions and those with strained budgets to afford. The physical model kits have the advantages of cheaper production and maintenance costs, thus making them more accessible to almost any training facility. This fact of affordability allows for both the student and the advanced alike to get proper training with their tools. The kits also allow institutions in developing areas with fewer resources to provide quality gyroscopic training without expensive equipment. The inclusion of such kits into the training programs conducted by a training center provides practical exposure to students hailing from various walks of life, thus bridging the much-needed gap between theory and practice.

Figure 2.3: Physical Model Kit (adfdidactic.com 2020)

Integrated Learning Systems

The integrated learning system has made new changes, especially in the introduction of gyroscopic training kits, in pilot training. Such systems follow the holistic approach to education, fusing classroom education with fieldwork. In most cases, aviation concepts have been traditionally taught using the theoretical approach, which usually appears abstract and hard for students to conceptualize. Integrated systems weave the theoretical components into real-life applications, enabling a far more interactive and relevant practice of what students learn. In this regard, integrated learning systems will not only help them retain information better but also develop the skills to confidently handle whatever real flying situation arises. This bridging between theory and practice in an integrated learning system makes the training in aviation far more effective and relevant.

Gyroscopic training kits form the main component of these systems in providing the students with hands-on experience on how to work with a gyroscope, which is an important part of aircraft instrumentation. This enables the student to practice behavior that gyroscopes undergo in flight, a hands-on experience that is vital for aircraft control. For example, students can study how gyroscopic precession and rigidity will affect an airplane in flight in both its movements and orientation. Besides offering hands-on experience, gyroscopic training kits let students test different scenarios, such as simulating an aircraft's changes in pitch, roll, and yaw. An integrated learning system with a gyroscopic kit provides a comprehensive educational experience that merges theoretical knowledge with practical training.

2.2 SPECIFIC LITERATURE REVIEW

2.2.1 Product Structure

2.2.1.1 Basic design of main structure

The Gyroscopic Training Kit has come with a square shape design for an efficient and simple method to learn about gyroscopes and their outstanding movements. Imagine a square frame with a gyroscope instrument's display in the center, moving up and down, right, and left. Because of its straightforward design, the square shape is stable and easy to handle, which makes it a perfect configuration for teaching. By manually adjusting the direction of rotation or applying external forces, students can see how the gyroscope behaves under different circumstances. This simple setup allows students to learn how the gyroscope responds to requires and movements. Understanding basic concepts like balance and rotation can be made possible by this hands-on learning.

One big advantage of this square design is that it is simple and affordable, making it accessible for schools and students. The square frame is simple to set up and offers students a simple way to see how the gyroscope operates. Students can make a comparison between what they see in practice and what they have learned in theory by adjusting the gyroscope to see what happens. This hands-on experience enhances their understanding about how important the gyroscope is for an aircraft.

It is very helpful for students who are interested in aircraft to use this gyroscopic training kit. They are encouraged to learn by doing, which makes the process of learning more interesting. They learn how to think critically and solve problems as they work with the gyroscope while getting an up-close look at how physics works in the aviation industry. The aviation industry students need to understand gyroscopic motion because it affects how aircraft navigate and maintain stability. This practical training may increase students' interest in aviation even more and was a biggest factor for their future education and professional careers in the field.

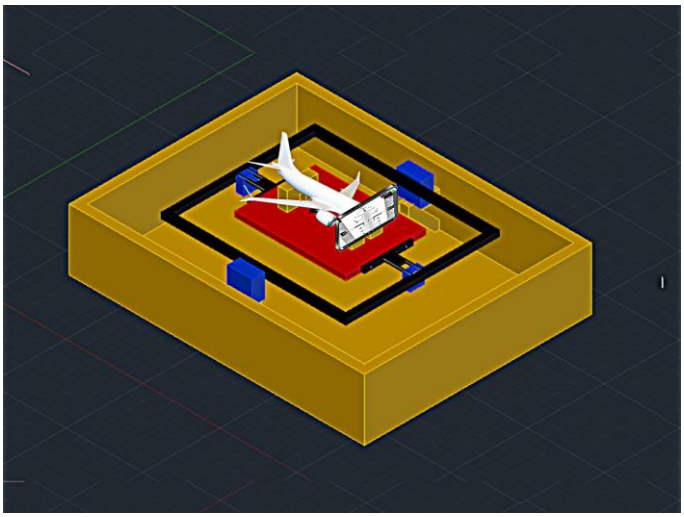


Figure 2.4: 3D model of Gyroscopic Trainer Kit

2.2.1.2 Type of material used for product structure

1. **Water Resistant Plywood (One sided PVC)**

Water Resistant Plywood with one-sided PVC is an excellent choice for creating a gyroscopic training kit. The PVC coating on one side shields the wood from moisture and wetness, making this plywood strong and water-resistant. Because of this, it is great for training environments where spillage and moisture exposure are possible, as it keeps the plywood in good shape and prevents it from damaging over time.

There are several important advantages to using this plywood for a gyroscopic training kit's ground platform and structure. Because of its strength and stability, it provides a solid base that is resistant to the forces and movements produced by the gyroscope. By shielding the wood and maintaining the platform's level surface and stability, the PVC covering improves durability. Because of its stability, students can concentrate on studying the operation of the gyroscope without having to worry about the platform moving or breaking, which is essential for accurate experiments.

The PVC surface is also simple to maintain and clean, which is most useful in an educational context. The platform can easily keep clean and usable by wiping away spills, dust, and other debris. Because of this, it's an excellent choice for learning environments where products must be long-lasting and low maintenance. Additionally, Water Resistant Plywood with one-sided PVC is reasonably priced and flexible, making it simple to customize to meet specific demands of the gyroscopic training kit and promoting learning and practical education.

Figure 2.5: Plywood with one-sided PVC (plywood-online.com Sep. 29 2020)

2. Mild Steel

Figure 2.6: Mild Steel (m.indiamart.com N.d.)

Mild steel, also called low carbon steel, finds very extensive use in the construction of the Gyroscopic Instrument Trainer Kit and is a construction material for Platform 1, Platform 2, and the Center Base because its properties are desirable, and it is easy to fabricate. Platform 1, fabricated from mild steel, serves as the principal structural bolster for the gyroscopic instrument components. This frame is of sufficient quality and strength to carry the weight of the components and withstand the operational stresses. It is readily cut and welded, making it possible to construct to precise specification with great accuracy. Stage 1 is normally treated with a protective coating, such as paint or powder coating, to protect against erosion and to increase its useful life

Platform 2 is constructed from the same mild steel as the structural support plane. It holds the extra components or acts as the middle level between the most structure and the gyroscopic instruments which guarantees the solidity and adjust of the total structure amid the operation of the servo engines. As the name recommends, mellow steel has the customization potential that permits Platform 2 to effectively be bored and adjusted to oblige mounting brackets, sensors, or other fundamental gear. It coordinates with Platform 1 perfunctorily to provide a firm, cohesive bolster framework for the gyroscopic instruments.

Centre Base, which is made from mild steel, is the central anchor point of the whole structure, providing the lead foundation to both Platforms 1 and 2. The base is of utmost importance in ensuring that the weight is as evenly distributed throughout the structure in a manner that

ensures that the gyroscopic noncompliant is properly aligned and functional. The tall rigidity of the difference reduces vibrations and development seemingly influence the accuracy of the gyroscopic simulations. The Center Base is easily assembled with other components using jolts, screws, or welding for a strong and permanent structure.

The advantages of using mild steel include its inexpensiveness, considering it provides satisfactory quality to support various loads and stresses, and its excellent workability, which makes the process of molding, cutting, and welding quite easy. Besides, mild steel is widely available in various shapes and sizes, making procurement much easier while minimizing lead times for construction. To improve the lifespan and effectiveness of the mild steel components, they are usually treated with protective coatings, such as painting, galvanizing, or powder coating. The treatment makes a difference in preventing rust and erosion, hence making the platforms and base stay in good condition during their operation.

3. 3D Printed Materials

3D printed materials are created using a 3D printer that builds objects layer by layer from digital models. These materials can include metals, plastics, and resins, depending on the kind of 3D printer being used and the qualities that the final object is going to have. 3D printed materials provide obvious advantages for building a aircraft on the training kit that improve the kit's functionality and design.

The ability to accurately and precisely produce components that are suited to specific demands is one of the major benefits of using 3D printing for a gyroscopic training kit. Complex shapes and elaborate designs that would be difficult or impossible to create using traditional manufacturing techniques may now be produced because of 3D printing. It also guarantees that every part of the kit fits and works according to plan, improving the kit's overall effectiveness and educational materials quality.

Furthermore, quick prototyping and modification can be made possible by 3D printing, which is very helpful for educational equipment like a gyroscopic training kit. Parts may be quickly created, tested, and improved by designers, which makes it simple to customize and improve the kit in response to user input and test results. Future enhancements are possible with this quick development period, and there are no major delays or expenses. Moreover, a lot of materials made with 3D printing combine durability and light weight to create the perfect mix of strength and handling efficiency. This improves the hands-on learning experience by guaranteeing that the gyroscopic training kit is durable enough to withstand daily use by students and lightweight enough for simple handling.

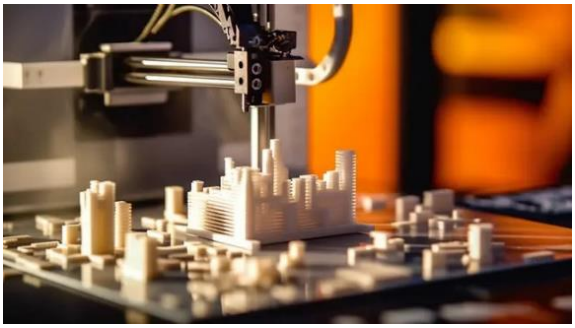


Figure 2.7: 3D Printed Material (pt.pngtree.com N.d.)

4. Filament 3D Print (PL/A)

A particular kind of thermoplastic material called PLA (Polylactic Acid) is used in Fused Deposition Modeling (FDM) 3D printers for filament-based 3D printing. Known for its ease of use and decent surface finish, PLA is a popular choice for creating precise 3D printed items, though it generally does not achieve the same fine detail as resin printing. PLA hardens layer by layer as it cools, allowing for the creation of solid designs with moderate detail.

Creating a gyroscopic training kit with PLA has some advantages as well. PLA printing is relatively straightforward and affordable, enabling the production of accurate components that are sufficiently precise for many educational applications. While PLA's accuracy may not match that of resin printing, it is still capable of producing effective gyroscopic parts that offer functional educational experiences. Additionally, PLA's ease of use helps make the production process more accessible and can lead to faster prototyping and assembly.

PLA is reasonably strong but less durable than resin. Although PLA may wear over time with frequent handling, it provides adequate durability for many educational settings. However, PLA's lower strength compared to resin may make it less resistant to stresses during gyroscopic tests, meaning components might require more frequent replacements. Despite these limitations, PLA's capacity to produce moderately complex shapes at a lower cost makes it a viable option for creating an educational gyroscopic training kit.

Figure 2.8: Filament 3D Print PL/A (gembird.com N.d.)

2.2.2 Product Mechanisms

A servo motor is an electromechanical device that offers precise control of angular or linear position, velocity, and acceleration. It consists of a motor, a control circuit, and a feedback mechanism. Accurate movements can be made possible by the feedback mechanism, which can be a rotary encoder or slider that feeds the control circuit current information. This capability makes servo motors ideal for applications requiring fine-tuned movements and precision, which are critical in mechanisms that need consistent and repeatable performance.

There are various advantages to including a servo motor in a gyroscopic training kit. The gyroscope can maintain precise positions and movements because of the servo motors' accuracy and precision, which is necessary for effective learning. To assure user safety and performance, the reaction system provides smooth and controlled motion immediately. Furthermore, servo motors can be programmed to do a wide variety of complex exercises, which increases the training kit's flexibility and efficiency. All these characteristics work together to make training reliable, durable, and effective.

1. Servo Motor

A servo motor is an electromechanical device designed to precisely control angular or linear position, velocity, and acceleration. It typically includes a motor, a control circuit, and a feedback mechanism. The motor can be either DC or AC, responsible for driving the mechanical load. The control circuit processes input signals to adjust the motor's movement, providing immediate position data to the control system. This feedback loop ensures that the motor reaches the required position accurately and maintains it as needed.

Adding a servo motor to a gyroscopic training kit has several advantages because of its controllability and accuracy. Accurate position input from servo motors makes it possible to maintain the gyroscope at precise angles and positions, which is necessary for effective training sessions. This accuracy improves the training's effectiveness and facilitates users' faster skill improvement by simulating real-life circumstances where precise motions are essential. Training becomes more reliable and flexible when one can do controlled and easy motions.

Moreover, servo motors have an outstanding amount of programming capability, which allows them to carry out complex motion patterns and adjust to various training periods. The gyroscopic training kit's programming ability makes it adaptable to a variety of skill levels and learning purposes. Actual control and adjustment of the gyroscope's force and movement enables specific exercise that meets each user's needs and offers the best possible outcomes for training. A high-quality, successful gyroscopic training kit requires reliable functionality and long-lasting operation, which is ensured by the implementation of servo motors.

Figure 2.9: Servo Motor (rockingtalent.com N.d.)

2. 9V Battery

A 9V battery is a type of power storage that produces a standard voltage of 9 volts. It is often used in backup power systems, motoring and other applications. There are many varieties of these batteries available, such as nickel-metal hydride, lithium-ion, and lead-acid. Their popularity comes from their reliability, high current output, and quite long lifespan. Because of their 9V standard, which offers a steady and consistent voltage output, they can power a variety of electronic systems and devices.

In a gyroscopic training kit, using a 9V battery as the power supply for an Arduino microcontroller offers significant benefits. The Arduino and its connected components, including sensors, actuators, and gyroscopes, are ensured to function consistently and without power failures thanks to the steady voltage output. For efficient training sessions and performance monitoring, the gyroscope's movements must be precise and accurate, and this constancy is crucial for maintaining such qualities. Enhancing the whole learning experience, an efficient power source such as a 9V battery ensures that the entire system operates at its optimum performance.

Furthermore, the convenience and flexibility of the gyroscopic training kit is greatly improved by the 9V battery's accessibility. A battery-powered setup, in place of connected power sources, enables the equipment to be used in a variety of options, including indoor and outdoor spaces as well as isolated sites without access to mains energy. The training kit's portability increases its versatility by allowing students to practice and learn in a variety of situations. Furthermore, 9V batteries usually have enough capacity to power the Arduino and its parts for extended periods of time, which minimizes interruption and allows learning sessions to continue uninterrupted. The training kit's increased operational duration and portability improve its use and effectiveness and enable it to be used for a wider range of training environments and needs.

Figure 2.10: 9V Battery (visionmedia.com.my Feb. 14 2019)

2.2.3 Software / Programming

1. **Arduino Uno ESP32**

The Arduino Nano 33 BLE is a compact, powerful microcontroller board equipped with Bluetooth Low Energy (BLE) capabilities. It is built around the nRF52840 microcontroller, which includes a 32-bit ARM Cortex-M4 CPU running at 64 MHz the board features 14 digital input/output pins, 8 analogue inputs, and a wide range of sensors and communication interfaces, making it highly flexible for various applications, including robotics and IoT projects.

There are a lot of important benefits to using the Arduino Nano 33 BLE in a gyroscopic training kit, particularly when servos are included to improve the learning process. First off, wireless control and communication are made possible by the BLE capabilities. This makes it possible for students to take part in modern and interesting experimentation and data collected by enabling them to interact with the gyroscopic mechanism remotely using a smartphone or tablet. The kit's wireless control feature makes it easier to set up and reduces the need for physical connections, increasing its convenience and accessibility.

Furthermore, the servos included in the gyroscopic training kit may be precisely controlled because of the Arduino Nano 33 BLE's great processing capabilities. Students can watch the effect of various indicators and acceleration in real time by coding servos to accurately change the gyroscope's rotation or position. This practical interaction helps in understanding difficult ideas like precession and angle momentum. Furthermore, the chip's tiny size and low power consumption make it perfect for implementation into small training kits, maintaining the entire design's portability while maintaining a strong educational purpose.

Figure 2.11: Arduino Uno ESP32 (my.mouser.com Feb. 15 2021)

2. Autodesk AutoCAD 2023

AutoCAD is a computer-aided design (CAD) software developed by Autodesk, widely used by professionals such as architects, engineers, and designers to create precise 2D and 3D drawings and models. It offers a comprehensive set of tools for drafting, annotating, and designing complex geometries and assemblies, supporting various file formats and interacts effortlessly with other design and engineering software. This versatility and precision make AutoCAD an essential tool for developing detailed technical drawings and plans.

Using AutoCAD for designing a gyroscopic training kit brings several advantages. The software's precision and accuracy ensure that all components of the kit are designed with exact dimensions, reducing errors during manufacturing and ensuring reliable performance. AutoCAD's 3D modelling capabilities allow for enhanced visualization of the entire assembly, helping designers identify and resolve potential issues early in the design process. Moreover, AutoCAD streamlines design iterations and documentation, enabling efficient updates and generating detailed drawings, parts lists, and assembly instructions. This thorough documentation aids in smooth production and assembly, ultimately leading to a more reliable and effective

Figure 2.12: Autodesk AutoCAD 2023 (3dtechstore.com N.d.)

3. Survey Questionnaire (Google Form)

Survey questions are like asking students what they think about something. For a gyroscopic training kit, it means asking students who use it questions to find out what they like and don't like. By listening to students' answers, the people who make the kit can figure out how to make it better. It's like asking students what they want in a game to make it more fun to play. So, survey questions help make the gyroscopic training kit better by listening to what students have to say.

When students answer survey questions about the gyroscopic training kit, it helps the makers understand how to improve it. They can learn what students enjoy and what they find tricky. This feedback guides the makers in making changes that could make the kit easier and more enjoyable for students to use. In the end, survey questions play a big role in making sure the gyroscopic training kit is just right for students.

Figure 2.13: Survey Questionnaire (1upbiz.com N.d.)

4. ChatGPT

ChatGPT is like a smart friend that can help students learn about gyroscopic training kits. Students can ask ChatGPT questions about these kits, like what they are and how they work. ChatGPT can give quick and accurate answers, which saves students time and helps them understand better. For example, if a student wants to know what parts are in a gyroscopic training kit or how it helps with exercise, ChatGPT can explain it in simple terms.

Another way ChatGPT helps students is by summarizing information. Students might have to write reports or presentations about gyroscopic training kits for their classes. ChatGPT can read articles or research papers about these kits and then explain the main points in an easy way. This makes it easier for students to understand the topic and write their assignments. Instead of reading long and complicated papers, students can get the important information from ChatGPT quickly.

Lastly, ChatGPT can be a helpful tool for students doing projects or experiments with gyroscopic training kits. If students have questions about how to set up the kit or how different parts work together, ChatGPT can provide explanations and guidance. This helps students learn by doing and ensures they get the most out of their projects. With ChatGPT's help, students can feel more confident and knowledgeable about gyroscopic training kits, making their learning experience more enjoyable and successful.

Figure 2.14: ChatGPT (cxnetwork.com Nov. 30 2023)

2.2.4 Accessories & Finishing

1. Adhesive Sealant

Adhesive sealant is like a special glue that's great for finishing touches on the plywood platform to attach with mild steel platform. When applied, it forms a strong, waterproof seal that keeps moisture out, protecting the kit from damage. This is especially helpful if the kit will be used outdoors or in places where there is a lot of moisture in the air. Plus, once it dries, adhesive sealant stays flexible and durable, so it can handle bumps and movement without cracking or breaking.

Using adhesive sealant also makes the attachment between the two different material platform look better. It fills in any gaps or rough spots, giving the kit a smooth and neat appearance. And because adhesive sealant comes in different colours, it can match the kit's design or add a pop of colour for a more stylish look. So, not only does adhesive sealant keep the kit safe, but it also helps it look its best, making it a handy finishing touch for a well-rounded for the attachment.

Figure 2.15: Adhesive Sealant (skyreach.ca N.d.)

2. Two Part Resin

A two-part epoxy resin is like a shiny, protective coating that can be applied to the surface of items, like adding a clear, durable layer on top. For a gyroscopic training kit, using this two-part resin as a finishing touch offers several advantages. First, it protects the kit from scratches and damage, especially on frequently handled parts. Think of it as a shield that preserves the kit's appearance and extends its lifespan.

Additionally, the two-part epoxy resin gives the gyroscopic training kit a sleek and professional look. The glossy finish adds a smooth, polished touch, making the kit visually appealing and inviting to use. Customization options, like adding colours or effects to the resin, allow for a personalized look that can match the kit's branding or style. So, not only does it offer protection, but it also enhances the kit's aesthetic.

Overall, using two-part epoxy resin ensures that the gyroscopic training kit remains in excellent condition and looks fantastic. With its protective coating, the kit can withstand everyday wear and tear without showing signs of damage. The glossy finish adds a professional and stylish appearance, making the kit more engaging and fun to use. It’s like giving the kit a polished makeover while reinforcing its durability and extending its lifespan.

Figure 2.16: Polish Epoxy Resin (makermaterialsupply.com N.d.)

2.3 Review of Recent Research / Related Products

2.3.1 Related Patented Product

2.3.1.1 Patent A

Table 2.1: Patent Product

No.	Patented Product	Patent Summary
1	N/A	**Title:** Gyroscope Educational Kit **Patent Number:** US6012960A **Inventor:** Richard A. Pasela **Publication Date:** January 11, 2000 **Origin Country:** United States **Description:** An educational kit intended to teach the principles of gyroscopes, this invention comprises a gyroscope, a support stand, and a set of instructions for conducting various experiments. The kit aims to demonstrate the behavior of gyroscopic forces, precession, and stability, providing a hands-on learning experience for students.

2.3.2 Recent market product

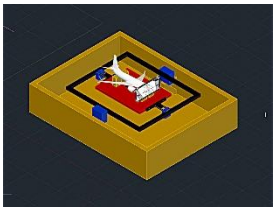
Table 2.2: Recent Market Product

No.	Market Product	Product Summary
1		**Product name**: IT-01 Cockpit Instrumentation Trainer **Publish date**: 2017 **Inventors**: Aerotrain. Corp **Description:** a full functional demonstration of the actual instruments used in aircraft. It includes standard flight instruments, engine instruments, and Pitot-Static instruments. All instruments and systems are fully functional. The trainer is not only a tool for the instructor to demonstrate working principles, it also provides hands-on training to students. As an option, flight line or workshop test equipment for the instruments may be supplied for hands-on maintenance training.
2		**Product name:** Aircraft Cockpit Instrumentation Trainer **Publish date:** 2020 **Inventors:** ADF ((DIDACTIC ENGINEERING EXPERIMENTAL DESIGN) **Description:** Aircraft Cockpit Instrument Training Set (CBT-100A) is a complete and fully functional simulation of typical aircraft cockpit. It includes essential flight, engine, and pitot-static instruments. This training set provides hands-on maintenance training while also functioning as a demonstration tool for instructors. It demonstrates the principles of gyros, altimeter, and the engine instruments, and can be used for teaching of instrument removal and replacement

2.4 Comparison Between Recent Research and Current Project

2.4.1 Patent A vs. Product A vs. Your Product

Table 2.3: Comparison Between Product

Product	Gyroscope Educational Kit	IT-01 Cockpit Instrumentation	Gyroscopic Instrument Trainer Kit
Design	N/A		
Dimension(cm)	N/A	75x52x120	25x35x35
Mobility	4 wheels	4 lockable wheels	No wheel
Portability	Yes	Yes	Yes
Complexity	Not complex	Little complex	Not complex
Features	Designed for training users to interpret and respond to gyroscopic effects.	Provides demonstration of the proper functioning of gyros, altimeter, and the standard engine instruments	To demonstrate the appliance of gyro mechanism in gyroscopic instrument

CHAPTER 3

RESEARCH METHODOLOGY

3.1 PROJECT BRIEFING & RISK ASSESSMENT

This chapter describes the activities performed to finish the project of the gyroscopic instrument trainer kit. These include the preparation of all necessary paperwork and approval by the supervisor. The project shall be developed as a practical learning tool for students and professionals in aviation to learn how to understand and operate gyroscopic instruments found in aircraft primary flight displays. The project will focus on assembling a functional trainer kit accurate, durable, portable, and easy to use.

Risks include, among other things, mechanical failure, erroneous gyroscopic emulation, design intricacy, user misunderstanding, and market competition. In mitigating these risks, the project will adopt the use of strong materials, thorough testing, design simplification, clear instructions, and continuous product improvement. This should ensure the delivery of a reliable training tool that enhances learning, skills, and safety in aviation.

3.1.1 Utilisation of Polytechnic's Facilities

To use all the facilities such as equipment, consumable materials and tools provided by Polytechnic, permission must be granted from the supervisor and workshop coordinator by filling up the necessary form. This form will specify the tools and equipment used to complete the project.

Example of Polytechnic's facilities that our group use:

- General Workshop

Figure 3.1: General Workshop

- Aircraft Structure and Airframe Workshop

Figure 3.2: Aircraft Structure and Airframe Workshop

- Composite Workshop

Figure 3.3: Composite Workshop

3.2 OVERALL PROJECT GANTT CHART

3.2.1: Gantt Chart for AEM

PROJECT ACTIVITIES		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
GROUP FORMATION AND DISCUSS PROJECT TITTLE WITH SUPERVISOR	P															
	E															
DISCUSS ABOUT ALL IDEA CONCEPTS AND FINALIZE THE IDEA	P															
	E															
SURVEY AND PRE-TEST IS	P															

CONDUCTED FOR PROBLEM STATEMENTS (ASSIGNMENT 1).	**E**															
DATA FROM THE SURVEY AND PRE-TEST IS RECORDED FOR PARETO CHART	**P**															
	E															
LIST OF IDEAS FOR CONCEPTIONAL IDEA OF PRODUCT (ASSIGNMENT 2).	**P**															
	E															
COMPLETION OF PUGH MATRIX (ASSIGNMENT 3)	**P**															
	E															

PRE-PROPOSAL PRESENTATION TO THE PANEL.	**P**															
	E															
COMPLETION OF WRITE-UP CHAPTER 1.	**P**															
	E															
COMPLETION OF WRITE-UP CHAPTER 2.	**P**															
	E															
COMPLETION OF WRITE-UP CHAPTER 3.	**P**															
	E															
PREPARE SLIDES FOR THE FINAL PRESENTATION.	**P**															
	E															
	P															

FINAL PROPOSAL PRESENTATION TO PANEL.	**E**															

Table 3.1: Gantt Chart for AEM

3.2.2: Gantt Chart for AEP

PROJECT ACTIVITIES		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
MATERIAL ACQUISITION (PHASE 1) • Hollow Steel • Imfra Board (30cm x 60cm x 0.9cm) x 5	P															
	E															
MEASURING, FILLING, LEVALING, AND CUTTING (PHASE 2) • Hollow Steel ➢ (48cm X 4) ➢ (37cm X 4) ➢ (10cm x 8) • Imfra Board ➢ (48 CM X 37 CM) ➢ (30 CM X 25 CM) ➢ (10 CM X 48 CM) ➢ (10 CM X 37 CM)	P															
	E															
WELDING AND GRINDING (PHASE 3) ➢ Learn MIG GAS welding ➢ Learn how to use MIG welding ➢ MIG welding used to join GITK base structure ➢ Grinder	P															
	E															

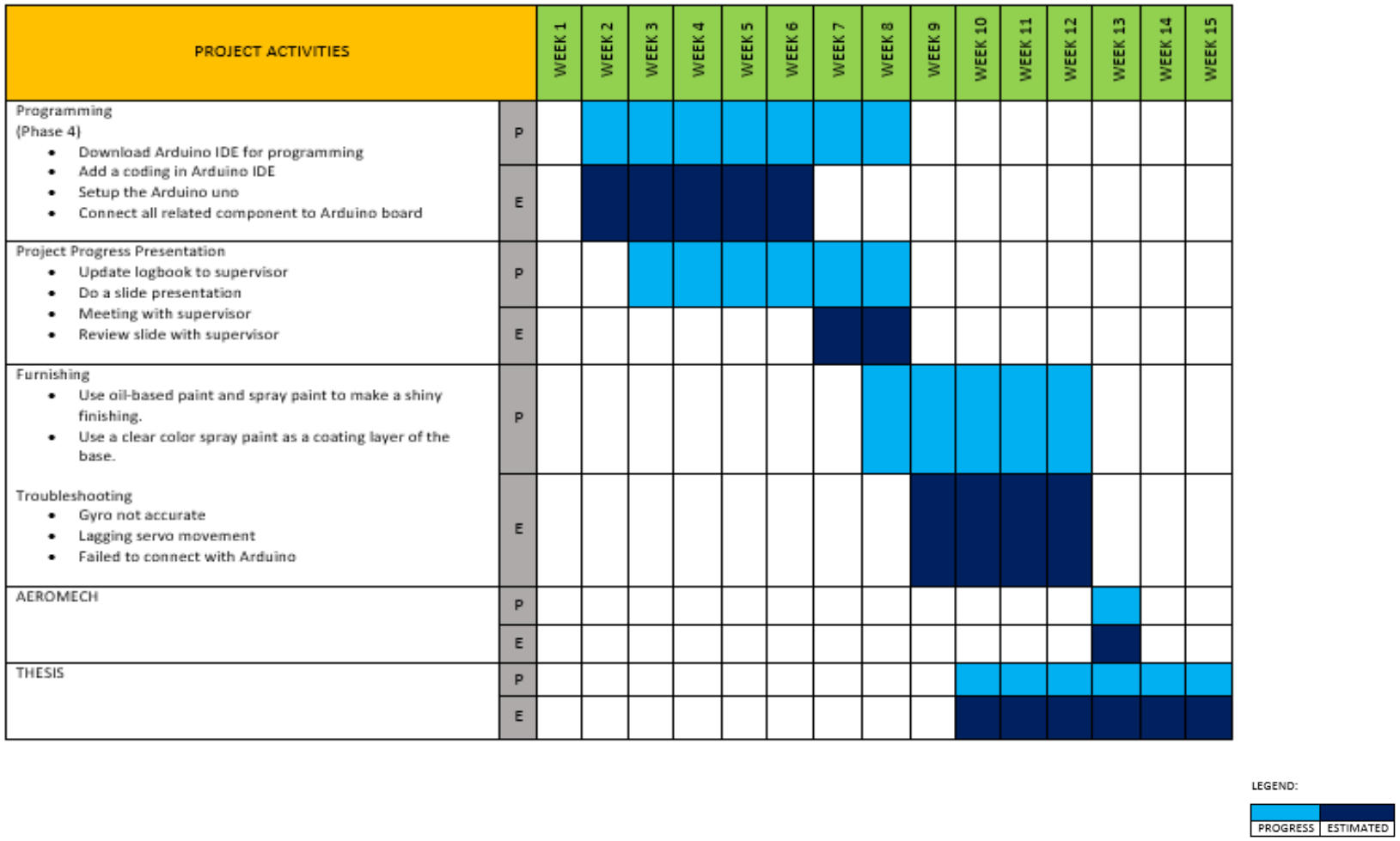


Figure 3.4: Gantt Chart For AEP

3.3 PROJECT FLOW CHART

3.3.1 Overall Project Flow Chart

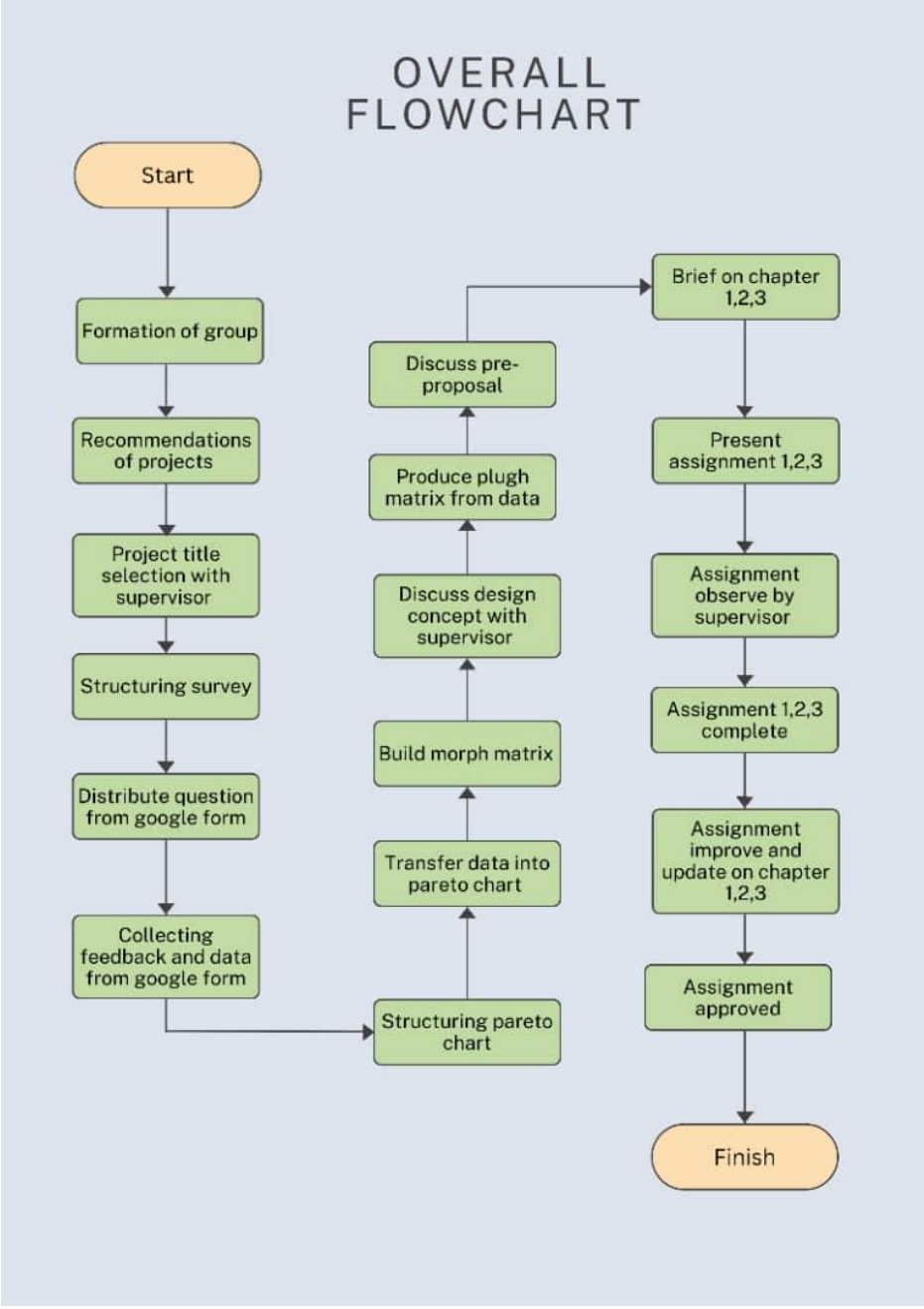


Figure 3.5: Overall Project Flow

3.3.2 Specific Project Design Flow

3.3.2.1 Product Mechanism

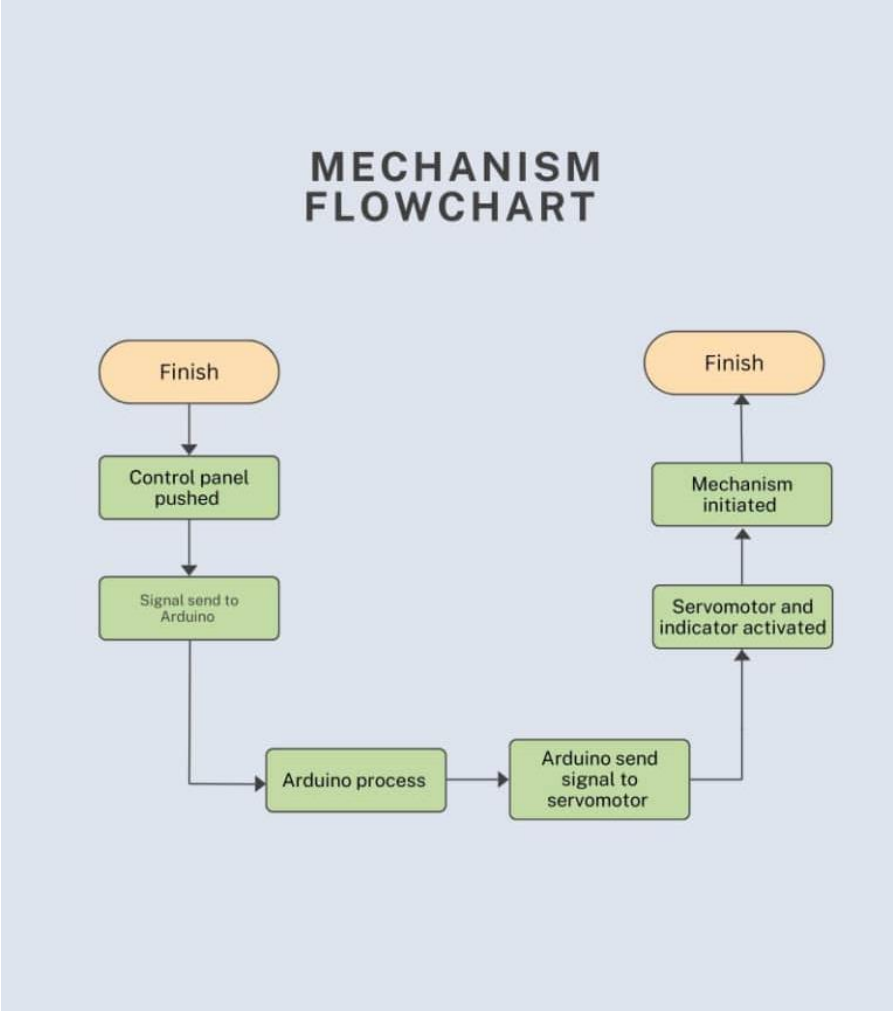


Figure 3.6: Product Mechanism Flowchart

3.3.2.2 Software/Programming

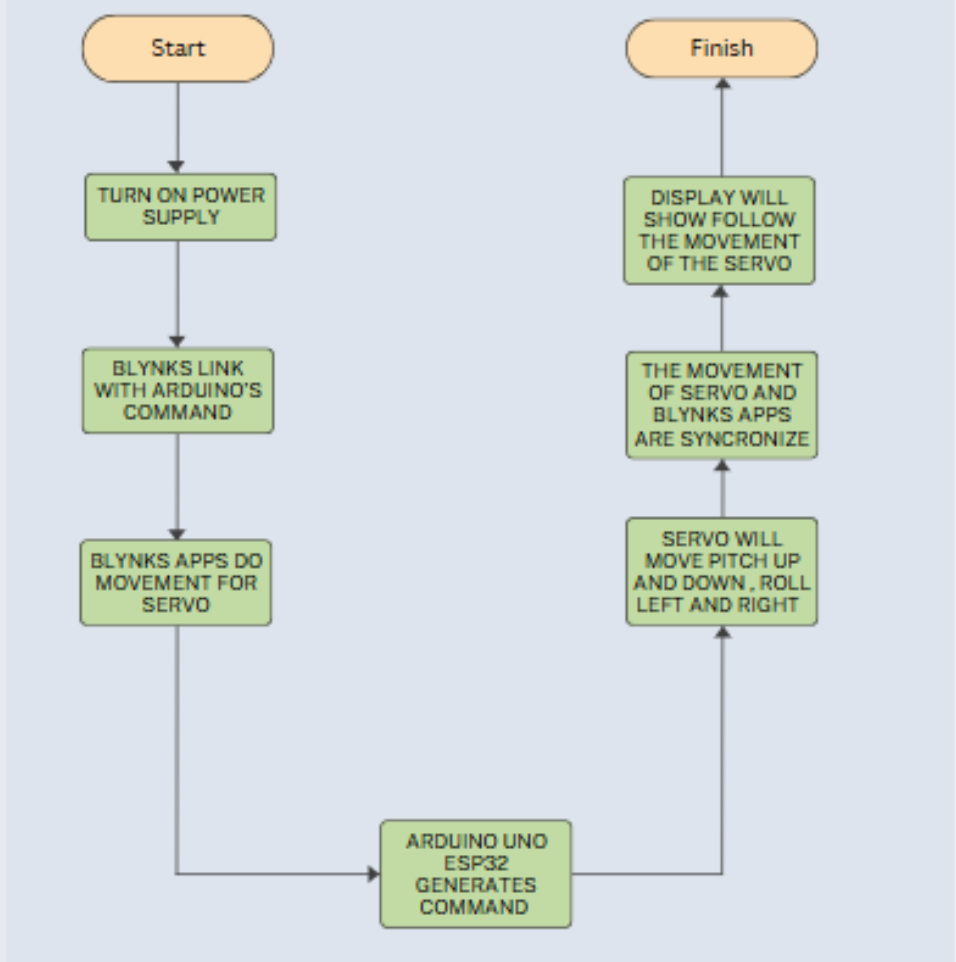


Figure 3.7: Product Software Flowchart

3.4 DESIGN ENGINEERING TOOLS

3.4.1 DESIGN REQUIREMENT ANALYSIS

3.4.1.1 QUESTIONNAIRE SURVEY

A questionnaire survey is a research method used to collect data from respondents through a series of questions, designed to gather information on various topics such as opinions, behaviors, experiences, or demographic details. These surveys can be conducted in several formats, including online surveys distributed via email or social media, paper surveys handed out or mailed to participants, telephone surveys conducted over the phone, and face-to-face surveys administered in person. The questions in a questionnaire can be open-ended, allowing for detailed responses, or closed-ended, providing specific answer choices. The collected data is then analyzed to identify trends, preferences, and insights, which inform decision-making in fields like market research, academic studies, and public policy. Overall, questionnaire surveys are a practical and efficient way to gather large amounts of data from diverse groups of people.

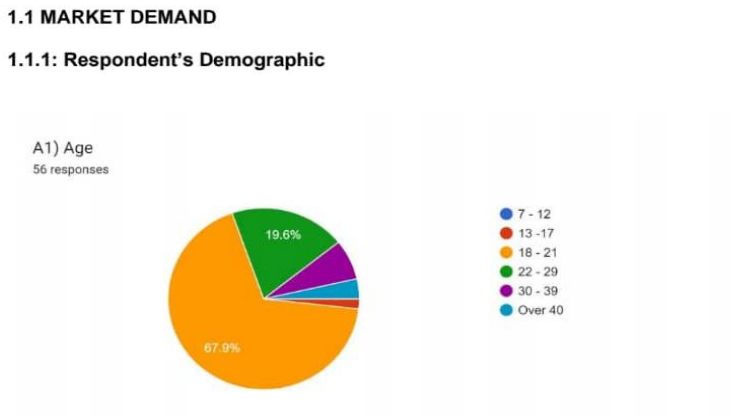


Figure 3.8: Respondent's Demographic

From the data collected from the survey, a total of 55 respondents have filled out this survey and the highest percentage is 67.9% or equal to 38 people who filled out the survey aged between 18- 21 years. The rest is a percentage of 19% equal to 11 people aged between 22-29 and followed by 7.1% equivalent to 4 people aged between 30-39. Finally, a total of 3.6% percent which is 2 people aged over 40 years and 1.8% percent equal to 1 person aged 13-17 years who became respondents

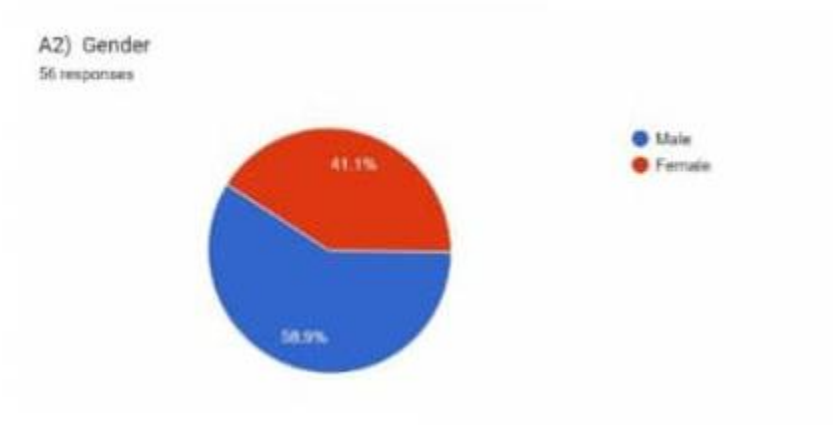


Figure 3.9: Respondent's Gender

From the chart above, it indicates that male respondents are more than female respondents which is from the 55 responses, 58.9% or equal to 33 people are male and the balance 41.1% or equal to 23 people are female respondents.

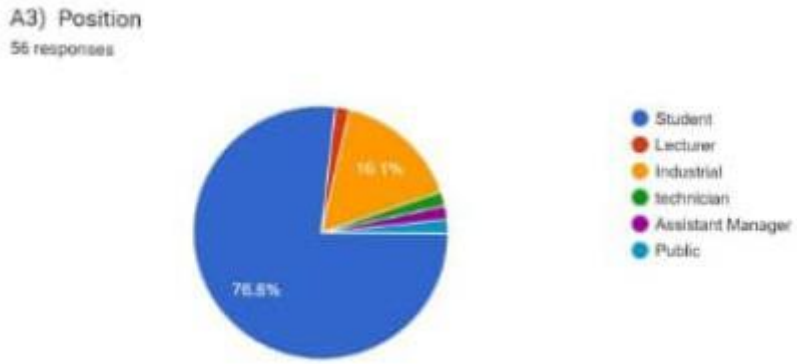


Figure 3.10: Respondent's Position

From the chart above, can be seen that from a total of 55 people, there is 78.8% or equal to 43 respondents are from the students and followed by 16.1% or equal to 9 respondents are from industrial field. Apart from that, the balance of respondents are lecturer, technician, assistant manager and public each contributing 1.8% that equal to 1 each of the total respondents.

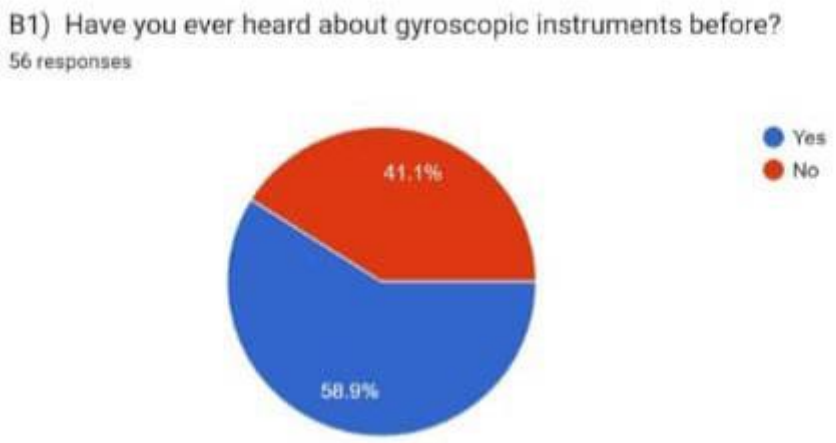


Figure 3.11: Respondent's Familiarity about Gyroscopic Instrument

For figure 4, based on the question asked, from the total respondents, 58.9% or equal to 33 people answer 'YES' while the other 41.1% or equal to 23 people answer 'NO' because they never heard about gyroscopic instruments.

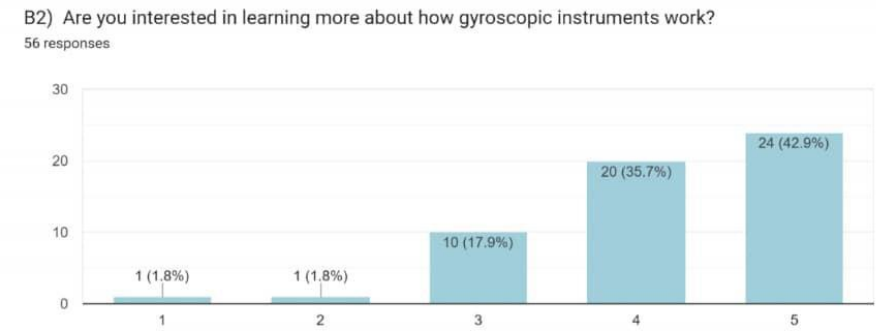


Figure 3.12: Respondent's Interest About Gyroscopic Instrument

This question is focused on respondent's interest about how gyroscopic operates. From the data collected, most respondents (96.5% or equal to 54 persons) are very interested to know more on how the gyroscopic instrument works.

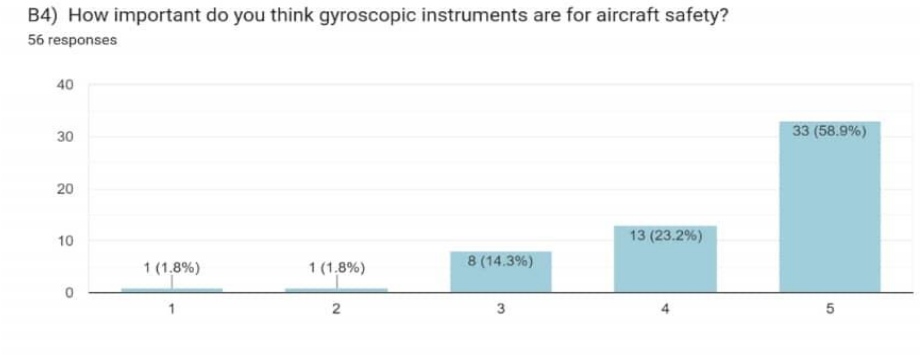


Figure 3.13 : Importance of Gyroscopic Instrument on Aircraft Safety

The data is based on the importance of gyroscopic instruments for aircraft safety. It shows that most respondents already know about the importance of gyroscopic instruments on aircraft.

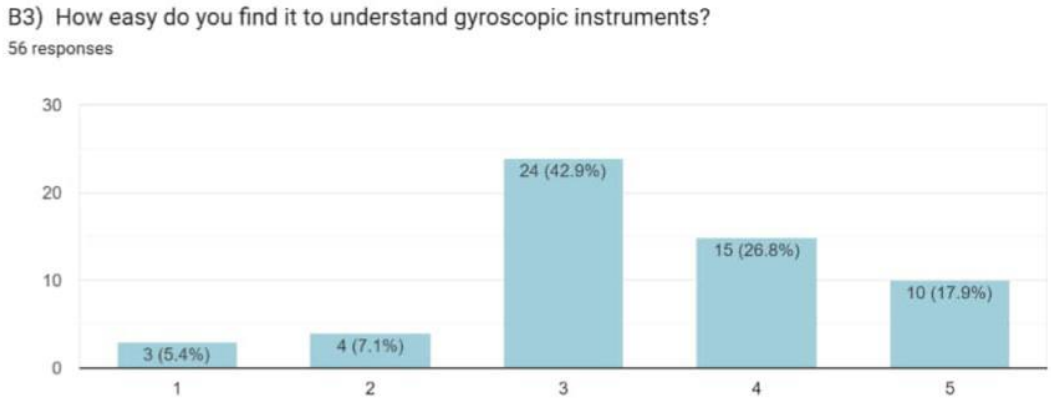


Figure 3.14: Score for Understanding Gyroscopic Instrument

From the bar chart above, the data shows that most respondents found that it is easy to understand gyroscopic instruments. But there are also some of them who do not find it easy to understand

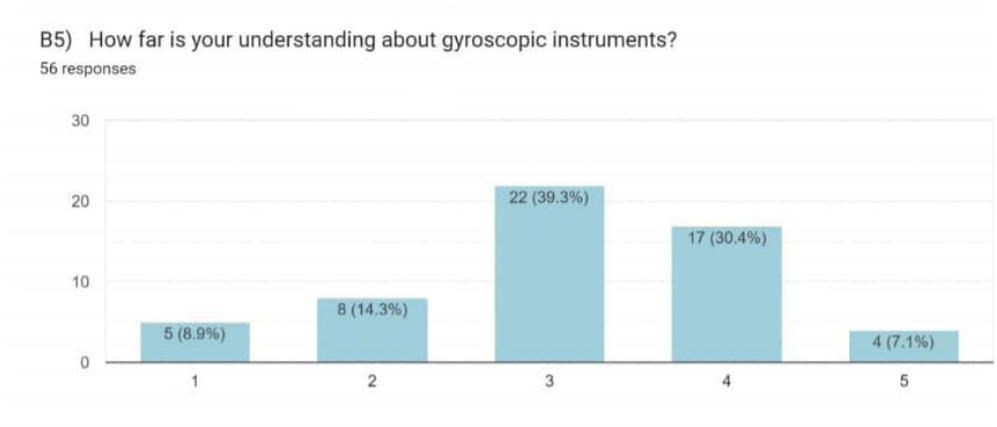


Figure 3.15: Understanding on Gyroscopic Instrument

From the bar chart above, the data shows that most respondents found that it is easy to understand gyroscopic instruments. But there are also some of them who do not find it easy to understand. The most respondents are with medium level of understanding about gyroscopic instruments while there also some of it is limited in understanding the instruments and the group that really understands is just a little amount.

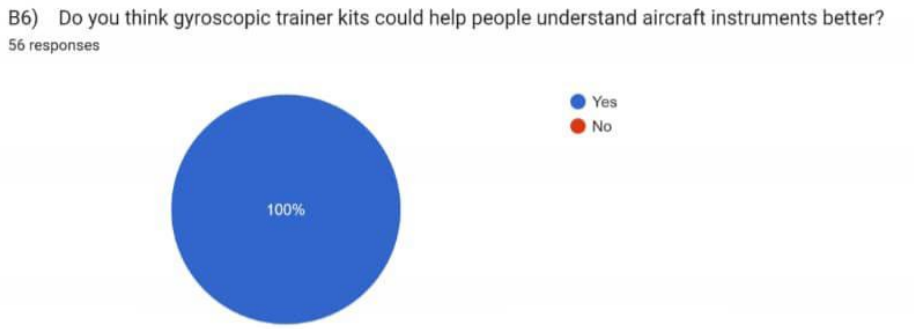


Figure 3.16: Respondent's Opinion About Gyroscopic Instrument

Based on opinion collected from the survey, all respondents are agreed with the presence of this gyroscopic trainer kits that could help people in understand about aircraft instruments

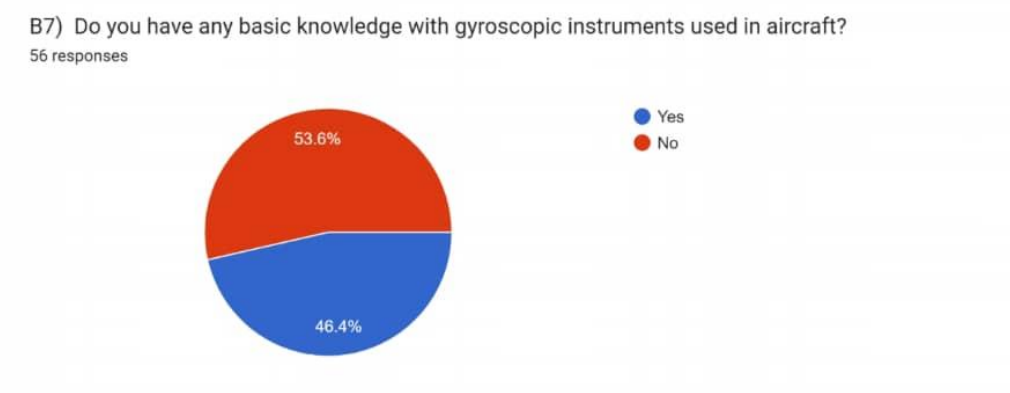


Figure 3.17: Respondent Knowledge About Gyroscopic Instrument

This question is being asked just to know the basic knowledge of respondents about gyroscopic instruments in aircraft. 46.4% or equal to 26 persons already know about gyroscopic while the other 53.6% or equal to 30 persons still do not know and familiar with gyroscopic instruments.

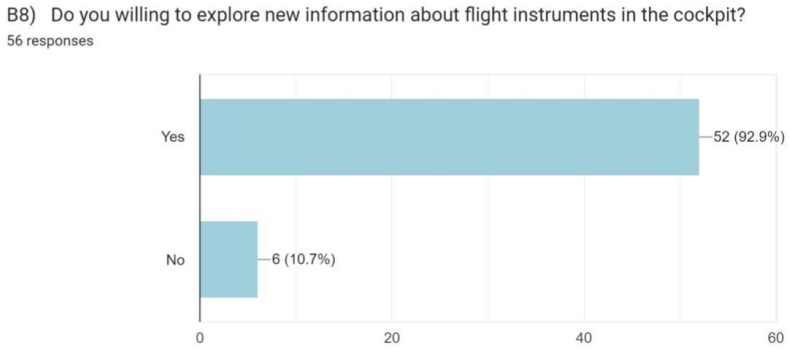


Figure 3.18: Respondent's Willingness To Explore about Flight Instrument

From the data above, most respondents are willing and interested to explore and gain new information about flight instruments that also include gyroscopic instruments in the cockpit.

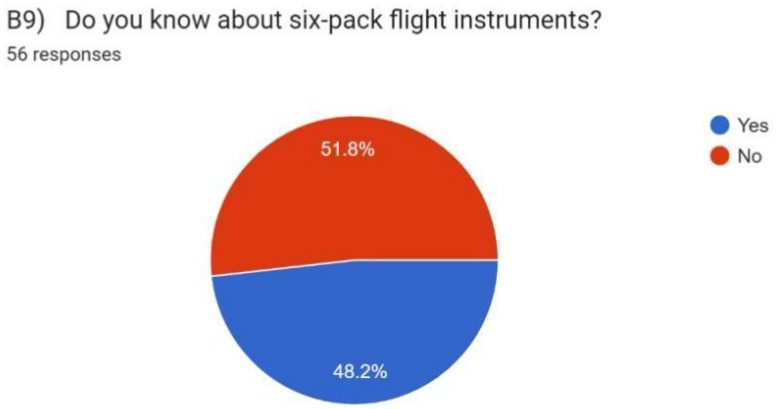


Figure 3.19: Knowledge About Six-Pack Flight Instrument

From the pie chart, 48.2% of the respondents have already know about six-pack flight instruments while the other balance of 51.8% of the respondents are not familiar or do not know about six-pack flight instruments on aircraft.

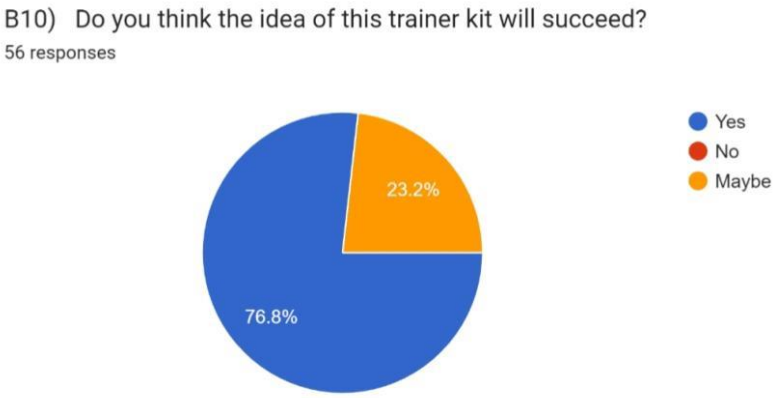


Figure 3.20: Respondent's Opinion

From the data collected, most of respondents predicted the success of this trainer kit with 76.8% or equal to 43 persons while others predict that maybe it will be success for this trainer kit project

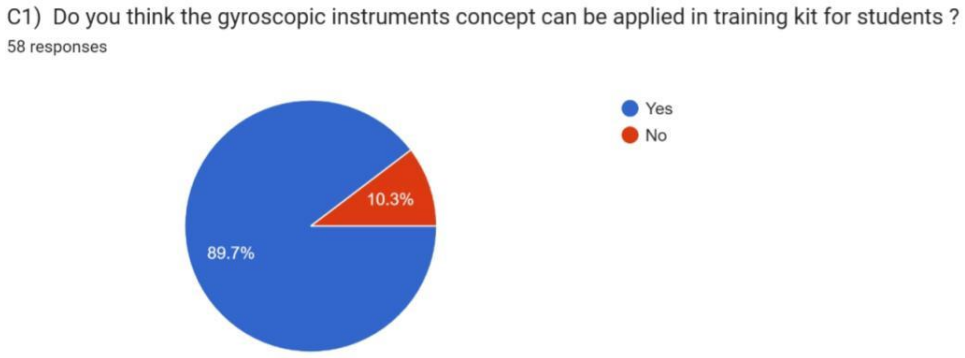


Figure 3.21: Gyroscopic Concept Can Be Applied For Students

From the data collected, most respondents agreed that gyroscopic instruments concept can be applied in training kit to be more effective.

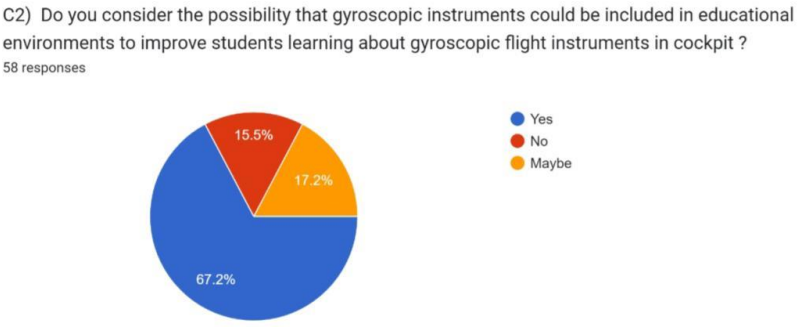


Figure 3.22: Gyroscopic instrument can Improve Students Learning

67.2% or equal to 39 of respondents agreed with the possibility that gyroscopic instruments can be included in educational environments to improve student learning while others have considered ‘YES’ and ‘MAYBE’ option for their answer.

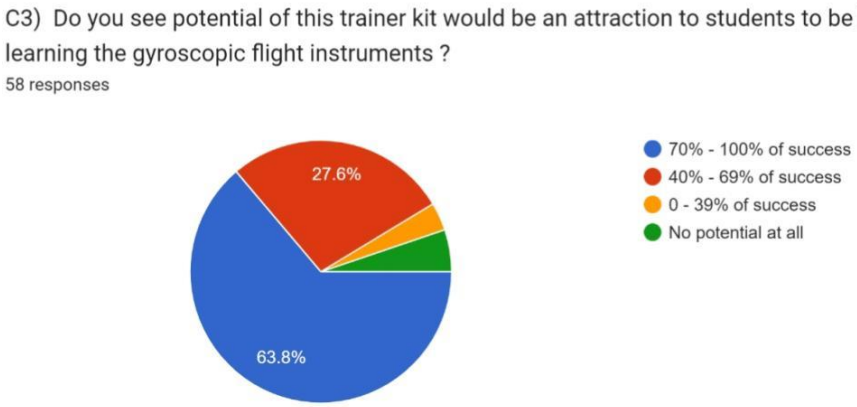


Figure 3.23: Potential of Trainer Kit

From the data, a total of 63.8% of respondents or equal to 37 persons see higher potential of the trainer kit development while 27.6% give rate of 40%-69% of potential success for this project. It indicates that this project has a brighter future to be done and beneficial to others.

3.4.1.2 PARETO DIAGRAM

FEATURES	FREQUENCY	PERCENTAGE	CUMMULATIVE %	PARETO BASELINE
Cost	21	36.21%	36.21%	80%
Effectiveness	16	27.59%	63.79%	80%
Ease of use	10	17.24%	81.03%	80%
Durability	6	10.34%	91.38%	80%
Precision	5	8.62%	100.00%	80%
TOTAL	58			

Figure 3.24 Pareto Table for Gyroscopic Instrument Learning Kit

From the Pareto diagram above, the most significant feature is Cost, which has the highest percentage of 36.21% with frequency of 21. Next, the second most significant feature is Effectiveness which carries a percentage of 27.59% with frequency of 16. Then, the third highest percentage is ease of use which carries 17.24% or equal to 10 persons. Further, the other 2 aspects, which are Durability and Precision, are left behind with the lowest percentage compared to the first 3.

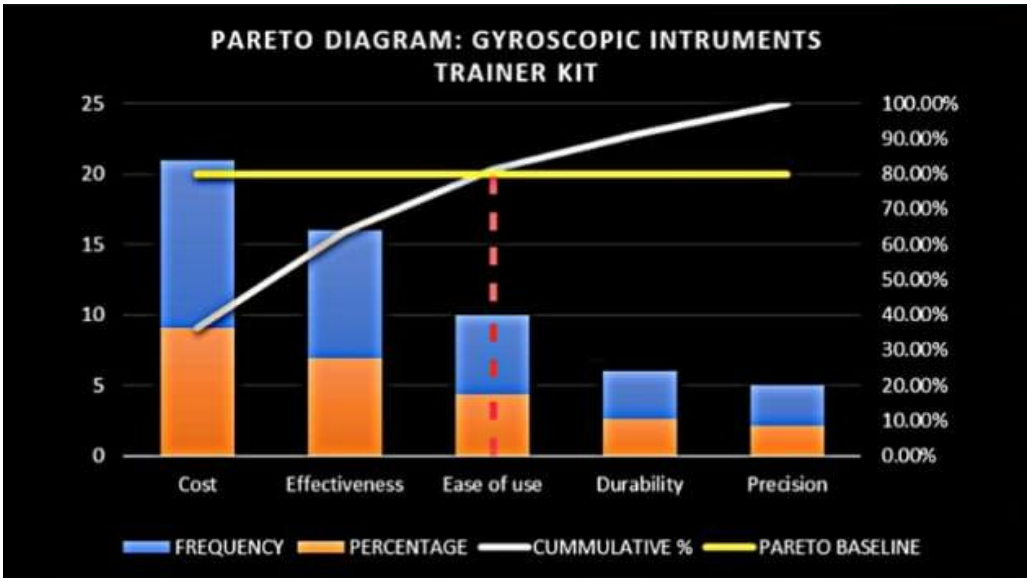


Figure 3.25 Pareto Diagram for Gyroscopic Instrument Learning Kit

Based on our research on the Pareto Diagram, the challenges that we face in Gyroscopic Instrument Learning Kit are focused on costing and followed by effectiveness in the second place.

3.4.2 DESIGN CONCEPT GENERATION

3.4.2.1 FUNCTION TREE

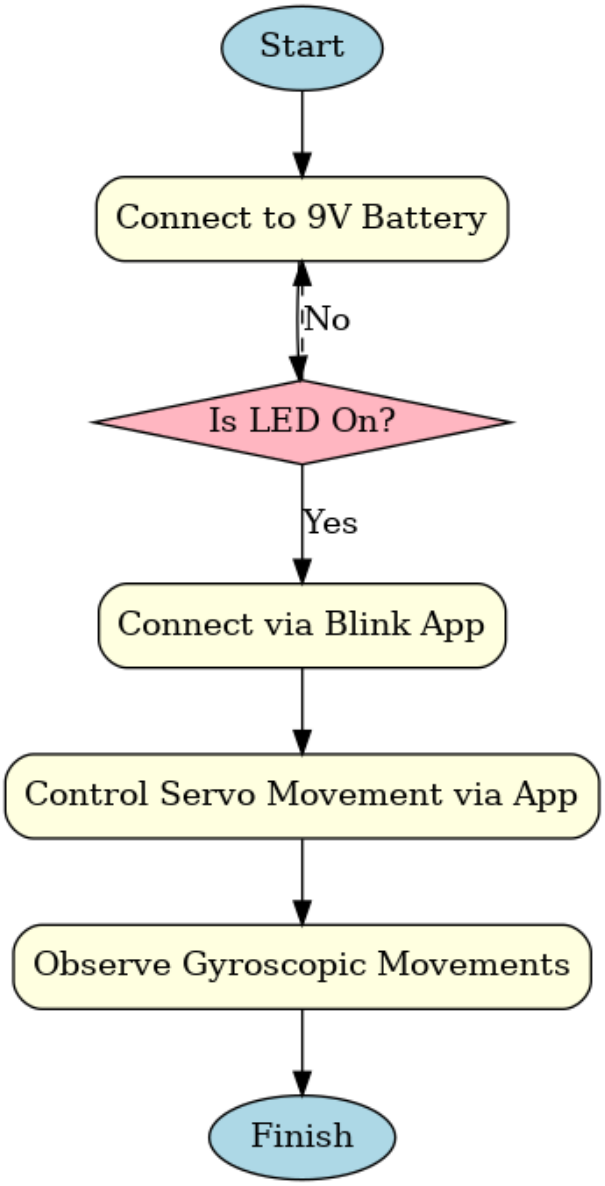


Figure 3.26: Function Tree

3.4.2.2 Morphological Matrix

Table 3.2: Morphological Matrix

FUNTION (SUB-FUNCTION)	IDEA 1	IDEA 2	IDEA 3	IDEA 4
MATERIAL (TYPE)	ARCRYLIC (PMMA)	CAST IRON	STAINLESS STEEL	MILD STEEL
DURABILITY	DURABLE	DECENT DURABILITY	VERY DURABLE	DEPEND ON SPECIFIC TYPE
COST	AFFORDABLE	AFFORDABLE AND EXPENSIVE	EXPENSIVE	AFFORDABLE
PRECISION	DEPEND ON VARIOUS TYPE	VERY DEPENDING	REFER TO THEIR INUFORMITY IN SIZE	HIGH LEVEL OF PRECISION
EFFECTIVENESS	EFFECTIVE FOR VARIOUS PURPOSE	DEPENDS ON FACTOR	HIGHLY EFFECTIVE	HIGLY EFFECTIVE
EASE OF USE	PORTABLE RISK TO REMOVE	PORTABLE AND EASY TO REMOVE	PORTABLE BUT HARD TO REMOVE	PORTABLE AND EASY TO REMOVE

The morphological matrix is a useful tool to generate design concepts in a structured way by considering all possible combinations of type of material, durability, cost, precision, effectiveness, and ease of use. The following matrix describes four specific ideas, each with specific characteristics. Idea 1: Material used is acrylic, or PMMA. It is durable, low in cost, and serves effectively for a wide range of uses. Idea 2 makes use of cast iron material, which is durable, moderately cheap, and precise depending on the circumstances. Idea 3 uses stainless steel; it is renowned for being highly durable, costly, and highly effective. Idea 4 involves the use of mild steel, a cheap material that is durable depending on its type and is highly precise. Each of those concepts has different attributes that will enable the designer to select the best option, given the needs of the project.

Considering these combinations, a morphological matrix allows designers to go through a wide array of alternatives and come up with an innovative solution in accordance with certain project goals and constraints. A structured process is enabled by this, allowing creativity and critical thinking that results in comprehensive and effective design concepts.

3.4.2.3 Proposed Design Concept 1

Table 3.3: Table of Proposed Design Concept 1

FUNCTION	CONCEPT 1	JUSTIFICATION
MATERIAL	ARCRYLIC (PMMA)	VERSATILITY
DURABILITY	DURABLE	DEPENDS OF SPECIFIC FACTORS
COST	AFFORDABLE	DURABLE DUE TO ITS RESISTANCE TO MOISTURE, WEAR AND ENVIRONMENTAL CONDITIONS
PRECISION	DEPEND ON VARIOUS FACTORS	OFFERS DECENT PRECISION, AS ITS SMOOTH, CONSISTENT SURFACE ALLOWS TO ACCURATE CUTTING AND ASSEMBLY
EFFECTIVENESS	EFFECTIVE FOR VARIOUS PURPOSE	COMBINES DURABILITY, EASE OF FABRICATION, AND A PROFESSIONAL FINISH
EASE OF USE	PORTABLE BUT RISK TO REMOVE	SMOOTH SURFACES AND COMPABILITY WIOTH STANDART TOOLS

The morphological matrix gives a structured method for generating design concepts based on the different combinations of material type, durability, cost, precision, effectiveness, and ease of use. It describes four different ideas; each one has a set of characteristics. Idea 1: acrylic, PMMA; this material provides durability, affordability, and effectiveness for a wide range of purposes. Idea 2: cast iron; the material is durable, with a cost range of middle, and with precision dependent on factors. Idea 3: This involves the use of stainless steel, which is very durable, costly, and efficient. Idea 4: This employs mild steel in its making hence proving to be affordable with durability varying in type yet very precise in work. Each of these ideas has different properties; therefore, it allows the designer to choose the best suited, depending on what outcomes the project should yield.

Considering these different combinations, the morphological matrix lets the designer explore a wide array of possibilities for identifying innovative solutions that meet specific project goals and constraints. This structured approach fosters creativity and critical thinking and helps in developing well-rounded, effective design concepts.

3.4.2.4 Proposed Design Concept 2

Table 3.4: Proposed Design Concept 2

FUNCTION	CONCEPT 2	JUSTIFICATION
MATERIAL	CAST IRON	STRENGTH
DURABILITY	DURABLE	RESILIENCE
COST	AFFORDABLE	ECONOMICAL
PRECISION	DEPEND ON VARIOUS FACTORS	STABLE
EFFECTIVENESS	EFFECTIVE FOR VARIOUS PURPOSE	DEPENDABLE
EASE OF USE	PORTABLE BUT RISK TO REMOVE	MALLEABLE

The morphological matrix systematically develops the design concepts by varying different material types based on durability, cost, precision, effectiveness, and ease of operation. This selection is going to revolve around Concept 2, whose main material will be cast iron. This justification is supported because it has strength and resistance to friction, hence is durable.

Besides, cast iron offers reasonable cost combined with reasonable accuracy, so it is of good value for money and may constitute a good choice for applications. As a material, it offers effective general-purpose applications; in addition, it is easily usable in portable appliances. Nonetheless, consider there might be removal difficulties in cast iron components, since this material is malleable and may need some specific tool or technique

3.4.2.5 Proposed Design Concept 3

Table 3.5: Proposed Design Concept 3

FUNCTION	CONCEPT 3	JUSTIFICATION
MATERIAL	STAINLESS STEEL	CORROSION-RESISTANCE
DURABILITY	DURABLE	LONGEVITY
COST	AFFORDABLE	ECONOMICAL
PRECISION	DEPEND ON VARIOUS FACTORS	ACCURACY
EFFECTIVENESS	EFFECTIVE FOR VARIOUS PURPOSE	EFFICIENCY
EASE OF USE	PORTABLE BUT RISK TO REMOVE	WORKABILITY

This morphological matrix will lead systematically to design concepts that can be generated by the various combinations of material type, durability, cost, precision, effectiveness, and ease of use. In this case, the matrix is dealing with Concept 3, for which stainless steel is the main material selected. The selection of such a material is appropriate since it offers very good resistance to corrosion, making a product last long.

Furthermore, the investment in stainless steel is a good balance between the cost and precision; hence, it is employable in many areas. It could serve a wide range of purposes and be applied to portable devices easily. At the same time, one should not forget about the possible difficulties which may arise in removing the pieces of stainless steel, probably requiring some special tools or technique.

3.4.2.6 Proposed Design Concept 4

Table 3.6: Proposed Design Concept 4

FUNCTION	CONCEPT 4	JUSTIFICATION
MATERIAL	MILD STEEL	VERSATILE
DURABILITY	DURABLE	TOUGHNESS
COST	AFFORDABLE	ECONOMICAL
PRECISION	DEPEND ON VARIOUS FACTORS	ADAPTABLE
EFFECTIVENESS	EFFECTIVE FOR VARIOUS PURPOSE	RELIABLE
EASE OF USE	PORTABLE BUT RISK TO REMOVE	WELDABLE

The morphological matrix has been utilized in the systematic exploration of design concepts. This is considered in the combination of material type, durability, cost, precision, effectiveness, and ease of use. In this matrix, consider Concept 4 with a main material of mild steel. Justification for this is the fact that mild steel is generally versatile.

Moreover, mild steel provides a good balance between cost and durability, thus making it reasonably inexpensive and strong. Being generic, it can serve in many applications and can be effectively used in mobile machinery also. However, the procedure for the extraction of the mild steel parts may give some challenges since they require welding techniques.

3.4.2.7 Accepted Vs Discarded Solution

From among these, Concept 4 was chosen after extensive research for our project. This is because mild steel, though versatile and cheap, may not serve our purposes optimally, but it would suffice for other standards in durability and weldability of some structures.

We are going to use mild steel for strength and durability, especially in the areas that must support much weight. The fact that it is weldable allows features of flexibility in design and assembly, hence being able to create intricate structures. Besides that, its cheapness will render it an economical choice within our project.

We will determine the working design of our project by choosing appropriate components and considering required conditions so that the structure made from mild steel should be strong and functional.

3.4.3 Evaluation & Selection Of Conceptual Design

3.4.3.1 Pugh Matrix

CRITERION	FACTOR	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4	CONCEPT 5
COST	0.3	3	DATUM	1	2	3
EFFECTIVENESS	0.25	2		3	3	3
EASE OF USE	0.2	2		1	2	3
DURABILITY	0.15	2		2	2	2
PRECISION	0.1	1		2	2	3
TOTAL SCORE	1.0	1.4		1.2	1.6	1.8
RANKING	-	3		4	2	1

Figure 3.27: Pugh Matrix

As for the Pugh Matrix, we make concept 2 as the DATUM because it has the best concept among others. Its criterion is mostly top notch among others. We also added Concept 5, which is we combine all the top criterion from concept 1 to concept 4 and make it the best choice in concept 5. It maybe has a weakness but the best accessibility of those 4 concepts, concept 2 is the winner. Then we found the best concept is concept 5.

3.4.3.2 Conceptual Design Of The Proposed Product

Table 3.7: Conceptual Design Of The Proposed Product

FUNCTION	CONCEPT 4	JUSTIFICATION
MATERIAL	MILD STEEL	VERSATILE
DURABILITY	DURABLE	TOUGHNESS
COST	AFFORDABLE	ECONOMICAL
PRECISION	DEPEND ON VARIOUS FACTORS	ADAPTABLE
EFFECTIVENESS	EFFECTIVE FOR VARIOUS PURPOSE	RELIABLE
EASE OF USE	PORTABLE BUT RISK TO REMOVE	WELDABLE

Based on the research of all the concepts, we chose Concept 4 as our final design for the project. This is because Concept 4 used mild steel as the main material, which is versatile and weldable, thus allowing for adaptability to various uses. Besides that, mild steel is durable and cheap, making it economical.

The design focuses on reliability and precision, and adaptability to different factors makes it effective for intended purposes. It is portable to make usage easy, but precautions shall be taken care of as there might be some risks during removal or handling. These considerations meet our objective, an affordable but realistic solution suitable for training and demonstration purposes.

3.5 PRODUCT DRAWING/SCHEMATIC DIAGRAM

3.5.1 GENERAL PRODUCT DRAWING

3.5.1.1 Orthographic & Isometric View

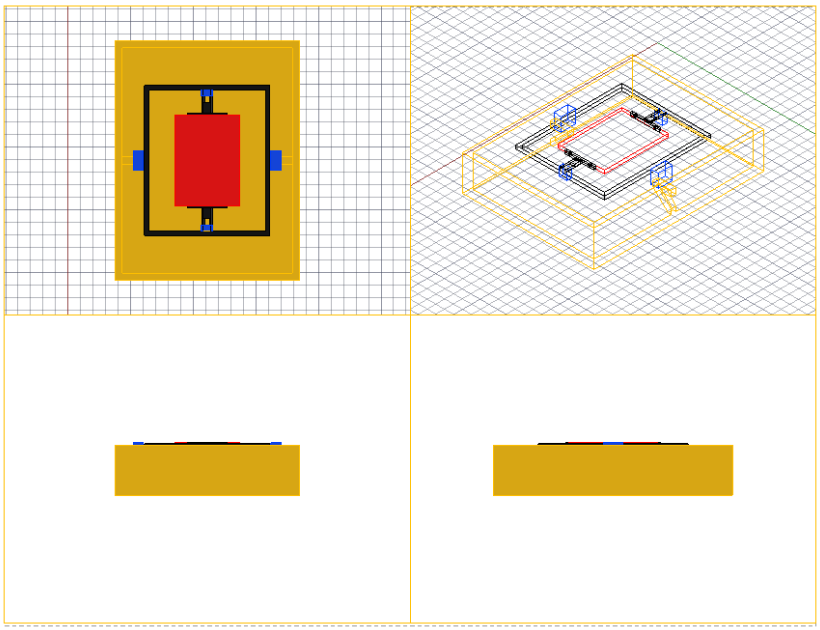


Figure 3.28: Orthographic & Isometric View

By projecting three-dimensional objects onto planes parallel to their coordinate axes, orthographic projection is a technical drawing technique used to portray objects in three dimensions. Because it gives precise, true-to-size measurements, it is essential for technical and engineering representations. Isometric projection, on the other hand, uses a two-dimensional plane to visually depict objects in three dimensions. With equal foreshortening along all three axes, usually at 120-degree angles, it creates a more realistic image. In architectural and creative contexts, isometric projection is frequently used, sacrificing exact measurements for aesthetic appeal. Both techniques have different uses; orthographic projection is more accurate, while isometric projection provides a more logical visual depiction.

3.5.2 SPECIFIC PART DRAWING/DIAGRAM

3.5.2.1 Product Structure

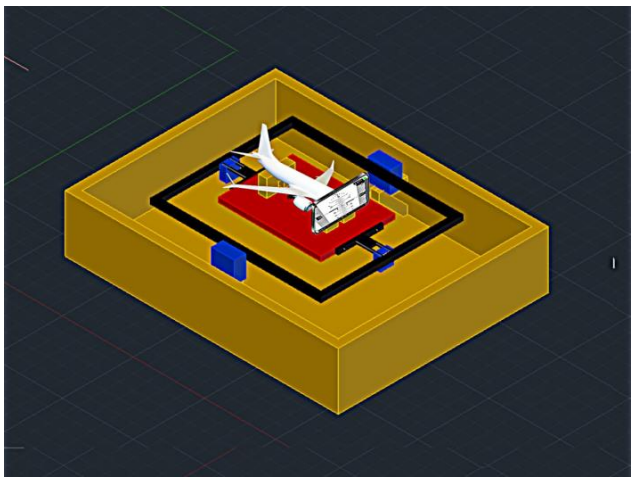


Figure 3.29: 3D Drawing of Product

Based on the product sketch, those are the features that are available in the Gyroscopic Instrument Learning Kit. This feature will help users who use the kit by understanding it easily and they can know the position and materials of the kit.

3.5.2.2. Product Mechanism

Inside the panel is a small gyroscope, which is any device that illustrates principles of rotary motions, such as precession and nutation. Behind the panel lies a servo motor, basically a small electric motor that is used for movement purposes. The servo motor will further enable the panel to move in different directions such as pitch up or down, yaw, or roll.

Above the gyroscope, there will be a clear acrylic plastic cover. This cover helps protect the gyroscope while allowing people to see the gyroscope in action, which is useful for learning. Additionally, a stick or lever acts as the controller for the servomotor. By moving it, the user is controlling how the gyroscope should move and thus can learn more about the different types of movement and how gyroscopes work.

3.5.2.3 Product software

It runs an Arduino Nano 33 BLE, which is a tiny but very powerful computer, helping it control the movement of the gyroscope. The reason this Arduino board is chosen is that it can control such movements specific to the gyroscopic instrument: roll, yaw, pitch up, and pitch down.

By using the Arduino, we make the learning process simpler and more straightforward. The Arduino is connected to a servo motor, which is responsible for the actual movement of the gyroscope in these directions. The Arduino sends instructions to the servo motor to perform these movements based on its input from the controller, such as the stick or lever.

Hence, by moving the controller, Arduino processes the input and guides the servo motor to act on moving the gyroscope. The combination of all three parts, Arduino, the servo motor, and controller make the whole system easy to operate and ideal for a beginner in learning about gyroscopes and their movements.

3.6 PROTOTYPE / PRODUCT MODELLING

3.6.1 Prototype / Product Modelling

Product modeling or prototyping is considered a significant task in product design since it assists in converting the idea into a workable version for testing and necessary improvement. The process begins by ideating on the concept and understanding the problem the product is set to solve. The next step is identifying the key features and how the product is supposed to work. Designers then make drawings or detailed 3D models using software such as AutoCAD, focusing on how the product looks and how it functions.

The first model may be just a simple one, fabricated with materials like cardboard or via a 3D printer, to be able to present the general shape and idea. The second model would have been more developed, to try out how the product functions, whether mechanical or electronic. This is further tested in practical conditions to identify any issues or areas of improvement. Once the problem is sort-out a final prototype made from similar materials and processes used in producing an actual product would be designed, ready for manufacture.

3.6.2 Prototype Development

We can create a prototype for Gyroscopic Instrument Trainer Kit using inexpensive materials such as an ice cream stick and a box. Inexpensive, it is an easy way to build a simple model, which helps in improving on our design through testing.

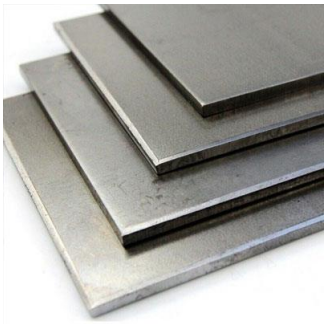
First, we use so-called ice cream sticks to make a framework. The sticks are light, firm, and easy to cut or profile. We hold them with the help of a hot glue gun to keep them together firmly and enable us to put the parts together fast, which is very convenient when making changes. It can be used as a base or container, which is usually in the form of a box and can easily be cut and modified to act as a support or enclosure for various parts of the prototype. It might hold other components or be used as the foundation for the structure of the ice cream stick. We can also add extra features, like small shelves or movable parts, using the same materials. For example, glue ice cream sticks together to make supports or hinges for it. The box can feature holes, slots, or cutouts for wires, storage, or other functions.

3.7 DEVELOPMENT OF PRODUCT

3.7.1 Material Acquisition

3.7.1.1 Base Structure of GITK

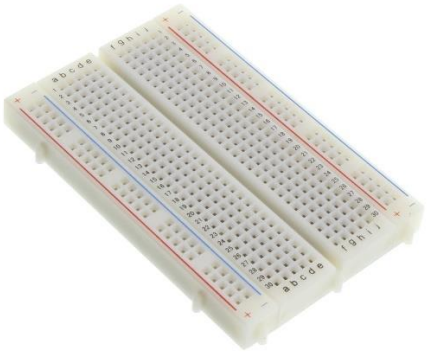
Table 3.8: List of Tools Used for Project Fabrication

Material	Description
 Mild Steel	Provides structural strength and durability for the framework or key part.
 Strawboard	Light, strong base or panel for the construction of enclosures or surfaces.
 Spray Paint	Used in finishing to enhance the product's aesthetic appearance and give it a smooth, professional look.

3.7.1.2 Electrical and Electronic Component of GITK

Table 3.9: Electrical and Instrument of the Gyroscopic Instrument Trainer Kit

Material	Description
 **Servo-motor MG-995**	Provides precise control of angular or linear motion, useful for moving or rotating components in the prototype.
 **ESP 32 Uno**	Serves as a microcontroller for controlling and managing the electronic components, with built-in Wi-Fi and Bluetooth for connectivity.
 **9v Battery**	Powers the electronic components and ensures the prototype operates independently of an external power source.

 9v Battery Connector	It connects the 9V battery to the circuit and provides a safe and stable power connection to components.
 Breadboard	This serves as the building platform for constructing and testing the electronic circuit without permanent soldering
 Wire Jumper	Connect different components on the breadboard, enabling electrical connections without soldering.

3.7.2 Machine and Tools

Table 3.10: List of Machine and Tools

No.	Type of Machine	Machine Description & Usage
1.	 **Hand Grinder**	**General Purpose:** Used for cutting, grinding, and polishing steel, wooden material, and other material**.** **Project Purpose:** 1.Used for grinding mild steel 2.Used to sand the welded effect
2.	 **MIG Welding Machine**	**General Purpose:** Used for welding metals together using a continuous wire feed. **Project Purpose:** 1. Joins mild steel securely to make the frame or structure
3.	 **Polish Machine**	**General Purpose:** Used for polishing surfaces to a smooth, shiny finish, often used on metals **Project Purpose:** 1. Polishes the mild steel structure to achieve a smooth and professional finish for the main base**.**

No.	Types of Hand Tool	Description
1.	 **Vice Bench**	**General purpose:** It used to secure an object to allow work to be performed on it during saw, drilling, filing and another task **Project Purpose:** Used to grip the mild steel when cutting, grinding, and polishing.
2.	 **File**	**General purpose:** The tool used to remove surplus fine amounts of material from a workpiece. **Project Purpose:** To file the excess welded effect to become flat surface
3.	 **Vernier Caliper**	**General purpose:** The instrument used to measure internal and external distances such as diameter and length of the object**.** **Project Purpose:** It is used to measure the length of respective measurement

4.	 **Steel L-Ruler**	**General purpose:** The tool suitable for carpenter's use. It used for measurement, especially for right-angles. **Project Purpose:** Used to mark vertical line.
5.	 **Steel Ruler**	**General purpose:** The instrument to measure distances or to rule straight line especially in geometry, technical drawing, printing, engineering, and building. **Project Purpose:** Used for measured length and make a horizontal line
6.	 **Allen Keys**	**General purpose:** Used for tightening or loosening screws and bolts with hexagonal sockets. **Project Purpose:** Secures and loosen small hexagonal screws or bolts at the hand grinder lock.

3.7.3 Specific Project Fabrication

3.7.3.1 Phase 1 (Base Structure)

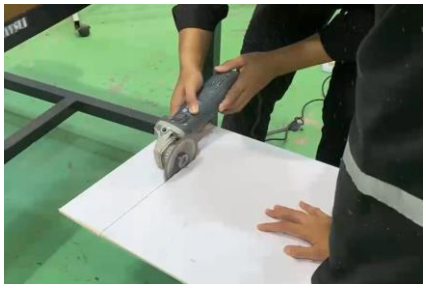
Table 3.11: Working Procedure for Base Structure

No.	Illustration	Working Procedure
1.		**Material Acquisition:** The mild steel is received from Shopee
2.		The steel was cut according to the measurements.
3.		The steel segregated into respective measurements

4.		The mild steel was welded to form the base structure
5.		By using arc welding machine in the Composite Workshop, the steel used to form the base has been welded
6.		The welding effects on the structure was grinded by using hand grinder.
7.		The base construction was completed.

3.7.3.2 Phase 2 (Accessories & Mechanisms)

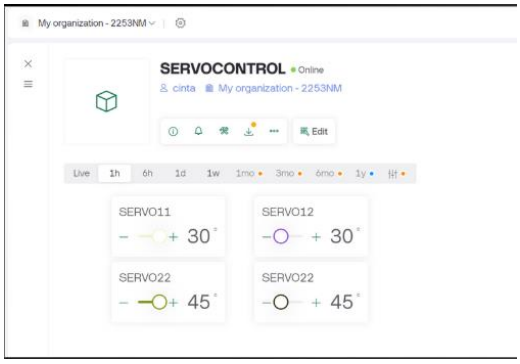
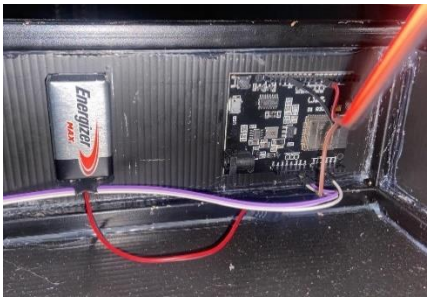
Table 3.12: Working Procedure for Outer Base Structure

No.	Illustration	Working Procedure
1.		The size of the structure has been measured again to get the actual size for the structure's frame
2.		The one-sided PVC has been cutted to the exact measurement.
3.		The base structure has been painted before next process.
4.		Using adhesive sealant, the base structure and the frame of one-sided PVC attached together.

3.7.3.3 Phase 3 (Programming & Electrical Circuit)

Table 3.13: Working Procedure for Electrical Part

No.	Illustration	Working Procedure
1.		Connected all electrical/electronic component refer to the circuit diagram
2.		Esp 32 board has been connected to the laptop
3.		Programming code has been uploaded to the Esp 32 board

4.		The coding from the laptop linked to the Blink apps on the phone
5.		The servo movement for pitch has been tested
6.		The servo movement for roll has been tested
7.		All component has been assembled to the main structure

3.7.3.4 Phase 4 (Finishing)

Table 3.14: Working Procedure for Finishing of Product

No.	Illustration	Working Procedure
1.		The main base structure painted using spray paint for smooth finishing
2.		After painted, the structure rubbed with the sand paper for any excess paint.
3.		All components have been installed into product although there has a small change for the main structure's color.

3.8 PRODUCT TESTING / FUNCTIONALITY TESTS

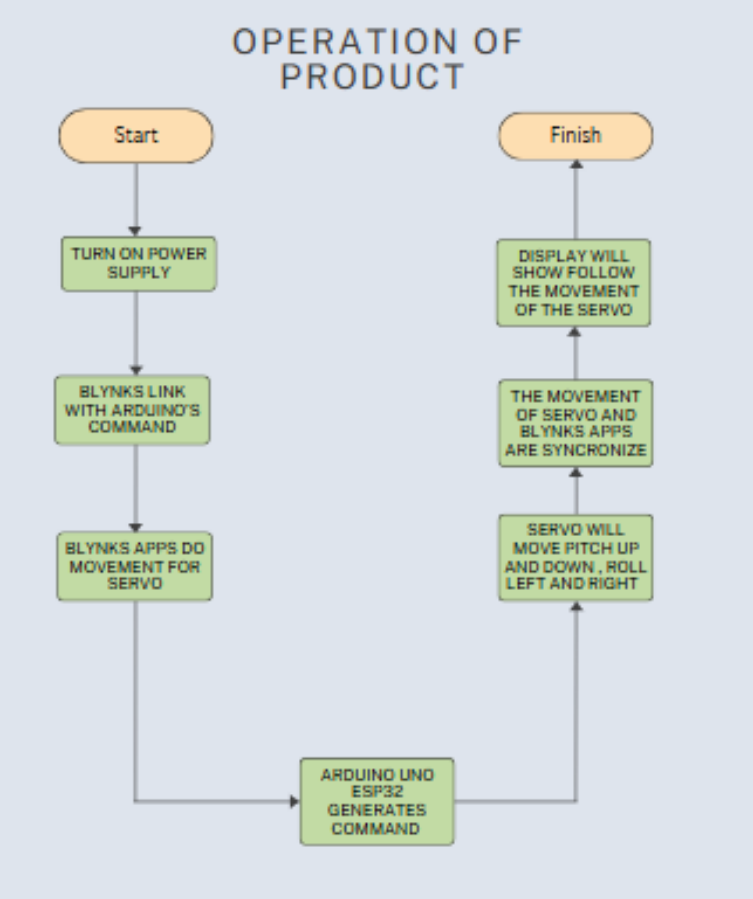


Figure 3.30: Functionality of Product

3.9 LIST OF MATERIALS & EXPENDITURES

3.9.1 Product Structure				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	**One – Sided Pvc Plywood**	**2**	**RM14**	**RM28**
2.	**Mild Steel**	**6**	**RM20**	**RM120**
3.9.2 Mechanical Mechanism				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	**Servomotor MG90S**	**2**	**RM 15**	**RM30**
2.	**Servomotor MG966R**	**2**	**RM 20**	**RM 40**
3.9.3 Electrical Mechanism				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	**Arduino Uno ESP32**	**1**	**RM 30**	**RM 30**
2.	**Battery 9V**	**1**	**RM 13.20**	**RM 13.20**
3.	**Arduino Wire**	**4**	**RM 3.20**	**RM12.80**
4.	**Battery Socket**	**1**	**RM 2.40**	**RM 2.40**
GRAND TOTAL				**RM 276.40**

Table 3.15: List Of Material and Expenditures

CHAPTER 4

RESULT & DISCUSSION

4.1 PRODUCT DESCRIPTION

The Gyroscopic Training Kit is an innovative teaching aid designed to simulate the practical effectiveness of gyroscopic rebellious present in the cockpit of more mature flying machines with basic essential flight displays, too referred to as the "six-pack" instruments. These rebellious provide fundamental information regarding an aircraft's heading, altitude, and airspeed during flight. The six-pack is divided into gyroscopic and pitot-static flight instruments. The gyroscopic instruments include the attitude indicator, turn coordinator, and heading indicator while the pitot-static disobedient include the altimeter, airspeed indicator, and vertical speed indicator. This training unit is designed to be a simple, flexible, and accurate system, suitable for teaching and demonstrating the operation of gyroscopic disobedient. Its easy-to-use design ensures user-friendliness, even by personnel with minimal technical knowledge. The movability of the kit allows it to easily be transported to classrooms, demonstration sessions, or exhibitions, thanks to its lightweight and ergonomic design. The Gyroscopic Training Unit reliably simulates the operational aspects of actual gyroscopic defiance encountered in cockpits. It is an Arduino-based system that controls the spinner for viewings of precise readings, just like in real life. The discuss channel and outlet setups within the kit are outlined fastidiously to imitate those utilized in real airplane frameworks and guarantee a reasonable preparing involvement.

4.1.2 Specific Part Features

4.1.2.1 Product Structure

The Gyroscopic Instrument Trainer Kit is carefully designed in such a way that it is sturdy and useful, yet easy to handle, hence an ideal teaching and training tool. Designed compactly with lightweight, it is easy to carry, whether usage is in the classroom, lab, or moved to some other location. The setup of the kit is very quick and very easy; therefore, there's no need to spend a great deal of time over thinking about how to use it. This will save them much trouble from assembly, allowing them to spend more time learning and practicing. It is simple to set up the kit without using any special tools or technical skills; thus, it can be used by anybody.

A strong and sturdy base holds in place important parts, such as servos and displays. This will keep the kit steady while in use, even when it gets bumped or moved a little. The stability is important to assure smooth and reliable demonstrations that help users learn without interruptions. It is a highly flexible kit design, apt for several uses in classrooms, laboratories, and workshops. The modular structure means additional parts or upgrades can be added with ease, thus allowing the kit to adapt to new teaching requirements in the future.

This Gyroscopic Instrument Trainer Kit is quite portable, durable, and easy to use, making the kit quite suitable for practical learning. This equipment will help students correlate what they have learned theoretically with real-life practice, thus serving as an important tool for learning engineering and related courses.

Figure 4.1: Gyroscopic Instrument Trainer Kit

4.1.2.2 Mechanical Mechanism

The trainer kit has a very solid structure between mechanical and electronic parts to make everything run in harmony for the sake of realistic learning. The servo motors will be controlled through the Arduino Uno ESP32, responsible for simulating the main movements that an aircraft may have, such as pitching up, pitching down, rolling left, and rolling right. Movement will be smooth and as precise as possible, just like real gyroscopic instruments behave in actual flight. The servos are meticulously placed in the kit to resemble how gyroscopic instruments are mounted in actual airplanes. In this setup, users will see precisely how such instruments respond when the plane alters its movement-for instance, when it tilts or turns. Having these movements with their own eyes allows learners to gain a much better understanding of how gyroscopic instruments work, as well as the way they assist pilots in keeping control of an aircraft.

A proper blend of the well-placed mechanical parts, combined with accurate electronic control, ensures that the trainer kit is a consistent and reliable kit for learning purposes. Users can trust that the kit will perform correctly without unexpected errors or breakdowns, so they can focus on learning the principles of flight. In such a setup, learners get to interact directly with the system and see for themselves how gyroscopic instruments respond to changes in pitch and roll. With this training kit, it is possible for learners to understand how various movements affect the aircraft's gyroscopic instruments. It is uncomplicated but ingenious in bridging the gaps between what is learnt in theory and how it works during actual flight. Other than using complex simulators, this kit offers a more practical way in which one can understand flight dynamics by seeing and interacting with the equipment directly.

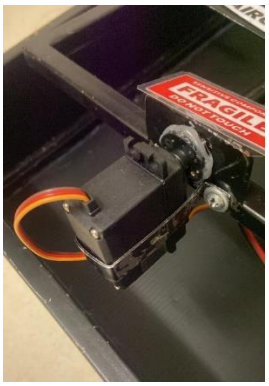


Figure 4.2: Moving Mechanism

4.1.2.3 Software/Programming

The software, which has been specially built on the Arduino Uno ESP32 board for this purpose, guarantees full and smooth integration with the Blynk app to provide users with an easy and comprehensible way of commanding the system. The app provides a simple interface on the smartphone, where taps will suffice to easily command the servo movements. This setup makes controlling the system incredibly easy, even for those without any deep familiarity with advanced programming or technical setups.

One of the great features of the software is that it uses Wi-Fi in such a way that the system can easily be controlled wirelessly. This will eliminate the need for users to be physically connected with the system through wires, thus giving them more freedom and convenience to operate the trainer from a distance. Whether in a classroom setting or at home, users can interact with the trainer kit from anywhere within the Wi-Fi range, making it a flexible tool for learning and practice.

The design of the software prioritizes ease of use. The interface is simple to navigate, with clearly labeled controls that make it easy for users to trigger specific servo movements. Each action provided through this application is directly associated with an exact servo movement, thus permitting users to realize visually how these movements are used to simulate the behavior of gyroscopic instruments in real flight. This clear connection between the user's input and the system's response helps build a deeper understanding of how the gyroscopic instruments function and how they affect flight.

In addition, software is optimized to handle real-time responses. It is coded to reduce any lag or delay between the user pressing a button on the app and the movement of the servo, hence making sure the system responds promptly and precisely to commands from the user. The real-time performance is critical in simulating exactly how gyroscopic instruments would behave during the real flight and making the training experience more realistic and effective.

The software will make the trainer kit convenient to use, fluid, and fast. The system, because of the wireless control, intuitive interface, and real-time performance, provides an integrated learning experience that facilitates a greater understanding of how gyroscopic instruments function.

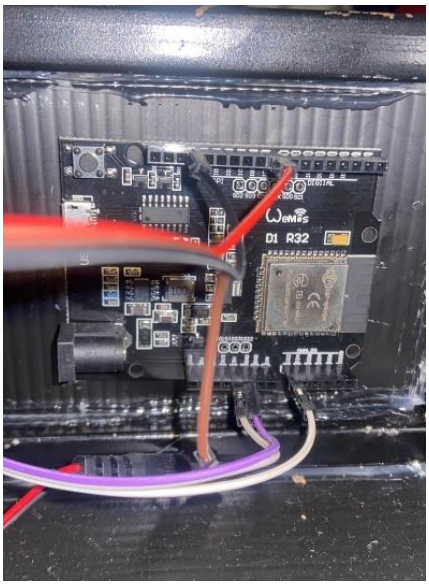


Figure 4.3: Electronic Circuit

4.1.2.4 Accessories and finishing

All the accessories and the finishing touches of the trainer kit have been meticulously thought out for ease of use, durability, and good looks. Every element of the design has been thought out so that the system will work with ease while it looks good.

The power supply in the trainer kit is a 9V battery, so therefore it does not need to be plugged into a wall. This will make the kit more portable, and any user can carry it with them and use it anywhere-for instance, in the classroom, home, or outside. One need not bother about searching for an electrical outlet to plug into or to worry about wires. This also makes the setting up of the kit a lot easier since one will not need to connect this to any power source, thus much faster and handier to get started.

Inside the kit, the electronics are kept within a protective housing. This casing protects the sensitive parts from getting damaged and helps to ensure everything remains neat and tidy. The materials used for housing are strong enough to protect the components, but light enough to keep the kit easy to carry. The case appears neat and tidy; there are no wires hanging out, which gives a polished, organized look to the kit.

The general design is quite user-friendly. Each component of the kit has its function labeled on it, thus making it easier for users to understand immediately what each part does. This makes using the kit quite easy, even for any amateur that may never have worked with any such system. The layout is quite ergonomic-the components are arranged in such a way that they are easy to handle. Use of the kit is comfortable for any extended period; hence, users can focus on learning, sans discomfort.

The Blynk application, used to control the trainer kit, is also developed with simplicity in mind. It has a clean and easy-to-understand layout, therefore, making users platform a piece of cake when it comes to handling the system. Even those with less technical knowledge can conveniently operate the app without difficulties. Further, controls are well-labeled, and the application is structured in a way that will help users send commands across the system quickly. This helps users stay focused on learning how gyroscopic instruments work, rather than struggling with complicated technology.

The app works smoothly with the trainer kit, ensuring that commands are sent and responded to in real time. This means that when users press a button in the app, the system reacts quickly, helping them understand the link between their actions and the movement of the gyroscopic instruments.

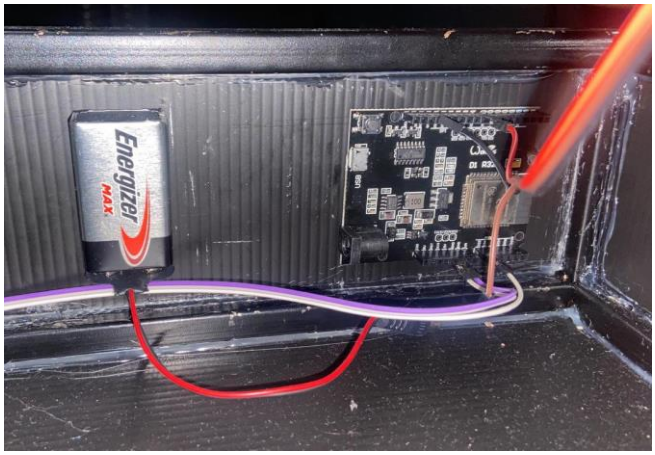


Figure 4.4: Power Supply

4.1.3 General Operation of the Product

This Gyroscopic Instrument Trainer Kit provides hands-on learning for its users, simulating how gyroscopic instruments work on older aircraft, mostly those using analog PFDs. It is rather an easy-to-use and portable training kit, ideal to learn the functions and operation of gyroscopic instruments. It allows users to see and understand how these instruments will behave in real life through interactive practice.

At the heart of the training kit lies an Arduino Uno and an ESP32 microcontroller. The Arduino Uno processes data from sensors and drives the servo motors, which simulate the motion of gyroscopic instruments. This helps in demonstrating how such instruments would respond to the movement of an aircraft, like banking or a turn.

The ESP32 microcontroller connects a smartphone application, Blynk, with built-in Wi-Fi capability. Users can thus easily operate this trainer kit in real time using their smartphones. The Blynk application provides a simple interface that allows users to communicate with the trainer kit to send commands for the operation of servo motors and view changes on gyroscopic instruments. The system is wireless since it uses Wi-Fi, which offers flexibility and therefore makes it easy to use the kit from a distance.

To summarize, this trainer kit works on the principle of combining the power of Arduino Uno to control hardware with ESP32 to connect through a smartphone app called Blynk. This, in turn, provides real-time control over the gyroscopic instruments**.**

4.1.4 Operation of the specific part of the product

4.1.4.1 Product Structure

Powering the System

The trainer kit gets its power from a 9V battery, which provides enough energy to run all the key parts of the system, including the Arduino Uno, the ESP32, the servo motors, and any other components that are connected. The 9V battery is a practical choice because it makes the system portable, allowing users to move the kit around without needing to be plugged into a wall outlet.

Once the system is powered on by connecting the battery, it goes through an initialization process. During this startup, the system checks all its components to ensure they are working properly. One of the first things that happens is that the spinner, which is part of the gyroscopic instrument, is calibrated. Calibration is the process of adjusting the system to establish a "starting point" or reference for the movements. This ensures that the servo motors will move accurately and reliably, allowing the system to display correct readings and simulate gyroscopic behaviour as expected.

In simple terms, when the system is powered on, it gets everything ready so that the user can begin controlling the kit and observe the precise movements of the gyroscopic instruments. The 9V battery makes sure the entire system has the energy it needs to work properly, while the calibration step ensures that the instrument functions correctly from the beginning. The structure also portable and can use anywhere and anytime. Its reasonable for educational purpose.

4.1.4.2 Product Mechnism

User Interface and Control

The main way users interact with the trainer kit is through the Blynk app on their smartphone. This app connects to the ESP32 module in the kit using Wi-Fi, which allows users to control the movements of the gyroscopic instruments and see the results in real-time.

Think of the app as a virtual cockpit display on your phone. It shows live data from the gyroscopic instruments, just like how a pilot would see the flight instruments in an actual

airplane. Through the app, users can send commands to control the system and watch the gyroscopic instruments respond immediately.

In simple terms, the Blynk app is like the "control panel" for the trainer kit, allowing users to easily manage and monitor the gyroscopic instruments while they learn about how they work.

The app makes it easy to see how the instruments behave based on different movements, providing a clear, hands-on way to understand their function.

4.1.4.3 Product Software

Simulating Gyroscopic Instruments

The training kit simulates three fundamental gyroscopic instruments:

1. Attitude Indicator:

Shows the aircraft's introduction relative to the horizon. The gyroscope identifies pitch (up and down) and roll (left and right) developments, which are reflected on the virtual display.

2. Turn Indicator:

Appears the rate of turn and makes a difference keep up coordinated flight. The gyroscope senses rotational developments around the vertical axis.

3. Heading Indicator:

Shows the aircraft's heading course. The gyroscope tracks changes in heading, giving precise directional information.

Controlling Movements

Movements such as pitch up, pitch down, roll left, and roll right are commanded through the Blynk app. The app sends signals to the ESP32 module, which at that point communicates these commands to the Arduino Uno. The Arduino Uno translates these signals and drives the comparing servo engines to execute the required movements.

Real-Time Display

The Arduino Uno processes information from the gyroscope and translates it into clear outputs. These outputs are sent back to the Blynk app, where they are displayed in real-time. This setup permits users to watch the prompt impacts of their control inputs on the virtual gyroscopic rebellious, upgrading their understanding of how these instruments react to distinctive flight conditions.

4.1.4.4 Accessories / Finishing

Portability and Ease of Use

Designed for ease of transport and setup, the Gyroscopic Instrument Trainer Kit is lightweight and ergonomically built. It can be effortlessly carried to classrooms, preparing centers, or show zones. Its clear plan guarantees that clients can rapidly get it and work the framework without broad preparing.

4.2 PRODUCT OUTPUT ANALYSIS

Table 4.1: Product Output Analysis

No.	Parameter	Result	Remarks/Description	Analysis
1.	Portability	Highly portable	Lightweight and compact design, easy to transport and set up.	Ensures ease of use in various educational settings, increasing accessibility and practicality.
2.	Servo Movement Accuracy	High precision	Smooth and accurate servo movements for pitch up, pitch down, rolling left, and rolling right	Provides realistic simulation of gyroscopic instruments, enhancing the learning experience.
3.	Power Supply	Reliable	Uses a 9V battery, providing a stable power source without the need for external connections.	Ensures the kit is self-contained and easy to use in different locations without dependency on external power sources.
4.	Control Interface	User-friendly	Controlled via Blynk app on smartphones, with intuitive interface.	Simplifies operation, making the kit accessible even for users with minimal technical background.

5.	Wi-Fi Connectivity	Stable connection	ESP32 module provides robust Wi-Fi connectivity for seamless operation.	Enables wireless control, adding convenience and flexibility to the training process.
6.	Mechanical Stability	Stable during operation	Solid base and secure housing for electronics ensure stability and durability.	Prevents disruptions during demonstrations, providing a consistent and reliable learning tool.
7.	Assembly and Maintenance	Easy to assemble and maintain	Simple design allows for quick setup and easy maintenance.	Reduces downtime and ensures the kit can be readily used for educational purposes with minimal hassle.

4.3 ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTION

4.3.1 Product Structure

Problems Encountered

When the trainer kit was first designed, there were a couple of key issues that needed to be addressed. One problem was with the structural integrity, or how strong and durable the kit was. The original design had trouble standing up to repeated use and transportation, especially if the kit was moved around frequently. This meant that parts of the kit could become damaged or loose over time.

Another issue was weight distribution. The kit has several components, like the battery and servo motors, that are heavy. In the initial design, it was difficult to balance the weight of these parts. If the weight was not spread out evenly, it led to instability during operation, making the kit harder to use and potentially affecting the accuracy of the movements.

Solutions:

To rectify these issues, a few enhancements were made. First, the quality of materials in the trainer kit was improved. From using rather weak materials, the design shifted to utilizing stronger and more resilient materials, such as high-quality plastics and lightweight metals. These enabled the structure to be much more solid and able to resist regular use without being damaged.

Further refinement was done in the design of the trainer kit: weight from components, such as batteries and servos, had been redistributed so that an even weight distribution is ensured; thus, further enhancement of the stability of the kit when operating is observed. The components were mounted well to prevent shifting and loosening, leading to overall stability and making the kit easier and more reliable to use.

4.3.2 Mechanical Mechanism

Problems Encountered:

One of the major issues that were initially experienced with the trainer kit was to do with servo calibration. The servo motors controlling the movements of the gyroscopic instruments did not support calibration in the initial stages. The servos, therefore, did not always move appropriately or consistently, causing inaccuracies in the display and performance of the system.

Another problem occurred at the component alignment stage. While assembling, not all mechanical parts were perfectly aligned, thus causing friction between moving parts. This friction made the system harder to operate with a lot of ease and affected the performance of the trainer kit.

Solutions:

To solve these problems, several improvements were made. First, the introduction of more precise calibration was affected concerning the servo motors. It involved carefully readjusting the motors so that they moved with accuracy each time consistently, solving the problem of imprecise movements.

The alignment tools and jigs that were employed in assembling it did not end. These tools aligned all the mechanical parts correctly such that friction reduced and the components moved with ease. The proper alignment of the parts made the system work almost four times more efficiently.

Finally, to increase the lifespan and performance of the kit, stronger parts were used and lubrication applied where friction occurred; this limited the wear and tear of the moving parts, maintaining the trainer kit in good condition for a longer period of operating.

4.3.3 Electrical Mechanism

Problems Encountered:

First, there were the power supply problems of the trainer kit-its 9-volt battery power sometimes did not provide consistent power. The consequence of this was that the system would simply stop working or show behavior that became unpredictable, meaning that during operation, it would get interrupted. Without a stable power supply, the kit simply would not function as expected, which frustrated users.

Another problem, though, was with the connection stability. Some electrical connections inside the kit were just not secure, be those due to wires or due to connectors. A loose contact or intermittent contact could also make the system lose power or stop responding and thus give reliability problems in the overall performance of the kit.

There was also the issue of electromagnetic interference. Other electrical components interfere with the interference of the Arduino and ESP32 modules, which are the heart of the system. This interference could cause malfunctioning or erratic behavior by these modules, which affects performance.

Solutions:

Some important changes were made to try to resolve these problems. First, to address the power supply issues, a voltage regulator was added to ensure a steady and reliable power source. The voltage regulator provided consistent power and averted disruption to the operation of the system. In addition, rechargeable batteries were used instead of single-use ones. This not only aided in the improvement of reliability but also granted environmental friendliness and cost-effectiveness over time for the kit.

To solve the problems in connection stability, soldered connections were installed instead of using loose wires. Soldering secures the connection and it will not loosen so easily. High-quality connectors had also been used to avoid any instance of intermittent contacts, which further improved the reliability of the electrical circuitries.

Shielding material was added around sensitive components, such as the Arduino and ESP32, to reduce the effects of electromagnetic interference. This helped in protecting these modules from interference, hence their proper functioning without erratic behavior.

4.3.4 Software Mechanism

The main problems the software of this trainer's kit was facing at first were the following: code instability, whereby early versions had bugs that made the system crash or perform in an inconsistent manner. Such bugs disrupted the smooth running of the kit and therefore became unreliable to the users.

Another problem arose with Wi-Fi connectivity. The ESP32 module connects the kit to the Blynk application and sometimes had trouble staying connected due to a constantly unstable Wi-Fi connection, especially in networks with heavy traffic when the Wi-Fi signal can be weak or unreliable. A non-steady connection simply means that the user could not control the kit properly, which caused frustration.

Another problem was with the user interface of the Blynk app itself. The app was not very intuitive, so it was difficult for users to fathom how the kit was to be controlled. A complicated interface added confusion, especially for those not familiar with the technology or app.

Solutions:

Several improvements were affected to fix these problems. Firstly, the stability of code improved a lot by doing much debugging and testing. The bugs were carefully checked by the development team in the reviewed software to ensure a system that ran smoothly. They also included error-handling mechanisms in the code to let the kit recover from small issues, instead of bringing down the complete kit.

Now, for the Wi-Fi connectivity issue, Wi-Fi settings were optimized. The settings were changed by the team so that the connection would be more stable and even included reconnection logics in the system. This simply means that every time the Wi-Fi connection dropped, the system tried to reconnect automatically to keep the user in continuous control.

Finally, to enhance the user interface, the Blynk application underwent a redesign to enable intuitive and easy usage. Controls were reduced, and the layout was made clearer for ease of comprehension by users on the operation of the kit. This design made the app much easier to navigate, even for those with little technical experience.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 General Achievements of the Project

The project for the Gyroscopic Instrument Trainer Kit has therefore achieved the primary objective of providing a comprehensive and effective learning tool for both aviation students and enthusiasts. It emulates the behavior of gyroscopic flight instruments correctly; thus, it gives users a real experience of how such instruments would operate in an actual aircraft. The achievement of importance here was the successful integration of Arduino Uno and ESP32 microcontrollers, working in concert to drive the servo motors that emulate the critical motions of pitch, roll, and yaw. These motions are essential in understanding how gyroscopic instruments respond to changes in aircraft position and orientation.

The project also utilized the Blynk application, which provides an easy and intuitive interface with which users can operate the trainer kit and monitor instrument readings directly from a smartphone. This approach not only simplifies the user's experience but also makes it more convenient because it enables wireless control. The Blynk app makes it easy for users to interact with the kit in real-time, providing immediate feedback as they manipulate the instrument's behavior.

Another major accomplishment is the design of a kit with easy portability and simplicity in use. The trainer kit is suitable for a wide array of applications that range from classroom demonstrations, individual study, to flight training environments. It is compact and light enough to be easily taken from one place to another and used literally anywhere, without cumbersome assemblies or intricate equipment.

Besides these several direct, practical benefits, the project has brought out the need to preserve traditional gyroscopic instrument knowledge that was once common in aircraft. As modern

digital displays become more prevalent, these older instruments are becoming increasingly rare; still, they are part of aviation history and training. The gyroscopic instruments original fundamentals are taught with digital tools to bridge the gap between analog systems and the modern hardware. It will ensure that students and enthusiasts alike can continue learning these systems while the technologies become rarer in aircraft of today.

Overall, the Gyroscopic Instrument Trainer Kit has provided an innovative and effective way for the people to learn about gyroscopic instruments but also a way to keep the legacies of older aviation systems alive with the use of technology.

5.1.2 Specific Achievement of Project Objectives

5.1.2.1 Product Structure

The structural aims of a gyroscopic instrument trainer kit have been successfully met by designing it as a compact, light, and portable learning tool. This would mean that the kit is sufficiently small to be carried and not space-consuming, thus ideal for various learning settings, such as classrooms or training centers. With its design, setting up and using this kit is fast and efficient; hence, one need not worry about complicated setups or handling big equipment.

It is also constructed to be tough and durable, assuring that the kit would withstand multiple uses without breaking or being damaged. The kit underwent rigorous testing to ensure that it could hold up in real-world conditions. This testing revealed that the kit is indeed not only tough and long-lasting but also suitable for daily use in educational settings.

5.1.2.2 Product Mechanism

The trainer kit has succeeded in mechanically replicating the movements of gyroscopic flight instruments with an excellent level of accuracy, while using servo motors controlled by the Arduino Uno and ESP32 microcontrollers to generate the key movement responses for pitch, roll, and yaw. These are exactly the movements that in-aircraft real gyroscopic instruments can respond to.

These servos were designed to be very responsive and accurate, which means they can move smoothly and precisely to emulate the exact behavior of gyroscopic instruments just like in real-life aircraft. This accuracy will help users see how these instruments would behave in different flight conditions and give them a realistic and interactive way of learning.

The mechanism of the kit is designed to give one a feel for how gyroscopic flight instruments work and to observe the changes in real time as one simulates various aircraft movements. This allows the learning process to be a little more interactive and realistic regarding flight dynamics.

5.1.2.3 Software/Programming

The software part of the project is quite a success. The project connects to the Blynk application using the ESP32 module's Wi-Fi capability, thus allowing users to control the gyroscopic movements and view the instrument readings directly on their smartphones. This makes the system very powerful and user-friendly, as users will be able to control and monitor the kit even from a distance.

The integration between hardware (such as servos and sensors) and software runs well, without glitches, to make everything run smoothly. Software ensures seamless communication between the microcontrollers (Arduino Uno and ESP32) and the Blynk app in sending information back and forth. This allows for real-time feedback to users who can make instant adjustments, similar to operating real flight instruments.

In other words, it is the software that ties everything together, ensuring the user can easily interact with the kit through their phone and the system responds to their commands with accuracy and speed**.**

5.1.2.4 Accessories and Finishing

Also, the final touches and accessories of the gyroscopic instrument trainer kit met the goals of the project. The inclusion of important accessories, such as a 9V battery for its power, ensures that this kit works without the use of any external sources of power, making it highly portable and easy to operate anywhere. Every detail in assembling the kit was done carefully to ensure that all parts fitted perfectly well, and their functions were good.

The result is a well-finished product ready to use, with all the components working in harmony. The kit has been designed not only to be an educational experience but also as user-friendly and enjoyable. Every part has been meticulously thought through in making the trainer kit effective in helping the users learn about gyroscopic instruments while being simple and nice to operate.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The Gyroscopic Instrument Trainer Kit is an important part of aviation training because it gives hands-on and easy access to the basics of flight instrument learning. Its capability for the realistic simulation of gyroscopic movements helps students and other enthusiasts fully understand the operation of these crucial instruments. Gyroscopic instruments are crucial for aircraft navigation and control, and this trainer kit offers a hands-on way to learn about them, making complex concepts easier to grasp.

The kit is easily portable and designed in such a way that it is quite easy to use for educational purposes, whether at school, flight schools, or simply personal study. The flexibility increases the learning experience by allowing users to engage in a manner that is convenient while effective.

One of the primaries influences the project has been to bridge older analog flight instrument knowledge with more modern digital technologies. Modern aircraft increasingly utilize digital displays, but this trainer kit also retains knowledge of the older analog systems, making sure that important concepts are not lost. It makes the learning process also more inclusive and open to an even wider audience. Sometimes, this means one is bound by previous technology or aircraft.

Moreover, the project is unique because it realizes an innovative solution by integrating hardware and software elements in such a way as to enhance the process of teaching and learning themselves. Such treatment of technology allows us to get an idea of what future educational tools might look like where advanced technologies will be utilized to create truly effective and interactive modes of learning. It teaches users not only about gyroscopic instruments but also how modern technology can be used to enhance education in aviation and other areas.

In summary, this gyroscopic instrument trainer kit assists in simplifying difficult-to-understand concepts related to aviation, provides hands-on experience, and helps bridge the gap between traditional and modern flight technology. Its integration of hardware, software, and portability will make it very valuable in the disciplines of aviation education.

5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

5.3.1 Product Structure

Although the present configuration of the gyroscopic instrument trainer kit is strong, easy to carry, and transport, some modifications could further enhance the product. One future improvement to consider would be to make it more modular; in other words, being able to interchange parts or upgrade them. This is to say that the mounting frame or the display housing can be designed to be changeable or upgradable independently according to users' needs. Flexibility like this would make the kit more adaptable to different learning environments or allow users to customize the kit to their preferences.

Again, applying more developed materials could make this trainer kit even lighter, but with no less strength or durability. In this respect, it would be even easier to carry and handle the kit for users who must transport it every now and then. The objective would be to keep the kit strong and practical for long-term use while making it even more user-friendly and portable.

5.3.2 Product Mechanism

The mechanical design of the gyroscopic instrument trainer kit can be extended with further improvements for better accuracy in work. Upgrades that can be done include additional degrees of movement-pitch and yaw. These extra movements would enable the kit to more closely simulate the behavior of real gyroscopic instruments, which may result in additional complex movements during real flight conditions.

Besides, enhancing the accuracy of servo movements would make such a simulation even more realistic. This can be achieved by using higher-quality servo motors or advanced actuators that can provide smoother and more accurate movements. These would give users a more accurate and realistic experience when learning how gyroscopic instruments respond to changes in aircraft orientation.

5.3.3 Software/Programming:

Future enhancements to the software may involve the addition of new features to develop this system into a much stronger one. Advanced algorithms could be employed, or even machine learning techniques, to simulate more flight conditions or instrument behaviors. This would provide an even deeper learning experience with the ability to explore detailed scenarios reflecting challenges that may arise in real life.

Other improvement might involve increasing the device/platform compatibility of the system. The software can be developed to be compatible with more devices or platforms, such as tablets or dedicated controllers. This would enhance the interaction of users with the system, making access to people for using the trainer kit on different types of devices quite easy.

Further refinement could be done on the Blynk app to make it more user-friendly, ensuring that even users without much technical knowledge can easily work with the kit. In addition, a simpler and more user-friendly design of the app will go a long way in making the trainer's kit understandable by most users for easy control.

5.3.4 Accessories and Finishing

In terms of accessories, there are many areas where more tools can be integrated and included to make the trainer kit even more valuable. Adding sensors or data logging to the sensors would enable tracking and analysis of the performance of the gyroscopic instrument in real time. This will provide more detailed feedback on how such an instrument would behave under different conditions.

Next, the overall look and feel of the trainer kit could be improved in various ways. Its upgrading about ergonomics would imply that it would be easy and comfortable to handle, thus more pleasant to use. Adding features such as customization-easy settings or personal preferences-could make the kit even more desirable and fit for individual needs.

LIST OF REFERENCES

1. Das, S., Matthews, B. L., Srivastava, A. N., & Oza, N. C. (2010, July). Multiple kernel learning for heterogeneous anomaly detection: algorithm and aviation safety case study. In *Proceedings of the 16th ACM SIGKDD international conference on Knowledge discovery and data mining* (pp. 47-56).

2. Helmreich, R. L. (1997). Managing human error in aviation. *Scientific American*, *276*(5), 62-67.

3. Arduino. "Arduino Nano." Arduino Official Store, store.arduino.cc/products/arduinonano

4. ARDUINO. "Arduino Uno Rev3." Arduino Official Store, 2021, store.arduino.cc/products/arduino-uno-rev3.

5. M. E. Cook, "Understanding gyroscopic instruments," Aircraft Owners and Pilots Association (AOPA), 2021. https://www.aopa.org/training-and-safety/gyroscopic-instruments.

6. P. G. Kimball, "Analysis and suppression of nonlinear effects in gyroscopic instruments," Sensors, vol. 19, no. 5, pp. 1123-1130, March 2019. https://www.mdpi.com/journal/sensors

7. MIT OpenCourseWare. "Chapter 2 Actuators and Drive Systems." Massachusetts Institute of Technology, 2014. [Online]. https://ocw.mit.edu/courses/2-14-analysis-and-design-of-feedback-control-systems-spring-2014/6385092cd050d8dc12b8ae64c8e962aa_MIT2_14S14_Lec2.pdf.

8. MIT FabLab. “Choosing a servomotor.” Massachusetts Institute of Technology, 2014. [Online]. https://fab.cba.mit.edu/classes/S62.12/people/michael.chang/choosing_servo.html

9. NYU Tandon School of Engineering. “Experiment 3: Modeling, Identification, and Control of a DC-Servomotor.” New York University, 2014. [Online]. https://engineering.nyu.edu/sites/default/files/2020-08/Exp3_Modeling_ID_Control_DC_Servo.pdf.

10. George Mason University. “Deriving State Equations for a DC Servo Motor.” George Mason University, 2016. [Online]. https://people-ece.vse.gmu.edu/coursewebpages/ECE/ECE_220/DC_Servo.pdf.

11. MIT OpenCourseWare. “Laboratory Assignment 6: Servomotor Velocity Control.” Massachusetts Institute of Technology, Apr. 2014. [Online]. Available: https://ocw.mit.edu/courses/2-14-analysis-and-design-of-feedback-control-systems-spring-2014/b933910c9c9271162ffa40dd6f652330_MIT2_14S14_Lab_6.pdf.

12. “Understanding Servo Motors,” Anaheim Automation. [Online]. Available: https://www.anaheimautomation.com/products/servo-motor-controller/understanding-servo-motors. [Accessed: 23-May-2024].

13. “Servo Motors and Control,” Moog Inc. [Online]. Available: https://www.moog.com/motion-servo/servo-motors-and-control. [Accessed: 23-May-2024].

14. “Introduction to Servo Motors,” Oriental Motor USA. [Online]. Available: https://www.orientalmotor.com/technology/articles/introduction-servo-motors.html. [Accessed: 23-May-2024].

15. “Basics of Servo Motors,” Kollmorgen. [Online]. Available: https://www.kollmorgen.com/en-us/resources/technical-tips/basics-of-servo-motors/. [Accessed: 23-May-2024].

16. “Servo Motors: An Overview,” Siemens. [Online]. Available: https://new.siemens.com/us/en/products/automation/technology/servo-motors-overview.html. [Accessed: 23-May-2024].

17. “Types of Servo Motors,” Yaskawa America, Inc. [Online]. Available: https://www.yaskawa.com/products/motion/servo-motors/types-of-servo-motors. [Accessed: 23-May-2024].

18. “Servo Motors: How They Work,” Schneider Electric. [Online]. Available: https://www.se.com/us/en/faqs/FA402634/. [Accessed: 23-May-2024].

19. “Advantages of Servo Motors,” Parker Hannifin Corporation. [Online]. Available: https://www.parker.com/portal/site/PARKER/menuitem.31c35c8909fb6b6689710435237ad1ca/?vgnextoid=bd6472b6f86f3610VgnVCM100000200c1dacRCRD&vgnextfmt=default. [Accessed: 23-May-2024].

20. “Servo Motor Technology,” Rockwell Automation. [Online]. Available: https://www.rockwellautomation.com/en-in/products/hardware/motion-control/servo-motor-technology.html. [Accessed: 23-May-2024].

21. Singh, P. (2024, March 11). 20 types of arduino boards and their features. Internshala Trainings Blog. https://trainings.internshala.com/blog/different-types-of-arduino-boards/

22. SourceCAD. (2019, June 20). AutoCAD Basic Tutorial for Beginners - Part 1 of 3 [Video]. YouTube. https://www.youtube.com/watch?v=cmR9cfWJRUU

23. Admin. (2022, December 29). Gyroscope: definition, diagram, types, working principle, applications. BYJUS. https://byjus.com/physics/gyroscope/

24. DroneBot Workshop. (2018, June 3). Robot Arm & Controller - Building the DFRobot 5 DOF Robot arm [Video]. YouTube. https://www.youtube.com/watch?v=dzyKqRVN2kc

25. "Buyer's Guide: How to choose the right resin for 3D printing," *ANYCUBIC-US*, Jan. 07, 2023. https://store.anycubic.com/blogs/3d-printing-guides/how-to-choose-the-right-resin-for-3d-printing

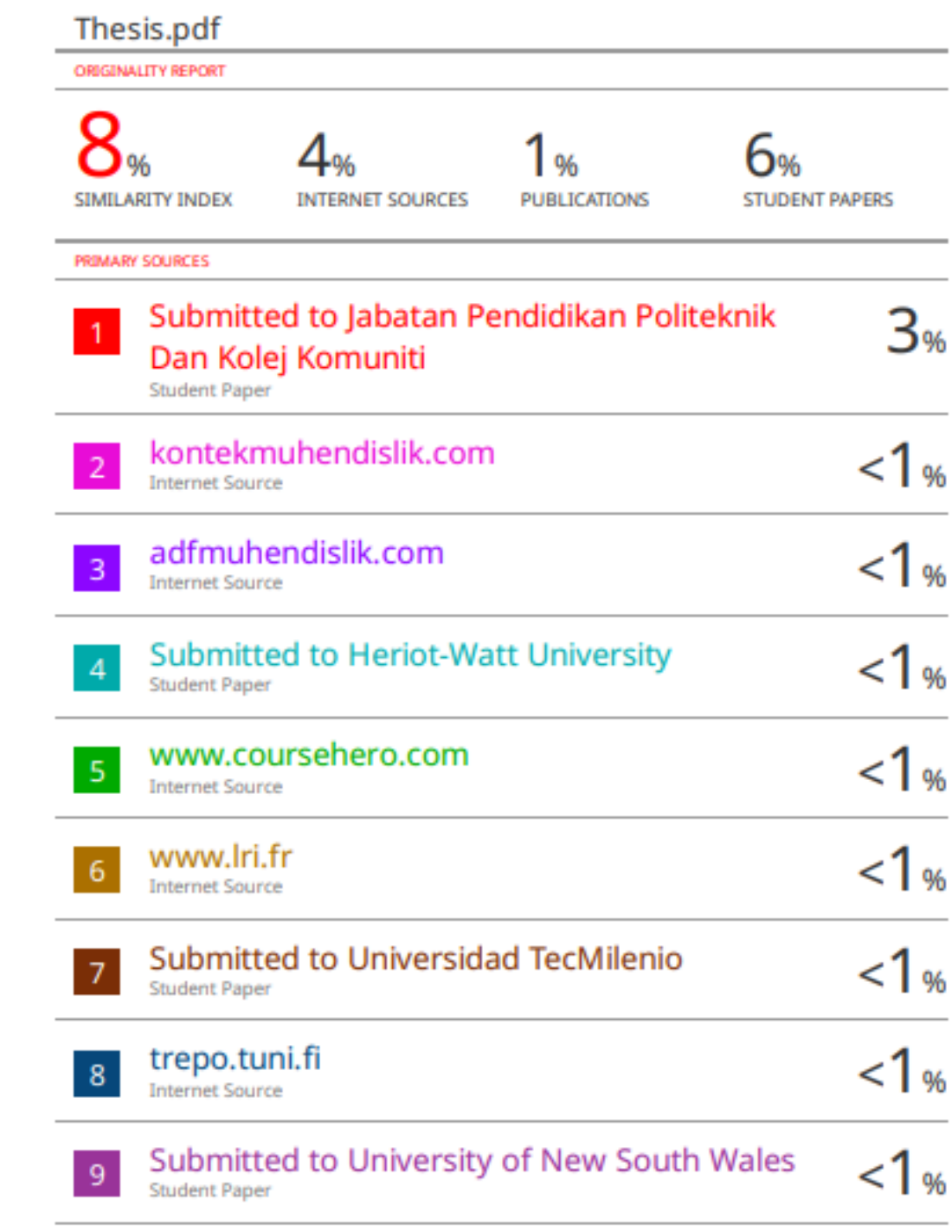
26. The Hayden Walt Bradley Channel, "Air compressor Vs. Gyroscope," *YouTube*. Jun. 24, 2022. [Online]. Available: https://www.youtube.com/watch?v=KSjTk67gPgw

APPENDIX A: DECLARATION OF TASK SEGREGATION

SUB-CHAPTERS	DESCRIPTION
AMIR BIN AZNAN	
1.3.2.1	Specific Individual Project Objectives: Product Structure
1.5.2.1	Specific Individual Scope: Product Structure
2.2.1	Specific Literature Review: Product Structure
2.3.1.1	Review Of Recent Research / Related Products: Related Patented Products
2.3.2.1	Recent Market Products: Product A
2.4.1	Comparison Between Recent Research and Current Project
3.3.2.1	Specific Project Design Flow / Framework: Product Structure
3.4.2.3	Design Concept Generation: Proposed Design Concept 1
3.2.2.1	Specific Part Drawing / Diagram: Product Structure
3.7.3.1	Specific Project Fabrication: Phase 1 (Base Structure)
3.9.1	List Of Materials & Expenditures: Product Structure
4.1.2.1	Specific Part Features: Product Structure
4.1.4.1	Operation Of the Specific Part of The Product: Product Structure
4.3.1	Analysis Of Problem Encountered & Solutions: Product Structure
5.1.2.1	Specific Achievement of Project Objectives: Product Structure
5.3.1	Improvement & Suggestions for Future Research: Product Structure
CINTA BINTI ZAINURI	
1.3.2.2	Specific Individual Project Objectives: Product Mechanisms
1.4.3	Specific Individual Scope: Product Mechanisms
2.2.2	Specific Literature Review: Product Mechanisms
2.3.1.2	Review Of Recent Research / Related Products: Related Patented Products
2.3.2.1	Recent Market Products
2.3.1	Comparison Between Recent Research and Current Project
3.1.2.4	Design Concept Generation: Proposed Design Concept 2
3.2.2.2	Specific Part Sketching: Product Mechanisms

3.2.4.2	Detailed Dimension on The Product Part: Top/Front/Slide Section
3.3.2.2	Specific Project Design Flow / Framework: Product Structure
3.4.2.3	Design Concept Generation: Proposed Design Concept 2
3.2.2.2	Specific Part Drawing / Diagram: Product Mechanism
3.7.3.2	Specific Project Fabrication: Phase 2 (Accessories & Mechanisms)
3.9.2	List Of Materials & Expenditures: Product Mechanism
4.1.2.2	Specific Part Features: Product Mechanism
4.1.4.2	Operation Of the Specific Part of The Product: Product Mechanism
4.3.2	Analysis Of Problem Encountered & Solutions: Product Mechanism
5.1.2.2	Specific Achievement of Project Objectives: Product Mechanism
5.3.2	Improvement & Suggestions for Future Research: Product Mechanism
NUR WASILAH BINTI JANURI	
1.3.2.3	Specific Individual Project Objectives: Software / Programming
1.4.4	Specific Individual Scope: Software / Programming
2.2.3	Specific Literature Review: Software / Programming
2.3.1.1	Review Of Recent Research / Related Products: Related Patented Products
2.3.2.1	Recent Market Products
2.3.1	Comparison Between Recent Research and Current Project
3.1.2.5	Design Concept Generation: Proposed Design Concept 3
3.2.2.2	Specific Part Sketching: Product Mechanisms
3.2.4.2	Detailed Dimension on The Product Part: Top/Front/Slide Section
HILMI JABBARUN NA'IEM BIN MUHAMMAD NABIH	
1.3.2.4	Specific Individual Project Objectives: Accessories & Finishing
1.4.5	Specific Individual Scope: Accessories & Finishing
2.2.4	Specific Literature Review: Accessories & Finishing
2.3.1.1	Review Of Recent Research / Related Products: Related Patented Products
2.3.2.1	Recent Market Products
2.3.1	Comparison Between Recent Research and Current Project
3.1.2.6	Design Concept Generation: Proposed Design Concept 4
3.2.2.2	Specific Part Sketching: Product Mechanisms

APPENDIX B: SUMMARY OF SIMILARITY REPORT (TURNITIN)



Thesis.pdf

ORIGINALITY REPORT

8%	4%	1%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Jabatan Pendidikan Politeknik Dan Kolej Komuniti Student Paper	3%
2	kontekmuhendislik.com Internet Source	<1%
3	adfmuhendislik.com Internet Source	<1%
4	Submitted to Heriot-Watt University Student Paper	<1%
5	www.coursehero.com Internet Source	<1%
6	www.lri.fr Internet Source	<1%
7	Submitted to Universidad TecMilenio Student Paper	<1%
8	trepo.tuni.fi Internet Source	<1%
9	Submitted to University of New South Wales Student Paper	<1%

10	Submitted to UOW Malaysia KDU University College Sdn. Bhd Student Paper	<1 %
11	digitalcollection.utem.edu.my Internet Source	<1 %
12	core.ac.uk Internet Source	<1 %
13	Submitted to American International University Student Paper	<1 %
14	Submitted to Lead College Pty Ltd Student Paper	<1 %
15	Submitted to National American University Student Paper	<1 %
16	recerc.eu Internet Source	<1 %
17	Submitted to Buckinghamshire Chilterns University College Student Paper	<1 %
18	Submitted to University of Rwanda Student Paper	<1 %
19	www.icao.int Internet Source	<1 %
20	Submitted to Al Musanna College of Technology Student Paper	<1 %

21	Submitted to Mt Maria College Student Paper	<1 %
22	behavioralpolicy.org Internet Source	<1 %
23	open.library.ubc.ca Internet Source	<1 %
24	Submitted to Info Myanmar College Student Paper	<1 %
25	Submitted to Swinburne University of Technology Student Paper	<1 %
26	Submitted to Central Washington UNiversity Student Paper	<1 %
27	Submitted to Lakes College - West Cumbria Student Paper	<1 %
28	Submitted to Malta College of Arts,Science and Technology Student Paper	<1 %
29	Submitted to Nilai University College Student Paper	<1 %
30	Submitted to University of Salford Student Paper	<1 %
31	berlmathges.de Internet Source	<1 %

32	www.youtube.com Internet Source	<1 %
33	Eric Lee, Irene Miller, Ken Bro, Michael Robertson, Myles Arendtson, Sarah Loew, Andy Wall. "Performance-Based Acceptance and Commitment Training in a Collegiate Flight Program", Open Science Framework, 2024 Publication	<1 %
34	globaljournals.org Internet Source	<1 %
35	pixcap.com Internet Source	<1 %
36	www.aui.ma Internet Source	<1 %
37	1library.net Internet Source	<1 %
38	Submitted to Wright State University Student Paper	<1 %
39	arxiv.org Internet Source	<1 %
40	dspace.mit.edu Internet Source	<1 %
41	jurnal.polines.ac.id Internet Source	<1 %

42	partyparty.net Internet Source	<1 %
43	vbn.aau.dk Internet Source	<1 %
44	etheses.dur.ac.uk Internet Source	<1 %
45	scienceinfo.com Internet Source	<1 %
46	www.star2.com Internet Source	<1 %
47	www2.mdpi.com Internet Source	<1 %

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		