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INTEGRATED OCEAN OBSERVATION SYSTEM (IOOS) FOR UNDERWATER STATION

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Bachelor of Mechatronics Engineering

December 2015

SUPERVISOR’S DECLARATION

“I hereby declare that I have read through this report entitle “Integrated Ocean Observation System (IOOS) for Underwater Station” and found that it has comply the partial fulfilment for awarding the Degree of Bachelor of Mechatronics Engineering”

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Date : ……………………………………………………

INTEGRATED OCEAN OBSERVATION SYSTEM (IOOS) FOR UNDERWATER STATION

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A report submitted in partial fulfilment of the requirements for

Bachelor of Mechatronics Engineering

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STUDENT'S DECLARATION

I declare that this report entitle "Integrated Ocean Observation System (IOOS) for Underwater Station" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Firstly, I would like to thanks to Allah for giving me an opportunity to finish this research paper. Besides, I would like to thank my supervisor Dr. Mohd Shahrieel Mohd Aras for his guidance, support and inspiration to complete this thesis. Most importantly, he has been a great source of knowledge, motivation and focus precisely at the times I needed them most. Other than that, I want to give foremost gratitude to my family for giving their support and love to complete this report. Finally, I would like to thank my colleagues and friends that help me along the way to finish this project. Last but not least, I would to thank to Universiti Teknikal Malaysia Melaka (UTeM) for giving the opportunity for making FYP which is one of the core program to get Bachelor in Mechatronic Engineering with Honours.

ABSTRACT

Since the establishment of marine technology, buoys have been developed with the capability to provide high quality oceanographic data that supports not only the near surface currents, but can also provide meteorological, biological, chemical and directional wave data for research, education, search and rescue. There is the clear opportunity and responsibility to use the Integrated Ocean Observation System (IOOS) resources, emerging knowledge, and advances in technology to address a broad range of user applications. The IOOS can support and help to find solutions for problems in a diverse range of areas, including natural hazards, marine operations, human and environmental health, resource sustainability, climate and weather, and national security. The various regional observing systems that have been, or are being, established address a number of these problems areas. However, as the regional systems are integrated and sustained, it will be increasingly important for successful components to convincingly demonstrate the feasibility of preoperational regional observing systems and their relevance to national needs. IOOS is our eyes on our oceans, and coasts that enable country to track, predict, manage, and adapt to changes in our marine environment and deliver critical information to decision makers to improve safety, enhance our economy and protect our environment. IOOS enables decision making every day and fosters advances in science and technology. In this project is studied, discussed and designed the component parts that are needed to be assemble together to Integrated Ocean Observation System (IOOS) buoy for underwater station. This buoy system will be equipped with sensors to sample oceanographic and meteorological data, and also will have hydrophone and camera to capture audio and visual data from the surrounding of the buoy. Even there are available buoy in the market nowadays, but the main function of this buoy is to act as the control room for the underwater station. This is because all the electronic board for underwater vehicle will be located inside the buoy. It also will give power supply for that station. The material produced in this report is definitely the beginning of new knowledge which can be deeply developed.

ABSTRAK

Sejak tertubuhnya pelbagai teknologi marin, pelampung telah dibangunkan dengan keupayaan untuk menyediakan data oseanografi berkualiti tinggi yang menyokong bukan sahaja arus permukaan terdekat, tetapi juga boleh menyediakan meteorologi, biologi, kimia dan data gelombang arah untuk penyelidikan, pendidikan, mencari dan menyelamat. Terdapat peluang dan tanggungjawab yang jelas untuk menggunakan Sistem Pemerhatian Lautan Bersepadu (IOOS) sumber, pengetahuan baru muncul, dan kemajuan dalam teknologi untuk menangani pelbagai aplikasi pengguna. The IOOS boleh menyokong dan membantu untuk mencari penyelesaian bagi masalah dalam pelbagai bidang, termasuk bencana alam, operasi marin, kesihatan manusia dan alam sekitar, kemampanan sumber, iklim dan cuaca, dan keselamatan negara. Pelbagai sistem serantau memerhati yang telah, atau sedang, alamat menubuhkan beberapa kawasan-kawasan masalah. Walau bagaimanapun, sebagai sistem serantau yang bersepadu dan berterusan, ia akan menjadi semakin penting bagi komponen yang berjaya untuk meyakinkan menunjukkan kemungkinan sistem memerhatikan serantau preoperational dan kaitannya dengan keperluan negara. IOOS adalah mata kita di lautan kita, dan pantai yang membolehkan negara untuk mengesan, meramal, mengurus dan menyesuaikan diri dengan perubahan dalam persekitaran marin dan menyampaikan maklumat kritikal kepada pembuat keputusan untuk meningkatkan keselamatan, meningkatkan ekonomi kita dan melindungi alam sekitar kita. IOOS membolehkan kita membuat keputusan setiap hari dan memupuk kemajuan dalam sains dan teknologi. Dalam projek ini dikaji, dibincang dan direka bentuk bahagian-bahagian komponen yang diperlukan untuk memasang bersama-sama untuk Sistem Bersepadu Lautan Pemerhatian (IOOS) boya untuk stesen bawah air. Sistem boya akan dilengkapi dengan sensor untuk sampel data oseanografi dan meteorologi, dan juga akan mempunyai hidrofon dan kamera untuk menangkap data audio dan visual dari sekitar boya. Malah ada boya yang terdapat di pasaran pada masa kini, tetapi fungsi utama boya ini adalah untuk bertindak sebagai bilik kawalan untuk stesen bawah air. Ini kerana semua papan elektronik untuk kenderaan bawah air akan terletak di dalam boya. Ia juga akan memberikan bekalan kuasa bagi stesen itu. Bahan yang dihasilkan dalam laporan ini pasti permulaan pengetahuan baru yang dapat sangat maju.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter is about an introduction of this project. This chapter will covers briefly about the research background, motivation, problem statement and objectives. The project scopes of work are determined and explained in detail. The report outline is executed.

Today, buoys are used for many purposes besides aids to navigation, including use as platform for scientific or engineering investigations, for gathering synoptic data, and supporting ocean operations such as oil tanker loading/unloading at production sites. There are strong supported from the institution for a sustained Integrated Ocean Observation System (IOOS) buoy to optimize use of existing resources and facilitate new technologies to deal with a variety of knowledge and application desires. Therefore, IOOS buoy can increase capability to satisfy challenges associated to predict the change of weather and its effects on coastal communities, marine operations, marine ecosystems, and sustained use of marine resources. Based on the Oxford Dictionary, buoy is outlined as navigation aids with floating objects, mounted to the lowest of the ocean or stream, that indicates reefs or different hazards, or for mooring. Each types of buoy have their own specifications, with different size, colour, shape and function.

The purpose of this report is to study on how to design an Integrated Ocean Observation System (IOOS) buoy for underwater station. An existing observation system features a stationary single or multiple measurement points with built-in data logger. Measurements of surface parameters require sensors that are mounted on an anchored buoy while the measurements of the bottom parameters require anchor-mounted sensing modules.

The contributions of all these observation and measurement method have been proved for several decades by providing us with significant amount of oceanographic data. However, there is still plenty of room for improving for increasing the efficiency of the system. Existing monitoring and observation systems are passive systems, whereby periodic data collections are required for further processing and interpretations. Passive observations system is exposed to several conceptual and technical disadvantages.

1.2 Motivation

This project is conducted at the Universiti Teknikal Malaysia Melaka (UTeM). The reason for conducting this research work is to Integrated Ocean Observing System (IOOS) buoy for underwater station. This buoy is very important because its work as a platform for underwater station. This platform and underwater station will connected each other through wire. Buoy can generated 12V electricity from solar panel or batteries and supply it to the station. It also gives information about weather condition such as wind speed, wind direction, surrounding temperature and rainfall.

1.3 Problem Statement

The problem for this project was to investigate the use of new flexible materials and construction techniques for use in the construction of lightweight buoys. Such buoys are expected to last longer, cost less, and resist collision damage better than the current steel and plastic designs. Besides, meteorological data such as wind speed and temperature surrounding are easier to collect systematically and can cover a wider area rather than measurements of wave parameters which very difficult to collect in real situation.

1.4 Objectives

The objectives of this project are:

a) To design and develop Integrated Ocean Observation System (IOOS) buoy for underwater station that can withstand high current environment.
b) To sample meteorological data from the weather station for the buoy.

1.5 Scope of Works

There are some scopes was outlined to achieve the stated objectives of the project.

1. To fabricate the buoy based on the design in SolidWorks.
2. To test the buoy from the point of the forces and equilibrium, and buoyancy Archimedes' principle and buoyancy force equation by immersed the buoy into water tank.
3. To test the sensors to take reading of meteorological data in real situation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, there are elaboration about the literature review from journals that I had study about buoy system based on some criteria that are design, controller algorithm, and performance.

2.2 Design

From journal Zdenka Willis, 2014, [1], some suggestion about the design of the buoy was emphasized. There are many factors to consider when designing buoy to ensure it serves the intended purpose. The first step when designing an IOOS buoy is to decide on the types of parameters to be collected and how they will be collected. Common parameters collected from an IOOS buoy are sea water temperature, air temperature and humidity, wave height and direction, current speed and direction and wind speed. Some buoys have visual, audio observation equipment and several specialized sensors. Stanley J. Boduch, 2006, [8] stated that the next consideration is designing IOOS buoy is power requirement for the buoy. It is depends on how large the sensors will be used and types of the sensors used. There are several options for generating power on a buoy system such as batteries, solar panels, and diesel generators. While based on Alan Jack Herr, 1971, [10] the buoy hull is a very important part because its act as a primary component of the buoy system, so it must provide the necessary buoyancy and positive stability for all conditions. It must support its own payload including power supplies, electronic equipment and antennae. It must also sustain the mooring forces and those of the environment including wind, current and wave drag. The positive stability will assure the buoy will not capsize due to the environmental loads or during routine maintenance operations. This may be accomplished by the proper location of weights, counterweights and by the design of the buoy geometry itself.

Figure 2.1: Model of Buoy

In conclusion, based on Figure 2.1, most buoys will have round shape for it based. This is because that shape will make less resistance to the waves. The lower part of buoy body is designed for high waves so that it can reduce the wave pressure. It is assumed a solid structure in consideration of use in case of the high wave condition. Other than that, the size of buoy depends on the component that will equip on it and the total weight of these components. The buoy should support its own payload neither normal condition nor extreme environment to carry out its duty as an IOOS buoy.

2.3 Controller Algorithm

In most systems, oceanographic and marine meteorological observation data usually only can get collected by additional delays, a day for minimum time while it can reach until a month long to get the "raw" data before transformed it in a usable format to the scientist. Norman L. Guinasso, 2009, [3] the buoy method had advanced, the method is underneath the actual time control of a laptop via a radio link. The info can then be presented to the scientist in any layout desired from the laptop in seconds after the observations are made. From journal [2], written by Kulkarni Amruta M, 2013, the power supply has end up tremendously important predicament, oftentimes even the bottleneck of the system. Utilising wires to attach nodes to vigour lines local just isn't realistic, considering the fact that the nodes mostly distribute in far off areas, and the total rate in connecting all these nodes is insufferable. A further approach is to make use of battery handiest. The benefits was apparent, however batteries have restricted lifespan and can't stand for a long time. Changing depleted batteries often is inconvenient. To prevent pointless work and make the method extra flexible to deploy, solar panel is to use on this system to supply vigour for the sensor node, at the side of the battery to recharge when sunlight is not sufficient, corresponding to at night time.

2.4 System Performance

Based on paper John C. Daidola, 1990 [14], it describes recent attempts to analyse the dynamics of typical buoys moored with synthetic line in shallow water, using an existing numerical model. Large-scale model wave tank tests have shown that the weight and drag of the synthetic line are negligible when compared to the tension forces. This allows the use of a single linear segment in the modelling of the mooring line. The procedure for extracting buoy hydrodynamic coefficients from wave tank data is outlined, along with the current capabilities of the numerical model to estimate mooring line tensions and buoy attitudes in various wave conditions.

Based on paper James Irish, 2006 [8], the buoy is powered by solar panel and wind energy. It can generate 60-watt electricity throughout clear, sunny days through solar panel and also wind generator can provides power throughout moderate wind. These systems can charge 24V and transfer it into 24V battery that can be used when sunlight is not sufficient like at night or in rainy day. The power from batteries will control all mechanism at the buoy. This provides power to the radio and controller to the pumps, valves, run down the most battery bank, and additionally permits diagnostic info to be measuring to shore to help within the identification and repair of the matter.

The system was designed and programmed to permit for land-based upgrading of the management programs while not having to be physically at the offshore website. 2 cameras strategically placed at intervals the fish cage to look at fish feeding and behaviour. This second measurement system has been tried to figure well systematically from land, however, camera and underwater cabling failure has caused the system to be unreliable to boot, a temperature and physical phenomenon sensing element is put in within the submerged cage. The four antennas on the left area unit for communications with shore management and also the relay of video to watch the temperature and salinity from at intervals the cage with a 15-minute sampling resolution each the instrument information and also the video stream area unit transmitted to the buoy through the conductors embedded in an exceedingly tailored, high-stretch feed hose wall. This feed hose, with embedded conductors, has tried to be very helpful for effort information remotely and such a system could also be utilized in future feed systems [3].

2.5 Buoyance Force

When an object is immersed in a fluid, the upward force on the bottom of an object is greater than the downward force on the top of the object. The result is a net upward force (a buoyant force) on any object in any fluid. If the buoyant force is greater than the object's weight, the object will rise to the surface and float. If the buoyant force is less than the object's weight, the object will sink. If the buoyant force equals the object's weight, the object will remain suspended at that depth. The buoyant force is always present in a fluid, whether an object floats, sinks or remains suspended [17].

The buoyant force is a result of pressure exerted by the fluid. The fluid pushes on all sides of an immersed object, but as pressure increases with depth, the push is stronger on the bottom surface of the object than in the top. The buoyant force can be calculated on an object by adding up the forces exerted on all of an object's sides.

The top surface has area A and is at depth h_1, the pressure at that depth is:

$$P_1 = h_1 \rho g \tag{2.1}$$

Where ρ is the density of the fluid and g = 9.81 ms^2 is the gravitational acceleration. The magnitude of the force on the top surface is:

$$F_1 = P_1 A = h_1 \rho g \tag{2.2}$$

This force points downwards. Similarly, the force on the bottom surface is:

$$F_2 = P_2 A = h_2 \rho g \tag{2.3}$$

If it is cylindrical, the net force on the object's sides is zero the forces on different parts of the surface oppose each other and cancel exactly. Thus, the net upward force on the cylinder due to the fluid is:

$$FB = F_2 - F_1 = \rho g A(h_2 - h_1) \tag{2.4}$$

2.6 Archimedes Principle

Although calculating the buoyant force in this way is always possible it is often very difficult. A simpler method follows from the Archimedes principle, which states that the buoyant force exerted on a body immersed in a fluid is equal to the weight of the fluid the body displaces. In other words, to calculate the buoyant force on an object we assume that the submersed part of the object is made of water and then calculate the weight of that water.

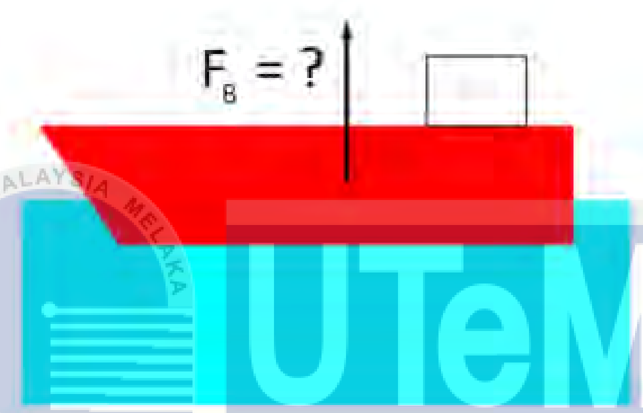


Figure 2.2: Buoyance force of the ship (a) [17]

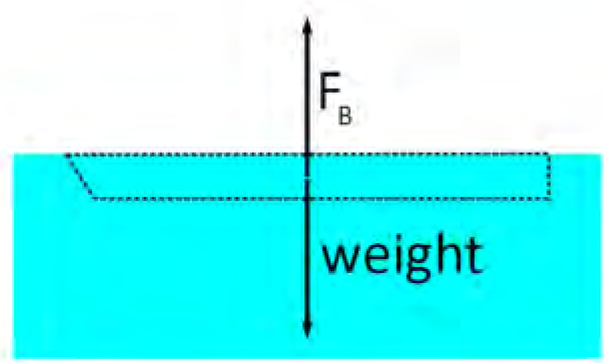


Figure 2.3: Weight of ship is equal to water displaced of the ship (b) [17]

The principle can be stated as a formula:

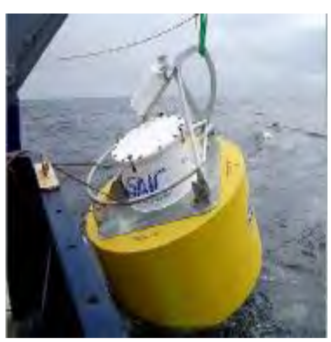
$$F_B = w_{fl} \tag{2.5}$$

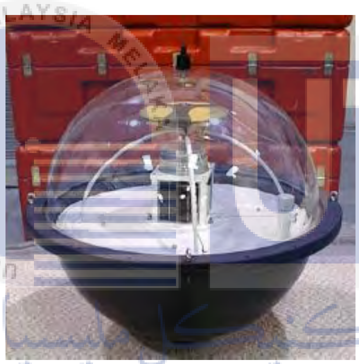
The reasoning behind the Archimedes principle is that the buoyancy force on an object depends on the pressure exerted by the fluid on its submerged surface. Imagine that we replace the submerged part of the object with the fluid in which it is contained, as in (b). The buoyancy force on this amount of fluid must be the same as on the original ship. However, we also know that the buoyancy force on the fluid must be equal to its weight, as the fluid does not sink in itself. Therefore, the buoyancy force on the original object is equal to the weight of the displaced fluid in this case, the water inside the dashed region (b). The Archimedes principle is valid for any fluid not only liquids such as water but also gases such as air.

2.7 Comparison between Current IOOS Buoy

Table 2.1 show the comparison between design of current IOOS buoy and the different between components that install on each design.

Table 2.1: Comparison between Current IOOS buoy

Journal No	Design Picture	Components Include In Design
Glen Dennison, 1997, [5]		• Simple design with mooring.
John N. Walpert, 2009, [6]		• This buoy use solar panel that can support 24V of power source.
R. A. Lawson, 2007, [7]		• Have GPS that can transmit signal and give warn to weather center.

Stanley J. Boduch, 2006, [8]		• This buoy is equip with sensor such as wind speed, air humidity, wind direction and wave high to sample of oceanographic and meteorological data..
Marshall D. Earle, 2000, [9]		• This design is using spherical shape make it have less resistance to ocean wave and wind.

2.8 Summary

In this chapter, all of the journals have been researched properly and being executed into three criteria of literature review that is design, controller algorithm and system performance. Based on Table 2.1, all the features from each journal will be include on my buoy system. This will make my buoy better from the available buoy in market and it can achieve the requirement for my project. From all these research, the process to design and develop IOOS buoy will be ease and fasten. In the next chapter, the method to develop the IOOS buoy will be explained briefly. All the procedure will be included throughout the next chapter.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Previous chapter has elaborated the research from the earlier researcher which have been carried out the experiments and evaluation the experiment related to this project. Chapter 3 indicates the methodology to conduct the experiments to be involved that will be implemented to accomplish this project. The venture procedure and the flow of approach operation might be explained by using utilizing flow chart and Gantt chart. Besides, this chapter will additionally presented the design option and the material decision for this project.

3.2 Flow Chart Explanation

According to flow chart in Figure 3.1 and Figure 3.2, the first step of the project is to analyse the problem statement for the corresponding title. After that, the literature review of the buoy need to be conducted from previous experiment and research paper. Idea that been generated from literature review is used to sketch several designs as option to be selected as a main design. Then, detail SolidWorks design is sketched for main design that is selected from several designs. For material and component selection, it has divided into three parts that are body of buoy, controller hardware and controller algorithm. In preliminary result, the main design was shown in isometric view, front view, side view and top view design. After that, the report for this thesis is submitted to supervisor and panel. The flow chart in Figure 3.3 shows the flow of the operation for completing the buoy. The first step is to fabricate the design and then test the design for its durability, sensor performance and stability based on buoyancy of the buoy.

3.3 Flow Chart of the Project

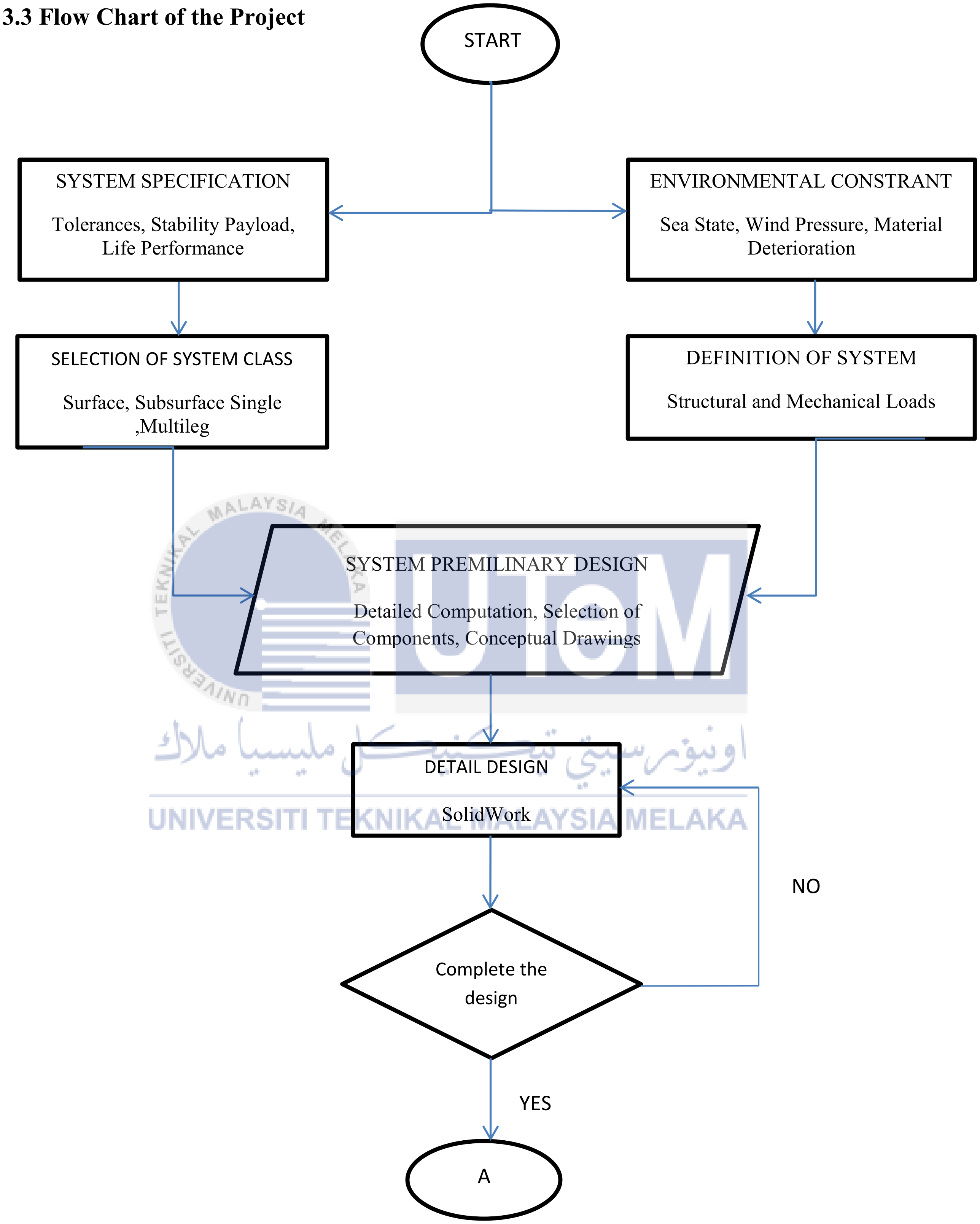


Figure 3.1: Flow Chart for FYP 1(A)

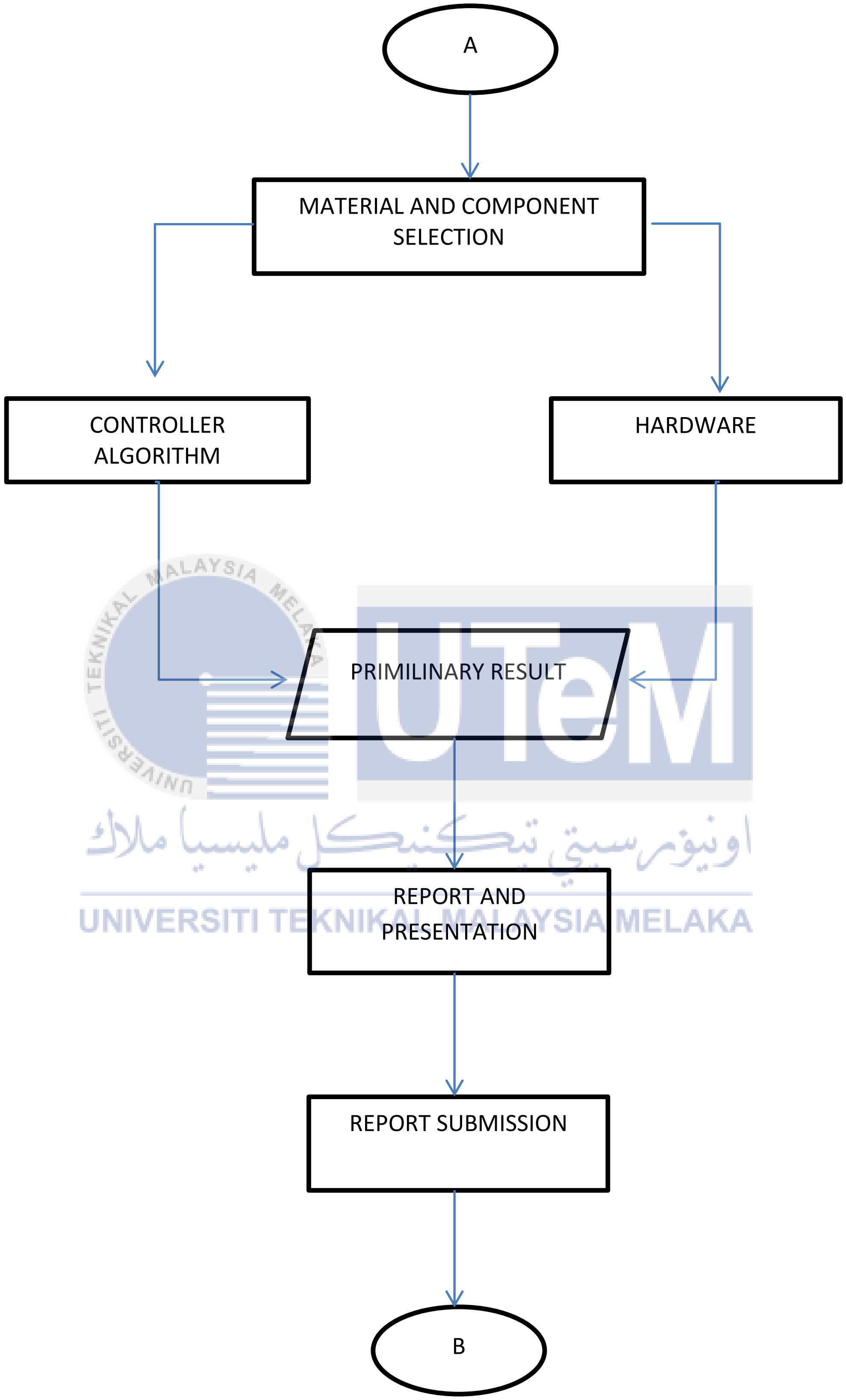


Figure 3.2: Flow Chart for FYP 1(B)

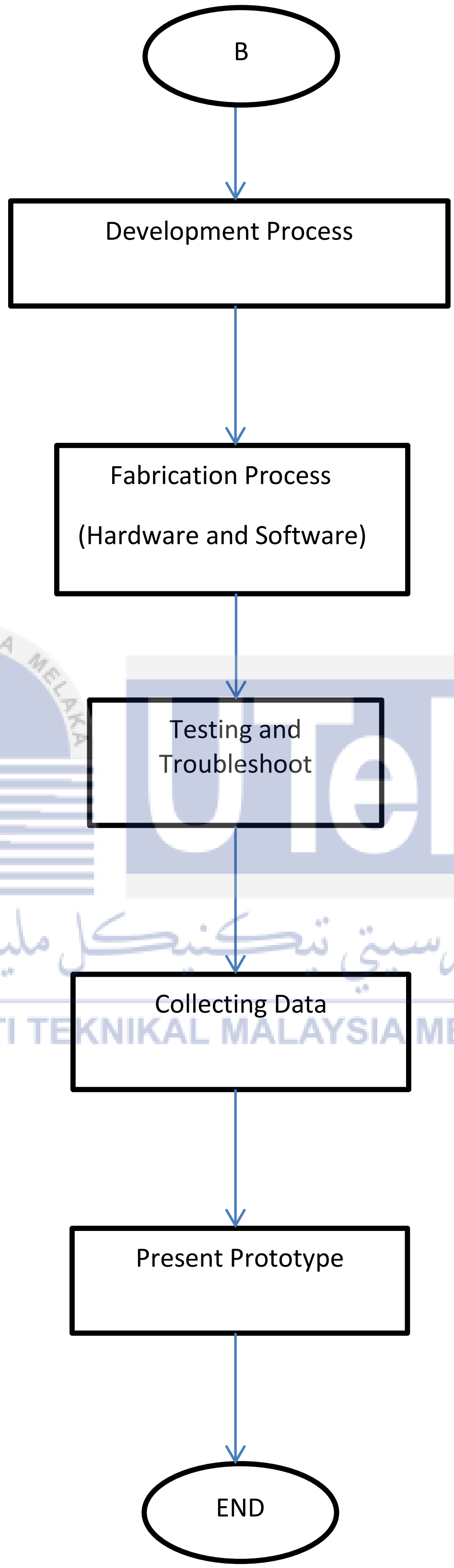


Figure 3.3: Flow Chart for FYP 2

3.4 Gantt Chart

Table 3.1 shows the Gantt chart for this project for two semester. Semester one started at the mid of February and end on June. For semester two, this project is started early in September and end in December.

Table 3.1: Gantt chart for first semester

ITEM	FEBRUARY				MARCH				APRIL				MAY				JUNE			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PROJECT'S INTRODUCTION - Detail discuss with supervisor - Problem statement - Objective - Scope																				
REVIEW LITERATURE WORK - Preview literature (journal and books) - Finding a additional knowledge about the project																				
WRITE LITERTURE REVIEW																				
SKETCH DESIGN OPTION																				
FIND ADVANTAGES AND DISADVANTAGES FOR EACH DESIGN																				
METHODOLOGY - Design part - Simulation work																				
SCHEMATIC DIAGRAM																				
LIST OF COMPONENT																				
FABRIFICATION																				
PROPOSAL REPORT SUBMISSION																				
PRESENTATION																				
FINAL REPORT SUBMISSION																				

Table 3.2: Gantt chart for second semester

ITEM	SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER				JUNUARY			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
HARDWARE DEVELOPMENT - Electronic housing - Buoy platform																				
TROUBLE SHOOTING - Waterproof - Stability - Disturbance																				
HARDWARE PERFORMANCE - Buoyancy test - Maximum additional load																				
EXPERIMENT AND COLLECTING DATA - Weather station																				
SUPERVISOR VIEWS - Hardware design - Experimental - Report																				
SUBMISSION REPORT TO PANEL																				
FINAL YEAR PROJECT 2 PRESENTATION																				
FINAL REPORT																				

3.5 System Design

Table 3.2 show the comparison design using CAD software (SolidWorks).with the actual hardware that already been fabricate. SolidWorks is a solid modelling computer-aided design (CAD) and computer-aided engineering(CAE) software program that runs on Microsoft Windows.

Table 3.3: IOOS Buoy

Design from SolidWork	Actual Design
	

3.7 Material Selection

In this sub topic, there are 3 criteria that are needed to be considered while designing and developing this buoy. There are body of the buoy, sensors system and other components. All these parts are equally important to complete the objective of this project.

3.7.1 Body of Buoy

The buoy body typically is supported on static legs hooked up to the ocean floor. Most of the buoy will have round shape for it based. This is because that shape will make less resistance to the waves. The lower part of buoy body is designed for anti-wave type to reduce the wave pressure at high waves. The buoy body water line is shallow, and it is suitable also for use in shallow water. It is assumed a solid structure in consideration of use in case of the high wave condition. In Figure 3.4 shows that the different size of buoy that already available in market.

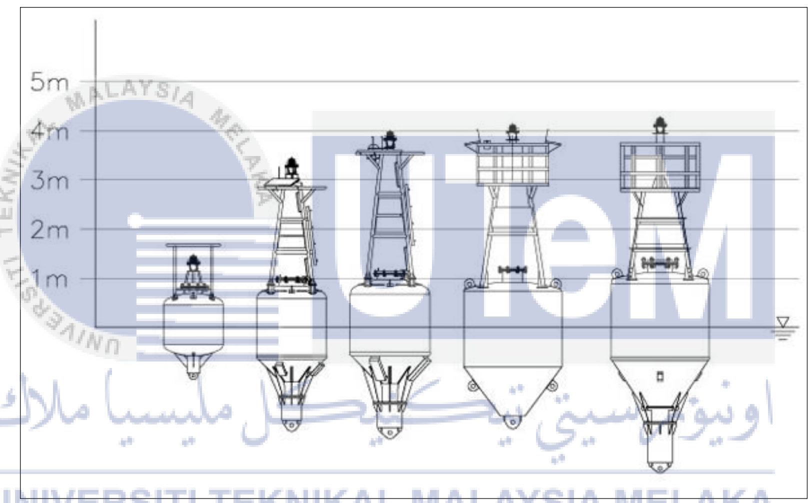


Figure 3.4: Difference Size of Buoy [14]

3.7.2 Sensors

The first step when designing an IOOS buoy is to decide on the types of parameters to be collect and how they will be collected. Common parameters collected from IOOS buoy are rainfall, air temperature and humidity, and wind speed and direction. For this buoy project, it will have extra features that are have visual, audio observation equipment and several specialised sensors. In Figure 3.5 shows sensors that available on IOOS buoy and the locations of each sensor.

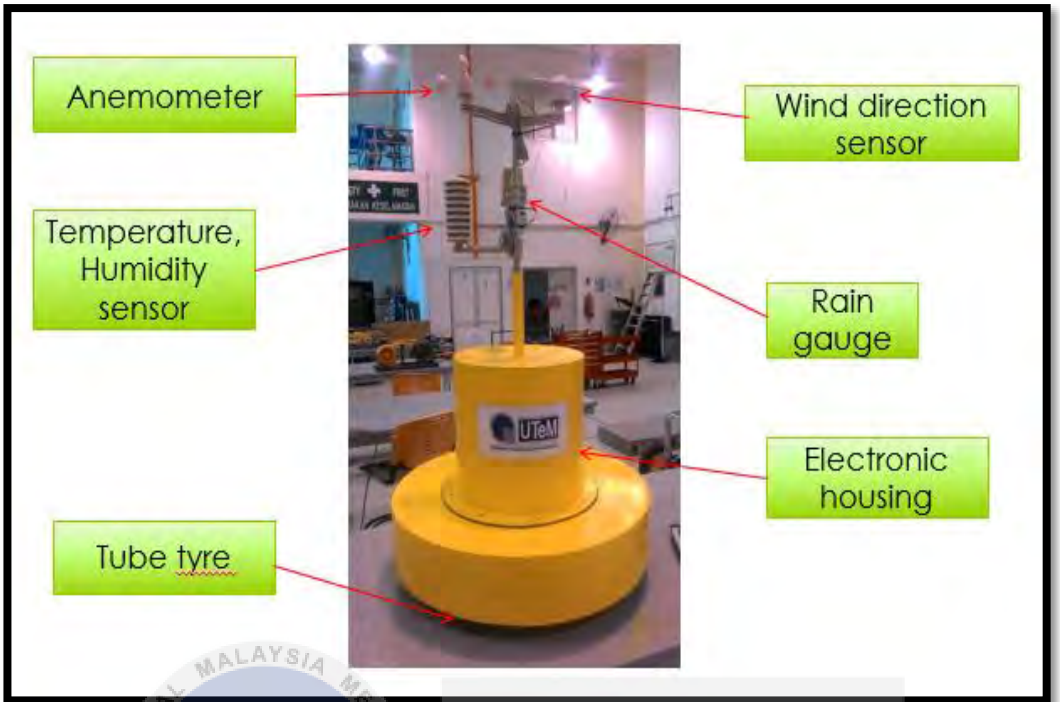


Figure 3.5: Parts in Buoy

List in Table 3.4 are various types of sensors installed on the Integrated Ocean Observation (IOOS) buoy. These sensors are required to measure oceanographic and meteorological parameters. The sensors are anemometer to read wind speed and its direction, temperature sensor to take reading of surrounding temperature, humidity sensor to measure air humidity and rain gauge to sample rainfall in set of period.

Table 3.4: List of Sensor on Integrated Ocean Observation (IOOS) Buoy

Sensor	Parameter
Anemometer	Wind speed and direction
Temperature sensor	Air temperature
Humidity sensor	Air humidity
Rain gauge	Rainfall

Figure 3.6 shows an example of wind cup anemometer. An anemometer is an instrument that measures the velocity of the wind or of a further flowing fluid. The most general style of anemometer includes a series of cups hooked up on the end of arms that rotate within the wind. The pace with which the cups rotate shows the wind velocity. On this kind, the anemometer also shows the course of the wind. Other anemometers include the strain-tube anemometer, which uses the strain generated by way of the wind to measure its speed, and the hot-wire anemometer, which makes use of the rate at which warmth from a scorching wire is transferred to the encircling air to measure wind velocity.

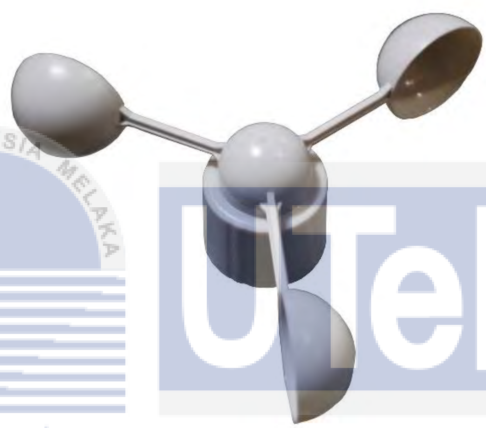


Figure 3.6: Wind cup anemometer

Figure 3.7: Rain gauge

A rain gauge is a type of instrument used by meteorologists and hydrologists to gather and measure the amount of liquid precipitation over a set period of time. Figure 3.7 is an example of rain gauge that have in weather station use on the buoy.

Figure 3.8: Temperature Sensor (Thermistor)

A thermistor is a resistance thermometer, or a resistor whose resistance is based on temperature. It's product of metallic oxides, pressed right into a bead, disk, or cylindrical form and then encapsulated with an impermeable material such as epoxy or glass. There are two forms of thermistors: Negative Temperature Coefficient (NTC) and Positive Temperature Coefficient (PTC). NTC thermistor will trigger when the temperature increases at the same time resistance decreases. Conversely, when temperature decreases, resistance increases. This style of thermistor is used essentially the most. A PTC thermistor works a bit in a different way. When temperature raises, the resistance increases, and when temperature decreases, resistance decreases. This form of thermistor is more often used as a fuse. As a rule, a thermistor achieves excessive precision inside a confined temperature range of about 50ºC across the goal temperature. This variety is based on the base resistance. Figure 3.8 is an example of temperature sensor (thermistor).

In Table 3.4 shows the comparison between thermistor with RTD and LM35. The parameters that have been compared are in terms of temperature range, relative cost, time constant, stability and sensitivity.

Table 3.5: Comparison between Thermistor and Other Sensors

Parameter	Thermistor	RTD	LM35
Temperature Range	Within ˜50°C of a given center temperature	−260°C to +850°C	−40°C to +100°C
Relative Cost	Very inexpensive	Most expensive	Moderately expensive
Time Constant	6 to 14 seconds	1 to 7 seconds	1 to 3 seconds
Stability	Very stable, ˜0.0009°C	˜0.05°C	˜0.01°C
Sensitivity	High	Low	Low
Advantages	• Durable • Long lasting • Highly sensitive • Small size • Lowest cost • Best for measuring single point temperature	• Best response time • Linear output • Widest operating temperature range • Best for measuring a range of temperatures	• Moderately expensive • Linear output
Disadvantages	• Nonlinear output • Limited temperature range • Slow response time	• Expensive • Low sensitivity	• Limited temperature range • Low sensitivity • Large size

3.7.3 Power Supply

A lithium ion battery with a suitable capacity is selected to a whole system, and this battery will be charged by solar panels to ensure continuous operation without the need to replace the battery. The capacity of the battery and solar panels are selected based on power consumption of the system, estimating various sensors sampling rates and frequencies, and the duration and intensity of sunlight through the year. The power for the buoy is managed by power module which is responsible for converting the battery voltage to 12V supply as shown in Figure 3.11 that are required by various instruments on the buoy.

Figure 3.9: Lithium Ion Battery

3.8 Stability

A floating body is stable if, when it is displaced, it returns to equilibrium. A floating body is unstable if, when it is displaced, it moves to a new equilibrium.

3.8.1 Method for solving buoyancy of the body.

1. From geometry of body and density of fluid and body equate:
   Weight of displaced fluid = Total weight of body.
   This will gives the depth of immersion of the body or the weight of the body.
2. The location of the centre of gravity, G of the body is determined to assess stability.
3. The location of the centre of buoyancy, B (centroid of displaced volume) is determined. For a regularly shaped body this will be at half the height of the immersed portion of the body.
4. The distance FG is calculated.
5. MF is calculated using:

$$MF = I / V_S \tag{3.1}$$

Note $I = \pi D^4 / 64$

For a circular section body and $bd^3 / 12$ for a rectangular section body (D is diameter, b and d are the sides of the rectangle).

6. Metacentric height is calculated using:

$$MG = Z_M .- Z_G \tag{3.2}$$

From,

$$MG = MF - FG \tag{3.3}$$

If MG > 0 then body is stable. If MG < 0 then body is unstable.

3.8.2 Stability of conventional buoy

The static stability of conventional buoy without its mooring can be calculated in the same way as the ship. The measure of static stability is sufficient expressed by the meta-centric height (MG). Figure 3.12 shows which forces are work to right a buoy of the skirt-kneel type when it heels at an angle ϕ. G is the centre of gravity, F is the centre of buoyancy when upright and F when at an angle of heel ϕ. For small heeling angle the metacentre is expressed by:

$$\text{Righting moment} = g\ D\ MG \sin\phi \tag{3.4}$$

Where

g = constant of gravity

D = mass of the volume of displaced water (kg)

The centre of gravity is situated above the centre of buoyancy when upright, so MG = MF – FG. It is easily be seen that this buoy will capsize when the angle of heel become too great.

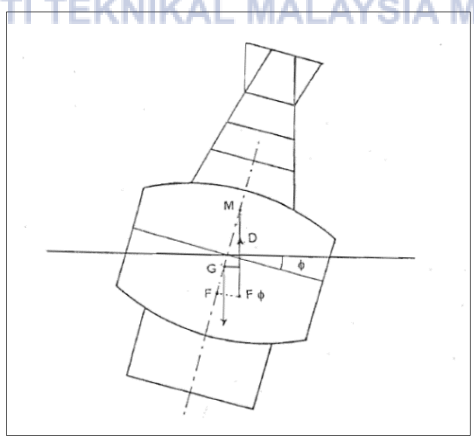


Figure 3.10: Forces that work on buoy

With a tail-tube type buoy, the center of gravity is situated below the center of buoyancy when upright, so that MG = MF + FG. This type will always right itself irrespective of the angle of heel. It is mono-stable. The distance FG depends on the distribution of the masses and the shape of underwater body of buoy. It can be proved that distance MF is equals to moment of inertia of the waterline divided by the displacement volume of water:

$$MF = \pi D^4 / 64 V \quad (3.5)$$

Where

D = diameter of the buoy on the waterline

V = volume of water displaced

3.8.3 Effect of wind

If the force exerted by the wind (F_W) is centered at a distance Y above the level of attachment of the chain, it will cause a moment F_W Y cos ϕ (for small change of heel). Equilibrium occurs when:

$$F_w \, Y \cos \phi = g \, D \, MG \sin \phi \quad (3.6)$$

so that the angle of heel caused by the wind is expressed by:

$$\tan \phi = \frac{F_w \, Y}{g \, D \, MG} \quad (3.7)$$

Where

F_W is expressed in Newton, D in kg.

Y and MG are in meter (m).

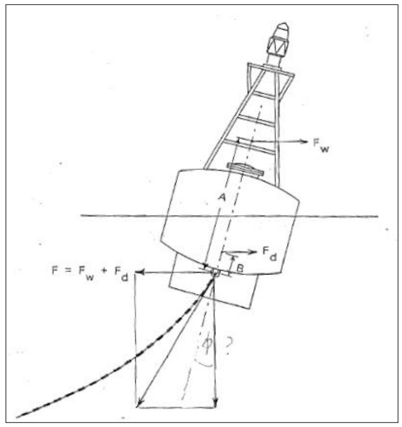


Figure 3.11: Effect of wind and current forces to buoy

Based on Figure 3.14, the angle of heel is caused by the forces of wind and current. In this case, both forces act in the same direction.

3.8.4 Effect of current

The point of application of the drag of the current exerted on a buoy usually a little above the level of attachment of the mooring chain. If the distance between these is B meter and the hydrodynamic forces is F_d Newton, there will be a moment B F_d cos ϕ (Nm). This moment is counteracted by the righting moment g D MG sin ϕ (Nm) for small angles. Equilibrium exists when:

$$B\ F_d \cos\phi = g\ D\ MG \sin\phi \qquad (3.8)$$

so that,

$$\tan\phi = \frac{B\ F_d}{g\ D\ MG} \qquad (3.9)$$

where;

F_d is expressed in Newton, D in kg.

B and MG are in meter (m).

3.9 Experiment Implementation

There are several experiments that are carried out to measure the performance of the project such as buoyancy test, waterproof test, stability test and disturbance test. Every experiment will be explain in detail with it step.

3.9.1 Experiment 1: Buoyancy of IOOS Buoy

Objective

1. Determine the buoyancy of the buoy.

Procedure

1. Measured the weight for buoy without any iron columns was attached for weighed.
2. Put the buoy into the lab pool and observe the position of buoy.
3. Increased the weight of buoy using iron columns with additional 2.5 kg for every experiment until the buoy have negative buoyancy.
4. The buoy will floating on the surface of the pool. By observation, check the buoyancy types either negatively buoyant, neutral buoyant or positively buoyant.
5. Observed and recorded the data.
6. The condition for floating is observed.

3.9.2 Experiment 2: Waterproof Testing

Objective

1. To determine the sealing condition for the electronic housing.

Procedure

1. The buoy are seal using gasket rubber sheet and screw between the housing and the platform.
2. The buoy are left floating upside down for 5 minute for every experiment.
3. The condition of buoy are observed.
4. The data of the buoy condition are recorded.
5. Step 1 until 4 is repeated until waterproof testing is succeed.

3.9.3 Experiment 3: Stability Test

Objective

1. To determine the stability of the IOOS buoy.

Procedure

1. The geometry of body and density of fluid and body equate:
   Weight of displaced fluid = Total weight of body.
2. The location of the centre of gravity, G of the body is determined to assess stability.
3. The location of the centre of buoyancy, B (centroid of displaced volume) is determined.
4. The distance FG is calculated.
5. MF is calculated.
6. Metacentric height is calculated.
7. If MG > 0 then body is stable. If MG < 0 then body is unstable.

3.9.4 Experiment 4: Disturbance Test

Objective

1. To determine the condition of the IOOS buoy when external forces act to buoy.

Procedure

1. Place the buoy on the water surface.
2. Give a low pressure to the water surface.
3. Record the movement and condition the buoy.
4. Repeat step 1 until 3 but with different pressure to the water surface for medium and high pressure.

3.10 Summary

In this chapter, the process of conducting experiments and method are defined. The flow charts of all techniques that are involved are explained well and Gantt chart for this project are also shown in this chapter. As opposed to that, this chapter indicates the several designs as alternative and will be choose in result based on simulation in SolidWorks and material selection for this project are determined. From this chapter, the work come to be systematically and organized well. The components of the project also are explained well.

CHAPTER 4

RESULT AND ANALYSIS

4.1 Introduction

This chapter is reviewed about the experiment that has been conducted to get the result for this IOOS buoy project. In this chapter shows the SolidWorks design with its properties. After the development of the buoy complete, the buoy is tested on the water to make sure this buoy can work perfectly and stand with the environment.

4.2 System Design

Figure 4.1 shows the example of system design flowchart for IOOS buoy.

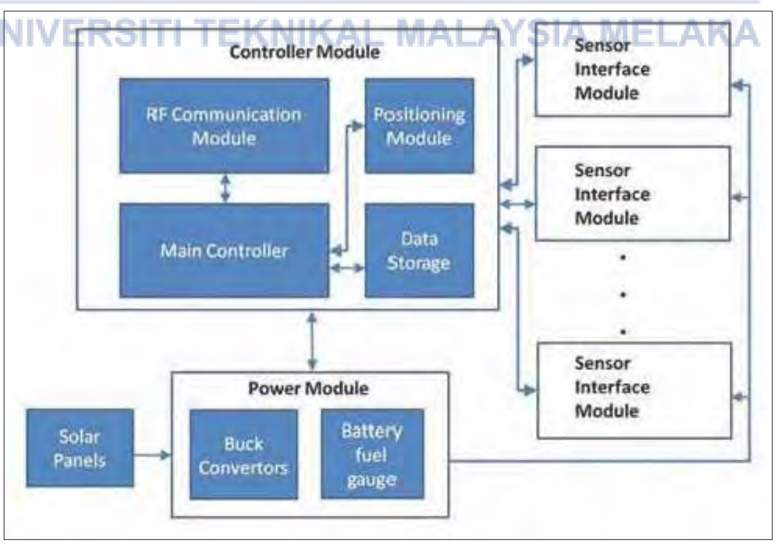


Figure 4.1: System Design Flowchart

4.3 Analysis for Design

4.3.1 Model Information (Electronic Housing)

Table 4.1 shows model information for electronic housing of the buoy using SolidWork software.

Table 4.1: Model Information (Electronic Housing)

Model name: Electronic housing
Current Configuration: Default

Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Shell1 	Solid Body	Mass:8.67909 kg Volume:0.00667622 m^3 Density:1300 kg/m^3 Weight:85.055 N	D:\SW Abu\electronik case.SLDPRT Apr 29 14:44:14 2015

4.3.2 Material Properties

Table 4.2 show the material properties and Table 4.3 shows load and fixtures for the electronic housing.

Table 4.2: Material Properties

Model Reference	Properties	Components
	Name: Alloy Steel Model type: Linear Elastic Isotropic Default failure criterion: Max von Mises Stress Yield strength: 6.20422e+008 N/m^2 Tensile strength: 7.23826e+008 N/m^2 Elastic modulus: 2.1e+011 N/m^2 Poisson's ratio: 0.28 Mass density: 7700 kg/m^3 Shear modulus: 7.9e+010 N/m^2 Thermal expansion coefficient: 1.3e-005 /Kelvin	Solid Body 1(Shell1)(baldi-1), Solid Body 1(Shell2)(platform-1)
Curve Data:N/A		
	Name: Natural Rubber Model type: Linear Elastic Isotropic Default failure criterion: Unknown Tensile strength: 2e+007 N/m^2 Elastic modulus: 10000 N/m^2 Poisson's ratio: 0.45 Mass density: 960 kg/m^3	Solid Body 1(Sweep2)(pelampung-1), Solid Body 1(Sweep2)(pelampung-2)
Curve Data:N/A		

4.3.3 Load and Fixtures

Table 4.3: Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 3 face(s) **Type:** Fixed Geometry

Load name	Load Image	Load Details
Force-1		**Entities:** 5 face(s) **Type:** Apply normal force **Value:** 1 N

4.3.4 Mesh Information

A mesh is a barrier made of connected strands of metal, fibre, or other flexible/ductile materials. A mesh is similar to a web or a net in that it has many attached or woven strands. Table 4.4 and Table 4.5 shows mesh information about the electronic housing of the buoy.

Table 4.4: Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	23.2181 mm
Tolerance	1.16091 mm
Mesh Quality	High

Table 4.5: Mesh Information-Details

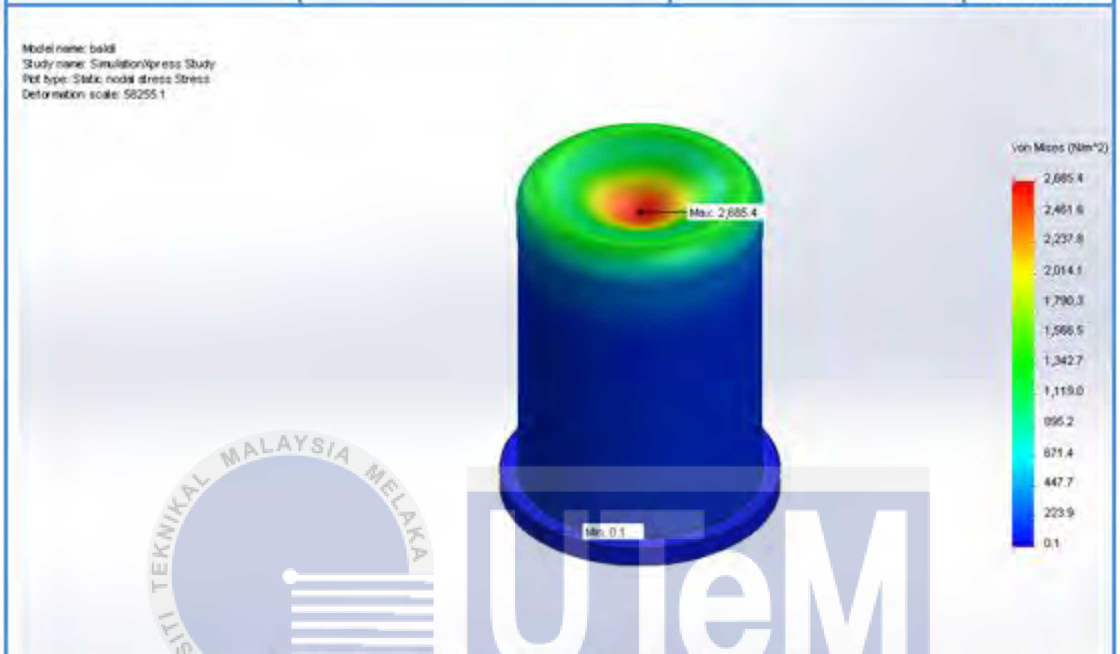
Total Nodes	15377
Total Elements	7620
Maximum Aspect Ratio	6.8689
% of elements with Aspect Ratio < 3	93.9
% of elements with Aspect Ratio > 10	0
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:03
Computer name:	EMAZFAR-PC

4.3.5 Study Result

Table 4.6 showed the result of stress that had been simulate using SolidWorks software. The blue colour indicated the strongest part while the red colour indicated the weakest part of this electronic housing when a certain force is applied on it.

Table 4.6: Study Result

Name	Type	Min	Max
Stress	VON: von Mises Stress	0.108341 N/m^2 Node: 791	2685.38 N/m^2 Node: 2045



Electronic housing-SimulationXpress Study-Stress-Stress

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0 mm Node: 110	0.0009097 92 mm Node: 4358

4.3.6 Model Information (Buoy Platform)

Table 4.7 shows model information about buoy platform.

Table 4.7: Model Information (Buoy Platform)

Model name: platform
Current Configuration: Default

Solid Bodies

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Shell2 	Solid Body	Mass:78.0343 kg Volume:0.0197056 m^3 Density:3960 kg/m^3 Weight:764.736 N	D:\SW Abu\platform.SLDPRT Apr 29 14:44:14 2015

4.3.7 Material Properties

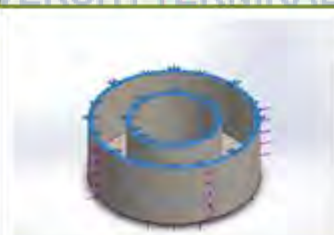
Table 4.8 show the material properties and Table 4.9 shows load and fixtures for buoy platform.

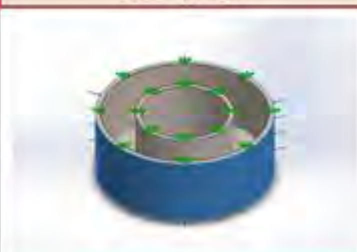
Table 4.8: Material Properties

Model Reference	Properties	Components
	Name: Alumina Model type: Linear Elastic Isotropic Default failure criterion: Unknown Tensile strength: 3e+008 N/m^2	SolidBody 1(Shell2)(platform)

4.3.8 Load and Fixtures

Table 4.9: Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		Entities: 4 face(s) Type: Fixed Geometry

Load name	Load Image	Load Details
Force-1		Entities: 2 face(s) Type: Apply normal force Value: 1 N

4.3.9 Mesh Information

Table 4.10: Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	28.3515 mm
Tolerance	1.41758 mm
Mesh Quality	High

Table 4.11: Mesh Information-Details

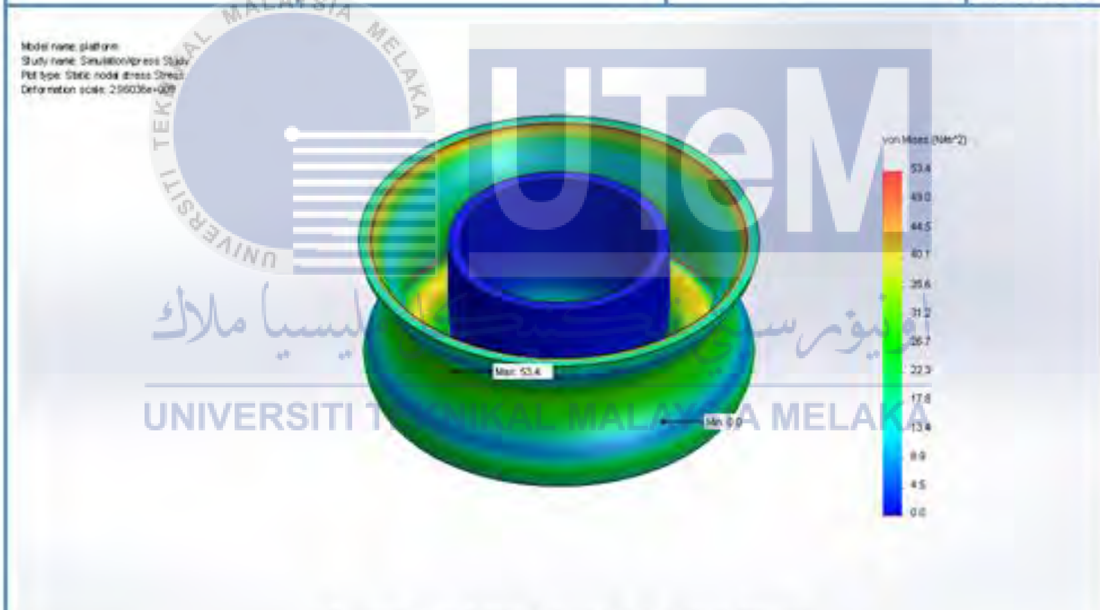
Total Nodes	15624
Total Elements	7719
Maximum Aspect Ratio	6.3901
% of elements with Aspect Ratio < 3	98.5
% of elements with Aspect Ratio > 10	0
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:03
Computer name:	EMAZFAR-PC

4.3.10 Study Results

Table 4.12 showed the result of stress of the buoy platform that had been simulate using SolidWorks software. The blue colour indicated the strongest part while the red colour indicated the weakest part of this buoy platform when a certain force is applied on it.

Table 4.12: Study Result

Name	Type	Min	Max
Stress	VON: von Mises Stress	0.0455935 N/m^2 Node: 8987	53.3966 N/m^2 Node: 3902



platform-SimulationXpress Study-Stress-Stress

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0 mm Node: 1	2.22386e-008 mm Node: 5349

4.4 Experiment Result

4.4.1 Experiment 1: Buoyancy of IOOS Buoy

The weight and the buoyancy of the buoy plays an important role for floating on water. The weight of the buoy before adding additional payload is 15 kg and the initial submerged of the buoy is 7.00 cm. Iron column is added as payload and it is standardized for 2.5kg every experiment. The experiment is conducted until the buoy have negative buoyancy force. The depth of submerged buoy and the condition of the buoy is recorded in the Table 4.13.

Table 4.13: Buoyancy Test for IOOS Buoy

Iron Column (kg)	Condition of the buoy	Submerged depth (cm)
0.0	Positive buoyancy	7.00
2.5	Positive buoyancy	7.70
5.0	Positive buoyancy	8.40
7.5	Positive buoyancy	8.95
10.0	Positive buoyancy	9.50
12.5	Positive buoyancy	10.25
15.0	Positive buoyancy	11.00
17.5	Positive buoyancy	12.25
20.0	Positive buoyancy	13.50
22.5	Neutral buoyancy	14.00
25.0	Negative buoyancy	14.50

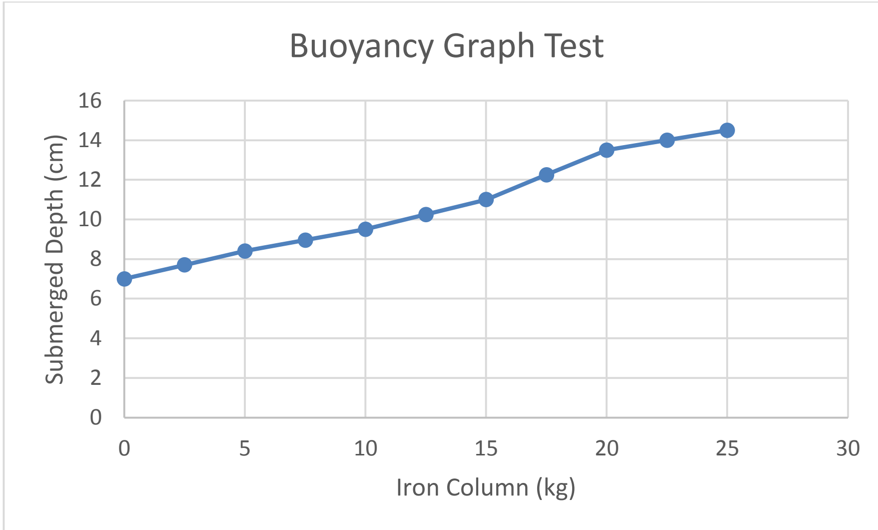


Figure 4.2: Payload again submerged depth of buoy

From Figure 4.2, the graph show payload again submerged depth of buoy. Every payload added will increase the depth submerged of buoy. From that, we can conclude that the payload is directly propositional to the depth of buoy. The experiment is conducted using 2.5kg of iron column is attached to the buoy and is added standardized until it achieved a negative buoyancy. The Table 4.13 shows that, the buoy can stand payload until 20.0kg without losing its stability. After 2.5kg of iron column, the tilt of the buoy increase because the centre of gravity is equal to centre of buoyancy. It mean that, the buoy now facing neutral buoyance force. Lastly, by adding 2.5kg iron column more, it make the buoy to rotate upside down. That mean, center of gravity now lower than center of buoyancy. So it's proved that the pressure at the bottom of a column of fluid must be greater than at the top of the buoy to support the buoy from sinking.

Similarly, the pressure at the bottom of an object submerged in a fluid is greater than at the top of the object. This pressure difference results in a net upwards force on the object from Archimedes Principle that the weight of the buoy when payload is added to 25.0kg is greater than weight of water displaces. So the buoy has a negative buoyancy to make the buoy rotate upside down. In addition, after adding until 25.0kg of iron column the total weight of buoy is 40.0kg.

Figure 4.3 and Figure 4.5 shows the different between buoy condition from initial condition and with the maximum payload while Figure 4.4 and Figure 4.6 shows the different between water level at zero payload and with maximum payload. In conclusion, we can see that the design of buoy had achieved its function as Integrated Ocean Observation System Buoy that we can attach more sensors on its body and also as a platform for underwater station to give power supply to underwater vehicle. The suitable payload that can be added on the buoy is between 10.0kg until 20.0kg based the data recorded on the Table 4.13.

Figure 4.3: Buoy condition at initial condition

Figure 4.4: Water level at zero payload

Figure 4.5: Condition of buoy at maximum payload

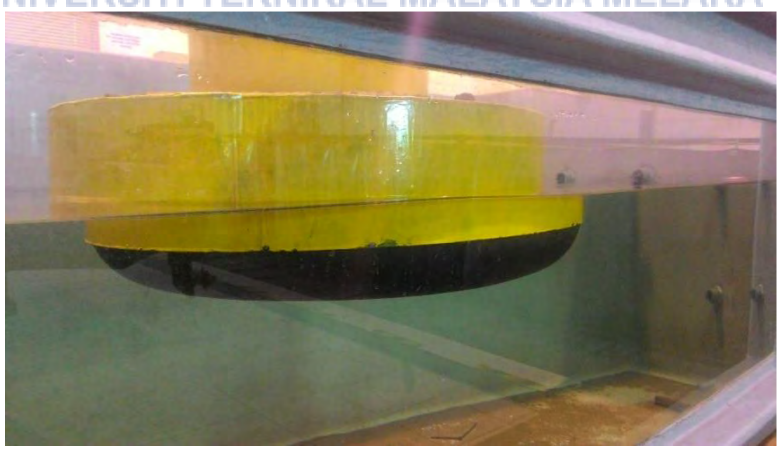


Figure 4.6: Buoy water level at maximum payload

4.4.2 Experiment 2: Waterproof Test for Buoy

The housing is an important part that need to be waterproofed for the IOOS buoy. It need to be waterproofed to protect all the controller and circuit for underwater station from being broke down or short circuit. The Table 4.14 shows the testing result.

Table 4.14: Waterproof Data Test

Time (min)	Test 1	Test 2	Test 3
5	Fail	Success	Success
10	Fail	Success	Success
15	Fail	Success	Success
20	Fail	Fail	Success
25	Fail	Fail	Success

According to the Table 4.14, test 1 to test 3 shows that the buoy have successfully to have positive buoyancy, therefore the floating application of the buoy is working. For test 1, the result is failure because the gasket rubber sheet is not place between the housing and the platform whereas test 2 have 15 minute for time taken before water enter the electronic housing. Finally, the third test have been succeed after it can stand longer than 25 minute. The buoy with load of 150 Newton can float to the surface of the water without water can enter inside the electronic housing. Therefore, the design of buoy have achieves the capability and stability to floating on water.

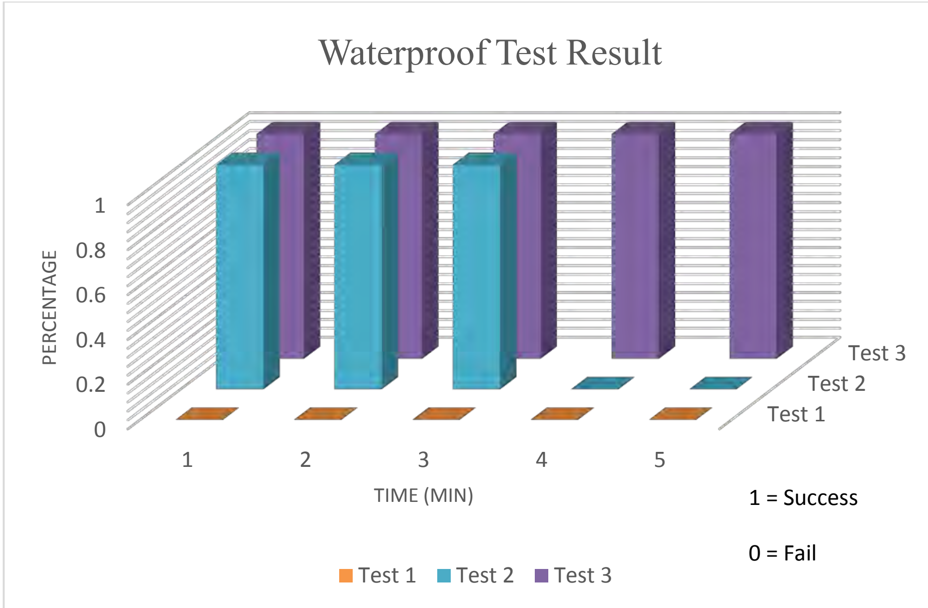


Figure 4.7: Graph for waterproof test result

Figure 4.7 shows the graph for waterproof testing result. Time taken for each test is divided by 5 parts. Each part is equal to 5 minute each. The total time taken is 25 minute for every test that have been done. If water enter the housing while testing in progress, the next time taken until reach 25 minute is considered a failure. Every test succeed will be mark as 1 while if fail, it will be mark as 0. Figure 4.8 and Figure 4.9 shows the condition of buoy when testing in progress and Figure 4.10 shows the position of leakage sensor while Figure 4.11 shows power source and its indicator for the sensor. The sensor is use to detect leakage when experiment in progress. The circuit will become closed circuit when water get touch from both end of the circuit. When the red indicator light up, its mean that there are water inside the electronic housing and the experiment will stopped immediately.

Figure 4.8: Buoy condition from rear view

Figure 4.9: Buoy condition from front view

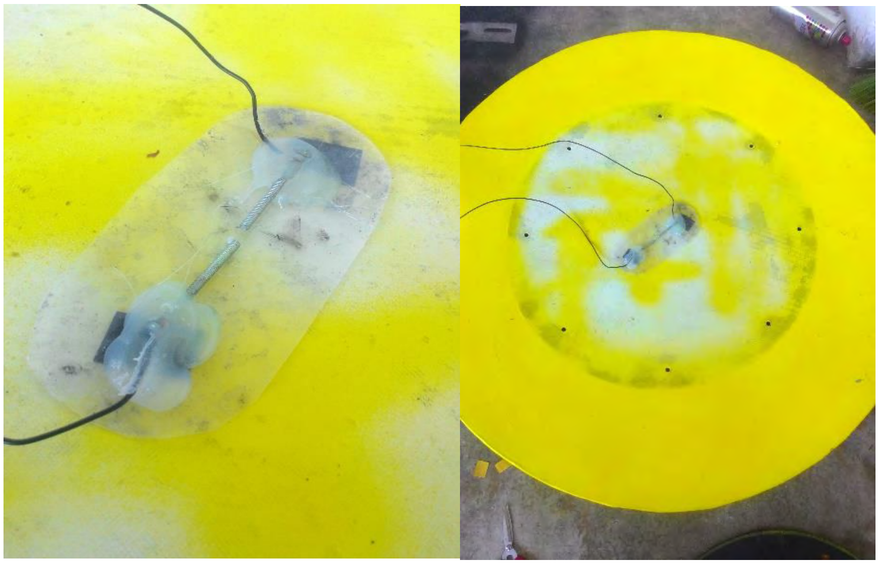


Figure 4.10: The position of leakage sensor

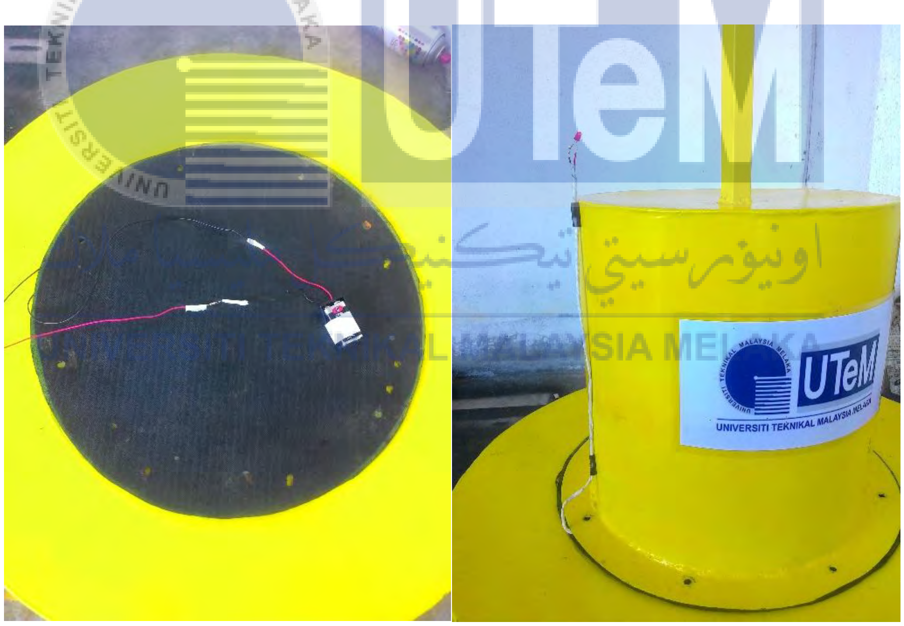


Figure 4.11: Power source and its indicator

4.4.3 Experiment 3: Stability Test

IOOS buoy wells are not rated for submersion, so proper ballast weight is critical to ensure that the buoy does not overturn, including when subjected to additional loading such as wave, rain, and high wind. The larger the distance from the location of added weight to the center of gravity, the greater the effect on the stability of the buoy will be. For example, if a weather sensor is mounted 1.00 meter above the water surface, it will cause more instability than if it were mounted 0.50 meter above the surface and, as a result, would require more subsurface ballast weight to counterbalance the buoy. Conversely, a ballast weight added further below the surface will provide a greater stabilizing effect than the same size weight mounted closer to the surface.

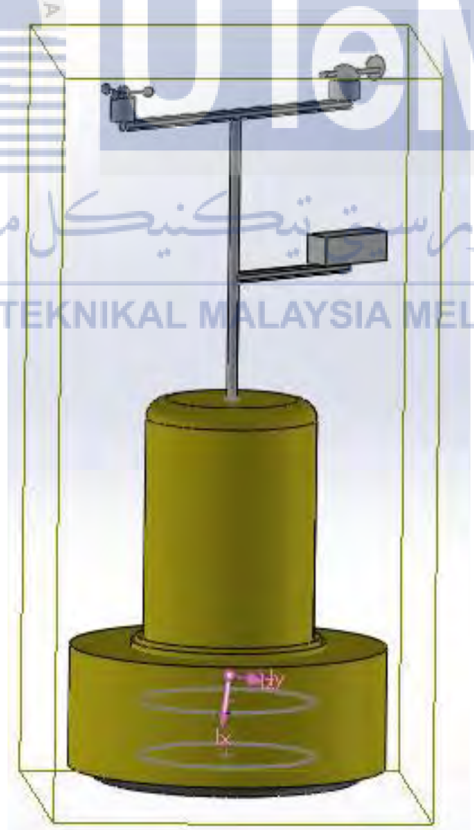


Figure 4.12: Center of gravity of the buoy

From the test that have been done, the total weight of the buoy is equal to 15kg or equal to 150N. It also equal to the weight of water displace. So, the buoyance force for this buoy is equal to 150N. Buoyance force is an upward force exerted by a fluid that opposes the weight of an immersed object. The two forces, weight and buoyancy, are equal but in opposite direction. Based on Figure 4.10, the center of gravity for this buoy is 0.16 m from the base of the buoy. The center of gravity is find using SolidWork. Refer to Figure 4.11, the center of buoyancy is 0.07m. The center of gravity is the average location of the weight of an object. Its can completely describe as the motion of any object through space in terms of the translation of the center of gravity of the object from one place to another, and the rotation of the object about its center of gravity if it is free to rotate while center of buoyancy is the centroid of the immersed part of a ship or other floating body, in this case is the immersed part of the buoy.

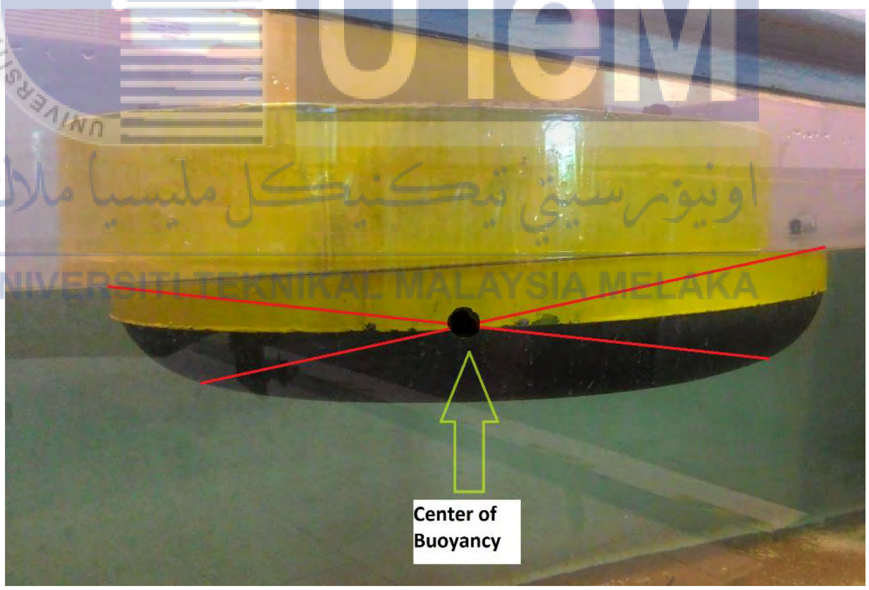


Figure 4.13: Center of buoyancy of the buoy

To calculate the stability of floating object, we need to know metacentric height of that floating object. If the metacenter, M lies above the center of gravity, G, then the body is stable. In other words the metacentric height, MG, is positive. If the metacenter, M lies below the center of gravity, G, then the body is unstable.

The metacentric height, MG is given by

$$MG = MB - GB \tag{4.1}$$

Before we can calculate MG, we need to calculate MB and GB first. So, to calculate MB, we are using $MB = I / V_S$. Note $I = \pi D^4/64$ for a circular section body and V_S is volume of buoy.

<u>Part 1 Top Buoy</u>

$$I = \pi (0.36)^4/64 \tag{4.2}$$

$$= 0.0008 \text{ m}^4$$

$$V = \pi h r^2 \tag{4.3}$$

$$= \pi (0.36) (0.18)^2$$

$$= 0.0366 \text{ m}^3$$

<u>Part 2 Bottom Buoy</u>

$$I = \pi (0.72)^4/64 \tag{4.4}$$

$$= 0.0132 \text{ m}^4$$

$$V = \pi h r^2 \tag{4.5}$$

$$= \pi (0.16) (0.36)^2$$

$$= 0.0651 \text{ m}^3$$

<u>Final Calculation</u>

$$I_T = 0.0008 + 0.0132 \tag{4.6}$$
$$= 0.0140\ m^4$$

$$V_T = 0.0366 + 0.0651 \tag{4.7}$$
$$= 0.1017\ m^3$$

$$MB = \frac{I_T}{V_T} \tag{4.8}$$
$$= \frac{0.0140}{0.1017}$$
$$= 0.1377\ m$$

$$GB = 0.16 - 0.07 \tag{4.9}$$
$$= 0.09\ m$$

$$MG = 0.1377 - 0.090 \tag{4.10}$$
$$= 0.0477\ m$$

Stability of a floating body was inspected by energy principle. This formulation makes it easier to solve such problems without referring to the concept of the metacenter. Archimedes' principle was derived too by considering the energy principle. If the vertical distance between center of gravity of the body and the center of buoyancy is calculated versus a set of suitable coordinates, it is straightforward to find any information about equilibrium positions of the body. The metacenter of the buoy is equal to 0.0477m that mean it have positive value and greater than 0. The buoy have good stability and achieve its objective to work as underwater platform.

4.4.4 Experiment 4: Disturbance Test

Table 4.15: Buoy condition

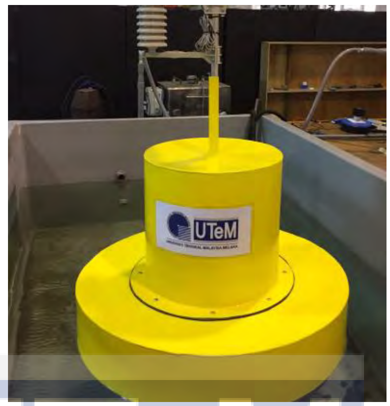
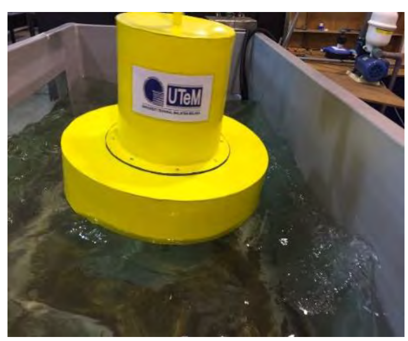
Level of Disturbance	Buoy Condition
Low	
Medium	
High	

Table 4.15 show buoy condition when disturbance test are in progress. This experiment must be done when the water at rest. Besides, it should not have external forces occur when this experiment occur like gust of wind or any movement in the water. For the first test, low force is applied to the water surface. When it happened, the buoy is still like at rest or no major movement on it. The observation mostly concentrate to the tilt angle of the buoy.

After that, medium force is applied to the water. Result from the table 4.15 show that the buoy have slightly movement. The tilt angle is about 20° but the buoy still showing the stability and immediately return to its initial position. The result show this buoy can accept medium disturbance even it already have additional load on it.

Finally, strongest disturbance had applied to water. The buoy have largest movement at least at 45° the tilt angle. Although time taken it wobble in long term period, but the buoy can hold the pressure. The buoy can still in the right position and not turn upside down. This means the hardware that have been fabricate is done successfully. The first object is achieve.

4.4.5 Weather Station Results

Table 4.16 shows the results that have been obtained from the weather station on the buoy.

Table 4.16: Weather station result

Date	Temperature (°C)	Relative Humidity (%)	Rain Fall (mm)	Wind Speed (m/s)
19/11/2015	30.9	68.3	0.0	1.8
20/11/2015	29.0	86.0	0.0	1.7
21/11/2015	28.8	84.5	3.0	3.1
22/11/2015	29.4	79.8	0.1	1.6

The result obtained shows the result for temperature, relative humidity, rain fall and wind speed that have been recorded using weather station on the buoy. Each parameter have been taken its data from 4.00 p.m until 6.00 p.m for four days. In one day, the reading have been recorded for 3 times by 1 hour interval for each reading. The result in this table is an average data for all parameter in a day. Figure 4.14 and Figure 4.15 shows the experiment is being conducted and the data have been recorded.

Figure 4.14: The data when raining have been collected

Figure 4.15: The experiment when sunny day

CHAPTER 5

CONCLUSION

5.1 Conclusion

This chapter discuss about the conclusion of the project, which is the whole project that have be done after all design and development of the mechanical and the electrical part as well as the controller from the beginning with the literature study until the result and analysis were implemented of the project. Other than that, this chapter also states the recommendation for the future development and more efficiently rather than previous system.

At the end, this project can be conclude that the first objective of this project is achieved. The first objective in this project is to design and development of Integrated Ocean Observation System (IOOS) buoy for underwater station. It started by designing the body structure of the buoy by using SolidWork software. After that, for the development of the buoy, the material selection had been conducted. It was important for body structure in order to get low cost material that can withstand the extreme environment and anti-corrosion.

Besides the structure of the buoy, this project also need to make sure that the electronic housing should be waterproof. This is because the buoy will placed in the environment that water is present. It should be waterproof to protect all the circuit and electronic component in it so that it can carrying its duty as Integrated Ocean Observation System (IOOS) buoy and also as source of power supply to underwater vehicle. If water can enter the electronic housing, it will not only damage the weather station circuit but also can broke down microcontroller board of underwater vehicle.

The buoy design is perfectly stable when there are additional load in range 10 kg to 20 kg. So, other sensor, oceanographic and meteorological data equipment and solar panel can be install on it. Other than that, the weather station is function well. It can record data every 5 minute sample interval.

Hence, after completing this thesis, all the objectives were successfully been fulfilled in order to design and develop the Integrated Ocean Observation System (IOOS) buoy for underwater station.

5.2 Recommendation

In order to improve this project, there are several recommendations that have been identified throughout the project. Firstly, to improve the safety of the ballast tank of the buoy. It should use high endurance of material besides using tyre tube that can easily leak if sharp object struck on it. Other than that, for disturbance test, it should use Inertial Measurement Unit (IMU) so that more analysis and result can be obtain through this device. By using this device, it also can have more accurate and precise data and surely this report can be use as reference to other project that need the exact data and result or guideline to do the same experiment. In addition, this buoy also will equip with hydrophone, an underwater camera, and an omni-directional surface camera to capture audio and visual information from the marine environment. This hydrophone and camera can be configured to automatically respond to certain trigger to initiate the recording and capturing.

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