DESIGN AND DEVELOPMENT OF PORTABLE WATER TREATMENT SYSTEM

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This report is presented in partial fulfilment of the requirement for the

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DECLARATION

I declare that this report entitles “Design and Development of Portable Water Treatment System” 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 the candidates of any degree.

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Date : 16 May 2018

APPROVAL

I hereby declare that I have read this report and in my opinion, this report is sufficient in terms of scope and quality for the award of Bachelor of Engineering in Mechanical Engineering.

Signature : ……………………………........................

Supervisor Name : Mohd Nazim Bin Abdul Rahman

Date : …………………………………….

DEDICATION

This report work is dedicated to my beloved father and mother, Mr. Othman Bin Molok and Madam Normah Binti Ismail whose have been a continual source of encouragement and support to overcome the challenges in engineering school and student life.. I am grateful for having you in my life. This work is also dedicated to my friends who have support and always help me. Without whose helpful support, it would not have been possible for me to complete this report.

ABSTRACT

Nowadays, many people suffer the lack of access for a clean drinking water. This problem also may cause to the death. It is happened because they do not have a proper water treatment system. In fact, current water treatment system comes in big scale of size and cannot be transported to the needed place. Therefore, the purpose of this project is to design and develop a portable water treatment system. This project will design a portable water treatment system that will work as well as any other current water treatment system. The outcomes of this project also will fulfil other requirement needed by the people such as reasonable price and easy to handle. A detail study on current water treatment system are made to develop and design the portable water treatment system that will produce a clean drinking water that is in line with the established standard of Water Quality Standard by the Ministry of Health Malaysia (MOH). The chemical dosing involve in the water treatment also must satisfy the guideline from the MOH. The final design of the water treatment system has been prove success as it has pass the analysis process. The final design also has follows all the guideline and requirement. A further study for the dosing process has been assign in order to improve the effectiveness of the final design.

ABSTRAK

Pada masa kini, ramai orang mengalami kekurangan akses untuk air minuman yang bersih. Masalah ini juga boleh menyebabkan kematian. Ia berlaku kerana mereka tidak mempunyai sistem rawatan air yang betul. Malah, sistem rawatan air semasa, datang dalam saiz yang besar dan tidak boleh diangkut ke tempat yang diperlukan. Oleh itu, tujuan projek ini adalah untuk merekabentuk dan membangun sistem rawatan air mudah alih. Projek ini akan merekabentuk sistem rawatan air mudah alih yang akan berfungsi sebaik sistem rawatan air semasa yang lain. Hasil projek ini juga akan memenuhi keperluan lain yang diperlukan oleh pengguna seperti harga yang wajar dan mudah diuruskan. Satu kajian terperinci mengenai sistem rawatan air semasa dibuat untuk membangun dan merekabentuk sistem rawatan air mudah alih yang akan menghasilkan air bersih yang sejajar dengan Standard Kualiti Air yang ditetapkan oleh Kementerian Kesihatan Malaysia (KKM). Dos kimia yang terlibat dalam rawatan air juga mesti memenuhi garis panduan dari KKM. Reka bentuk terakhir sistem rawatan air telah membuktikan ianya berjaya kerana ia telah lulus proses analisis. Reka bentuk akhir juga telah mengikuti semua garis panduan dan keperluan. Satu kajian lanjut untuk proses dos telah diutarakan untuk meningkatkan keberkesanan reka bentuk tersebut.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

SUBSCRIPT	**DEFINITION**
PAC	Poly Aluminium Chloride
MOH	Ministry of Health
HOQ	House of Quality
PDS	Product Design Specification
ANSI	American National Standards Institute
CATIA	Computer-Aided Three-Dimensional Interactive Application
FEA	Finite Element Analysis
BOM	Bill of Material

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The idea of invention the portable water treatment system comes from the flood that struck Malaysia every year when the monsoon season is happening. The flood will cause the lack of clean drinking water access as the surrounding sources of water are contaminated. During that situation, the access of clean drinking water not only become important but also the needed of clean drinking water increasing compare to the normal situation. The lack of clean drinking water in other countries also brings lead into this creation.

Red Cross (2005) stated that over 1.1 billion people lack access to safe drinking water. It causes over 2.2 million people die from unclean drinking water every year. From these deaths, 90 percent of them are children under five years old. Moreover, 4500-6000 children die from water related diseases as reported by British Broadcasting News.

Nowadays, there are many water treatment processes include reverse osmosis water treatment plant, ultraviolet purification system, household water purifiers and desalination plants. All these products and systems quite expensive and required a specialist to run and control the process. Moreover, the size and the complexity of the systems will limit the portability.

This project will bring into an invention of portable water treatment system that is easy and simple to handle.

1.2 Problem Statement

Water is a substance that is essential for life, yet 1/6 of the global population lacks access to clean drinking water. We are facing a global water crisis. In fact, providing access to a clean drinking water has even identified as one of the 14 grand challenges that our planet is facing. For example in India of Africa, some of the people are drinking the water from a stagnant pool that is surely dirty and contaminated. In Malaysia, majority of the residents can get an access to the clean drinking water supply. Only a small percentage of the resident who lives in an inland having a difficulty to get a clean drinking water access. However, when the Monsoon season arrive, which is usually from November to March, some places like the East Coast states, will experience floods. This is when the lake or river water becomes quick source for drinking water.

For the water treatment system, the current product or the current system comes in big scale of size and some of them needs a big source of current supply to run the system. As a result, the user will have a limitation, as the product only can be use at the particular area. Moreover, the current water treatment systems are expensive. Finally yet importantly, the current water treatment systems are complex to handle and difficult to understand.

1.3 Objective

To design a portable water treatment system.

1.4 Scope of Project

The scopes of this project are:

i. The target water for this water treatment system is the flood in Malaysia residential.

ii. The water treatment system must be portable.

iii. The output water must meet the Drinking Water Quality Standard by MOH.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section explain about the Literature Review of the study based on the journal, books and internet. That information can be achieve through the website and the library. There is a summary of the information or any related knowledge, which can guide and lead the study case.

2.2 Aeration

Generally, aeration is a process of mixing or circulated air with liquid. This method propose was to increase the oxygen saturation of the water. This process bring the liquid and air closely contact by exposing drops or thin sheet. This aeration process consist two method to collect the oxygen into the system. There is passing the liquid through air such as fountains, paddle wheels or cascades. Secondly, the passing air through the liquid such as venture tube or compress air. The first method is absorption of oxygen when the water coming out of the fountain and return back into the tank. Next, the second method is, there is tube of ceramic and combine with the diffuser in purpose to dispersion the fine air or gas bubble into liquid. In this case, there is small bubble produce in the tank and supply the oxygen into the system. Then, let the air producing arise through the water. Besides, the more exposed gas to the liquid will increase the efficiency of the gas transfer. According to Kossay K. Al-Ahmady, (2006) [1], aeration system determine the effect of coverage area of diffusers and the percentage of oxygen absorption. This aeration process is a sub process of producing a clean water. In other words, this aeration is a part of treatment required to produce the clean water. The other name of this process also known as aerification process. This stage would the important roles, as it was an effective method to reduce the contaminants. This method is treated domestic waste by remove the nutrients and the odour issues without producing other environmental problems.

The both processes and procedure are producing the desired same results [2]. Next, there is two main physical process of the system that is scrubbing action and oxidation of certain gases. The function of the scrubbing action is to mix the water and air together. Therefore, the process can be faster as the scrubbing action physically remove the gases from the any solution in water. This situation enhance them to escape into surrounding air. As this process need only the oxygen gases, the scrubbing action can remove the carbon dioxide and hydrogen sulphide. Indirectly, it remove the water from taste and odour problem. Meanwhile, the oxidation process is the phase of removal of certain mineral and gases from the water. Then, the process produced the unwanted material in the water. The suspended material can be remove by the filtration process. In holistic, the efficiency of the aeration process depending on the amount of the surfaces contact between the water and air.

2.3 Coagulation and Flocculation

Coagulation and flocculation is the stage of remove turbidity, bacteria, taste and odour. The treatment involved typically for surfaces water. Generally, those treatment are used to separate and easier to remove the suspended solid substances from water. The objectives in this phase is to change the surface change of the particles. The suspended solid in the water are having the same charge and make them repel each other when they in closed position. That situation lead them come close together after the violation. Therefore, the particles can combine completely and stick together forming the large particles. Then suspended substances will remain in suspension and will not stick together. Those particles will settle by the gravity. The particles produced called floc.

This treatment consist several steps, and should run in succession. This way allowed the particles to collide each other then become floc. Both process are related and need to be complete as the process to remove the suspended solid [3]. Then, the sedimentation phase can run successfully. The flocculation stage is synonym with the mixing stage. The stage is undergo the mixing of chemical to increase the size of the particle by make them collide each other. The differences size of the particles is from sub microscopic micro floc to visible particles. The collision occur make them to bond and stick then increase in size. The floc will continue to build, as there is still have collision on the system. Next, the macro flocs produced with high molecular weight polymers and it may use to help bridge and strengthen the floc. Finally, the water is ready for the next stage once the floc reached it optimum strength and size.

Next, this treatment has their own coagulant reagents. The commonly used for this phase is metal coagulations. The metal coagulation have divided into two categories. The categories based on aluminium and another based on iron. The aluminium based coagulant most widely used and probably known as aluminium sulphate [4]. The aluminium sulphate called “alum” was been used for the water treatment for long decades ago. It made up from the reaction of bauxite ores and sulphuric acid. Any kind of the product produced from “alum” is acidic. It made up as a liquid and mainly used industry. This application of metal coagulations is widely spread because the relatively save the cost. In addition, it is simpler application route to apply.

Besides, there is another coagulant reagent that produce according there are many chemical coagulant that used in water purification releasing harmful substances. This study focusing on rural area as that place becoming major focus. Cactus trees seen as a suitable reagent coagulant and the objectives of the study to identify and analyse the coagulant activity of cactus powder using the jar test [4, 5].

2.3.1 Jar Test

The jar testing is a method of simulating a scale of water treatment process. This test providing a reasonable system of the way a chemical treatment will operate. Besides, it helps the researcher to identify which treatment chemical can work the best with their raw water. There is different value of coagulant use and it cannot be same with the other researcher. This due to the raw water came from different way and sources. The jar test carried as a pilot-scale test of the chemical treatment that used in a particular water plant. It is simulates the coagulation and flocculation process for producing water treatment.

The jar testing needs some adjustment of the amount of chemical treatment and the sequence of the raw water. The best way to achieve the optimum value, the jar test need to run for several beaker in the same time, refer Figure 2.1. There is a proper procedure can be run to achieve the best result of the jar test. The following procedure below uses the aluminium sulphate as the coagulant material.

Figure 2.1: The Jar Test Machine. Taken from "Coagulation and Flocculation." *Introduction to Potable Water Treatment Processes*, Mar. 2009, pp. 26–42., doi:10.1002/9781444305470.ch3.[3]

Procedures

1. Prepare the six-gang jar tester and the chemical (aluminium sulphate) for coagulation reagent.
2. Add 1000 millilitre (mL) water into each of the jar beakers of 1000 millilitre (mL) graduated cylinder.
3. Alkalinity the raw water before the start the mixing phase.
4. Prepare the stock solution by dissolving 10 ppm of alum into 1L raw water.
5. Repeated the same procedure and add another 20 ppm, 30 ppm, 40 ppm, 50 ppm, 60 ppm for every beaker provided.
6. After dosing each breaker, turn on the stirrer to stir the substance in certain period.
7. Observe the particles inside the breaker and make the comparison of the colour and substances contain.

2.3.2 Formula to Calculate the Coagulant Dosing

Example:

- From the jar test, the chosen value is 30 ppm
- Flowrate raw water: 4.545^3m/hr
- Specific Gravity coagulant: Standard Gravity PAC=1.31

Formula $= \dfrac{\text{Dos Optimum (ppm) x Flowrate Raw Water } (\text{m}^3/\text{hr})}{\text{1000 x Standard Gravity}}$

$= \dfrac{\text{30 ppm x } 4.545^3/\text{hr}}{\text{1000 x 1.31}}$

= 104.0 L/h

2.4 Sedimentation

Sedimentation is another physical water treatment process that removes suspended solid from water by the gravity. Settling by gravity is the most extensively applied for remove the suspended solid from water and wastewater. The solid substance produced by the turbulence movement may be discard naturally by sedimentation process. This process required for high turbidity water that detention time about two to four hour [7]. The particles settle from the suspension become sediment and in water treatment process, it called as sludge. This phase of treatment functional as to reduce the concentration of the particles in suspension before or after the coagulant phase. In this study, the sedimentation treatment was applied after the coagulant as a purpose to reduce the concentration of solid substances in suspension. Therefore, the next phase can function more efficiently.

In general, there is two aspects concern to clarify the water. It is the flow pattern through the tank and the settling characteristics of the particles. Firstly, the flow pattern need to clarify based on the configuration of the tank and the parameter involves such as water flow rate, solid concentration and temperature. The second part is about the characteristic of the particles that concern about shape, size and interaction of water through buoyancy and drag force. Next, there are several types of sedimentation tanks in the water treatment which influents certain parameter [8]. The common types of sedimentation tanks are horizontal flow tanks, radial flow tanks, inclined settling and ballasted sedimentation. Those types consist different parameter as it influences the sedimentation process.

The horizontal flow tanks are the simplest tanks of sedimentation is the water treatment. This treatment is to fill tank or jar with water. Then, leave the water for a long enough time to make the particles to settle and remove the resulting water without the sediment. This way of practice was rarely used in this particular area. Generally, this simplest method is use rectangular tank at ended outlet with the horizontal flow. The water with the particles in suspension will be introduced at the end of the tank and the water flows oppositely to the end of the tank settlement. Clearly, this parameter used to achieve a large proportion of the settling particles manage. Then, reach the tank floor before the water is remove out from the tank. The flow is such horizontal flow tanks and built with a floor that sloping down to the inlet end to the hopper. Then, the tank is combine with the hydraulic to scrape all the sediment from the inlet end to the outlet end. This action makes the water flow uniformly and more fluent.

Next, the radial flow tanks. This tanks are circular in shape with the inlet at the centre and the peripheral outlet. This tanks need to concern about the shape and design as to support uniform distribution of flow blow to the whole tank. Then, the sediment will scrape to a central to discard. Sometimes, the circular tanks need additional features in the middle for flocculation. Then, ballasted sedimentation is the differences between the particles and water produced by coagulation and flocs. Generally, they produced in very small size and they settle slowly.

The inclined settling was the most frequently used in the industry. This settling tank size is governed by the time to be allowed for particles easy to settle trough the depth of water. Normally, the inclined settling constructed with light material which can easily positioned in the tank. The flow can be co-current, cross-flow or counter flow. In the co-current arrangement, the flow moves towards downward between the plate and the direction of settlement particles. The counter-current arrangement is the water flows upward between the plates against the direction of the settlement particles. Lastly, there is water flow cross the plate at the right angle towards the direction of particles settlement. There is need to maximise the distribution flow of water within and between the plate to maximise the efficiency of the particle removal. Besides, the inclined tube can use in the same arrangement except the cross flow arrangement. The tube modules can be constructed in variety ways since the cross-sectional shape of the tube can perform various forms.

2.5 Filtration

In this section describe the next stage of the standard water treatment process. The water treatment may slightly different depending on the technology and the water sources of the plant. The principles are normally the same for all the process. This process used to treat and filter the particles that are too small. These small particles were escaped from the sedimentation process. According to (Devadas, 1984) the provision of quality and good sanitation of water services is vital for the protection of human resources.

Slow sand filtration process is the process of physical filtration of particles or biological removal of any organics in the upper biologically layer of the sand bed called as biofilm. It been identified by technology for drinking water treatment in rural area. This process has been suggested to recognize as a technology for removing water borne pathogens and remove the turbidity. Based on several research and investigation, there is material and method concern on this process. This phase of the process played an important role to make sure the hygiene and safe water supply guaranteed.

The materials concern in this phase is the filter basin. The filter basin can be constructed using various of materials such as earthen berm construction or concrete. Besides, the selected material influences by the size of the filter basin and the sources of raw water. The turbidity test is used for different sources of raw water with high turbidity. The test functional to determine the efficiency of the slow sand filter and reduce the turbidity. Normally, the small size of filter basin can be constructed from polyethylene or fiberglass [12]. Those materials provide uniform flow rate. The gravel coarse functional to make the under drain medium. It is important to measure the grain and sorted through mechanical sieves. This action to prevent the clogging and make the flow smoothly. Therefore, it is important to have the effective size to produce the uniform coefficient. The inlet or outlet flow is controlled by slow sand filter. The flow can be either constant or declining rate. Finally, the outlet to drain is the treated water.

Next, the method of the operation of the slow sand filter undergo the formation of gelatinous layer. The layer also called as hypogeal layer that formed in the first 10 to 20 days of operation. The layer consists bacteria, protozoa, fungi and a range of aquatic insect larvae. The surfaces biofilm is the layer that provides the effective purification in water treatment and the sand support medium this biological treatment layer. The foreign matter will trap in the mucilaginous matrix and the soluble organic materials is absorbed by the water passed through the hypogeal layer. The water produced from exemplary show sand filter in excellent quality [11]. The biofilm need to discard as the thickness of it can slowly reduce the performance of the slow sand filter. There are two methods commonly used to refurbish the filter. Firstly, the fine sand need to discard and scraped as to expose the expose a new layer of clean sand. The second method is wet harrowing that involves lowering the water level just above the hypogeal layer. Then, stir the sand to make the participate solid held in the layer and allowing the remain water to wash the sand. The filter column will be filled to full capacity and the system back into services.

Holistically, this slow sand filtration produces an effluent the turbidity, free impurities and virtually free from bacteria. The main performance of filtration is to remove the bacteria, viruses and parasites. The variation in bacteria removals can be attributed from differences water sources quality condition. Then, the filter operation also plays an important role to remove the small substances, virus and parasites such as giardia and cryptosporidium.

Table 2.1: The Filtration Stage of Water Treatment in Malaysia. Sources from "Bertam Water Treatment Plant" [16]

Stages of filtration	Size (mm)	Depth (mm)
1. Course gravel	6-15	150
2. Fine gravel	2-5	75
3. Course sand	1-2	75
4. Anthracite	0.85-0.95	400

2.6 Disinfection

Drinking water safety affected by the presence of disease such as human viral pathogens. Water disinfection act as deactivation, removal or killing the pathogenic microorganisms. Pathogens is very dangerous microorganism as it can bring diseases towards the people that drink the water without killing them. The entire water source from surface water or ground water need to undergo this process. According to (EPA, 2008)[4], it is a must for all the raw water and wastewater to have disinfection process. This method for ensuring the safety of drinking water supply and risk management approach in water supply from catchment towards consumer. This disinfection process is affected by processes involving coagulant chemical, sedimentation and followed by filtration and other filtration process.

Currently, the world use of water supply with the disinfection as a prevention risk of public health. Drinking water treatment obviously can reduce high numbers of pathogens. However, many of the disinfection chemical is overdosed and used inappropriately [13]. There are several ways to make disinfection in the water treatment. The most common chemical disinfection for water treatment is chlorine. This treatment is generally obtained as liquefied chlorine gas or sodium hypochlorite solution.

Next, the materials and method is the two concern things in disinfection process. According to (Alyaa M. Zyara et al., 2016)[5], ultraviolet (UV) irradiation is an another way to disinfect water. Unfortunately, there is some viruses can resist to UV. Drinking was disinfected with UV after penetrate with MS2 other different coliphages isolated from municipal wastewater. Some of the coliphages were disinfected with combination of chlorine and UV treatment. Besides, some UV-resistant coliphages used to combine with MS2 to produce a very good indicator for viruses in UV-disinfection test [14]. The coliphages were isolated from wastewater as described before [11] by using double layer technique. Disinfection of this method was carried out with the collimator device at low pressure of mercury arc lamp. The sources used is UV irradiation and the lamp was turned on for certain period before initiation of the experiment obtain constant UV output of intensity.

2.6.1 Formula to Calculate Chemical Dosing

2.6.1.1 Fluoride (fluoridation)

Example:

- The target of fluoride remains in the clean water = 0.6ppm
- Flowrate of the raw water = 3.220m^3/hr (17MGD)
- Concentration of Fluoride = 0.5%

$$\text{Dosing} = \frac{\text{Fluoride balance (ppm)x Flowrate}(m^3/hr)\text{ x 100}}{\text{1000 x Concentration}}$$

$$= \frac{0.6\text{ppm x } 3.220\ m^3/hr \text{ x } 100}{1000 \text{ x } 0.5}$$

= 389.4 L/hr

2.6.1.2 Chlorine (chlorination)

Example

- The balance of chlorine remains = 3.5ppm
- Flowrate raw water = 4.545m^3/hr (24MGD)

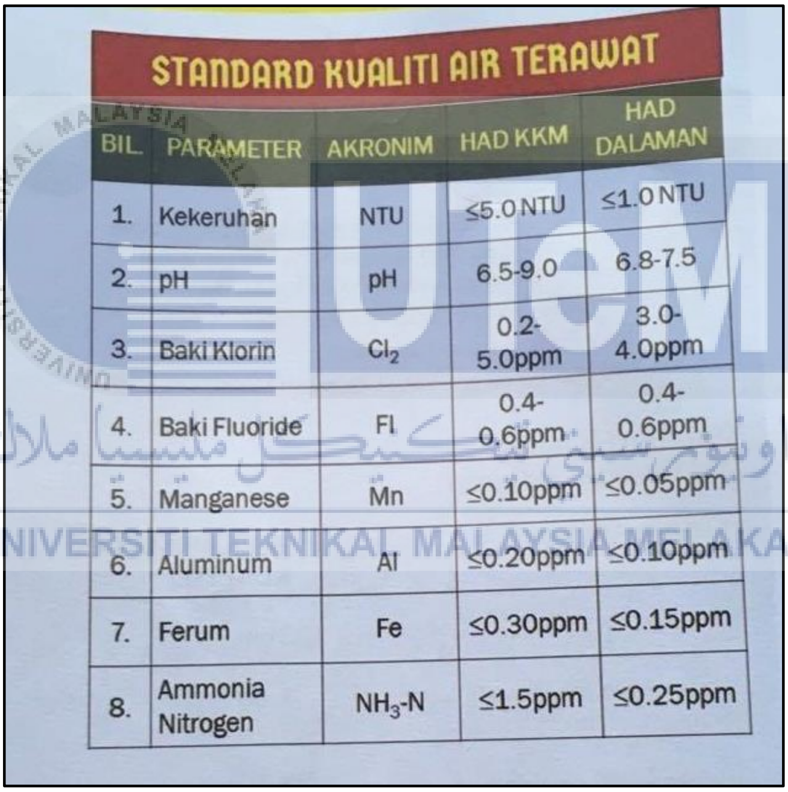
$$\text{Dosing} = \frac{\text{Chlorine balance (ppm) x Flourate }(m^3/hr)}{1000}$$

$$= \frac{3.5\text{ppm x } 4.545 m^3/hr}{1000}$$

= 15.90 kg/hr

2.6.2 Standard Drinking Water Quality

After all the process of water treatment has been done, the output water, which called clean water, must done some tests before it's been delivered to the user. The purpose of the tests was to see whether the clean water produced reach the water quality standard that has been determined by the Ministry of Health (MOH). There was some parameter that need to be observed, refer Figure 2.2.



STANDARD KUALITI AIR TERAWAT

BIL.	PARAMETER	AKRONIM	HAD KKM	HAD DALAMAN
1.	Kekeruhan	NTU	≤5.0 NTU	≤1.0 NTU
2.	pH	pH	6.5-9.0	6.8-7.5
3.	Baki Klorin	Cl_2	0.2-5.0ppm	3.0-4.0ppm
4.	Baki Fluoride	Fl	0.4-0.6ppm	0.4-0.6ppm
5.	Manganese	Mn	≤0.10ppm	≤0.05ppm
6.	Aluminum	Al	≤0.20ppm	≤0.10ppm
7.	Ferum	Fe	≤0.30ppm	≤0.15ppm
8.	Ammonia Nitrogen	NH_3-N	≤1.5ppm	≤0.25ppm

Figure 2.2: Water Quality Standard by MOH of Malaysia. Taken from "Bertam Water Treatment Plant" [6]

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the methodology used in this project to design the portable water treatment system. The flow chart of the project is shown in Figure 3.1. All the processes involved were based from the flowchart. Briefly, this project starts by studying the process of water treatment from the current treatment and ends by designing the whole system. All the in between steps also will be explained in this chapter.

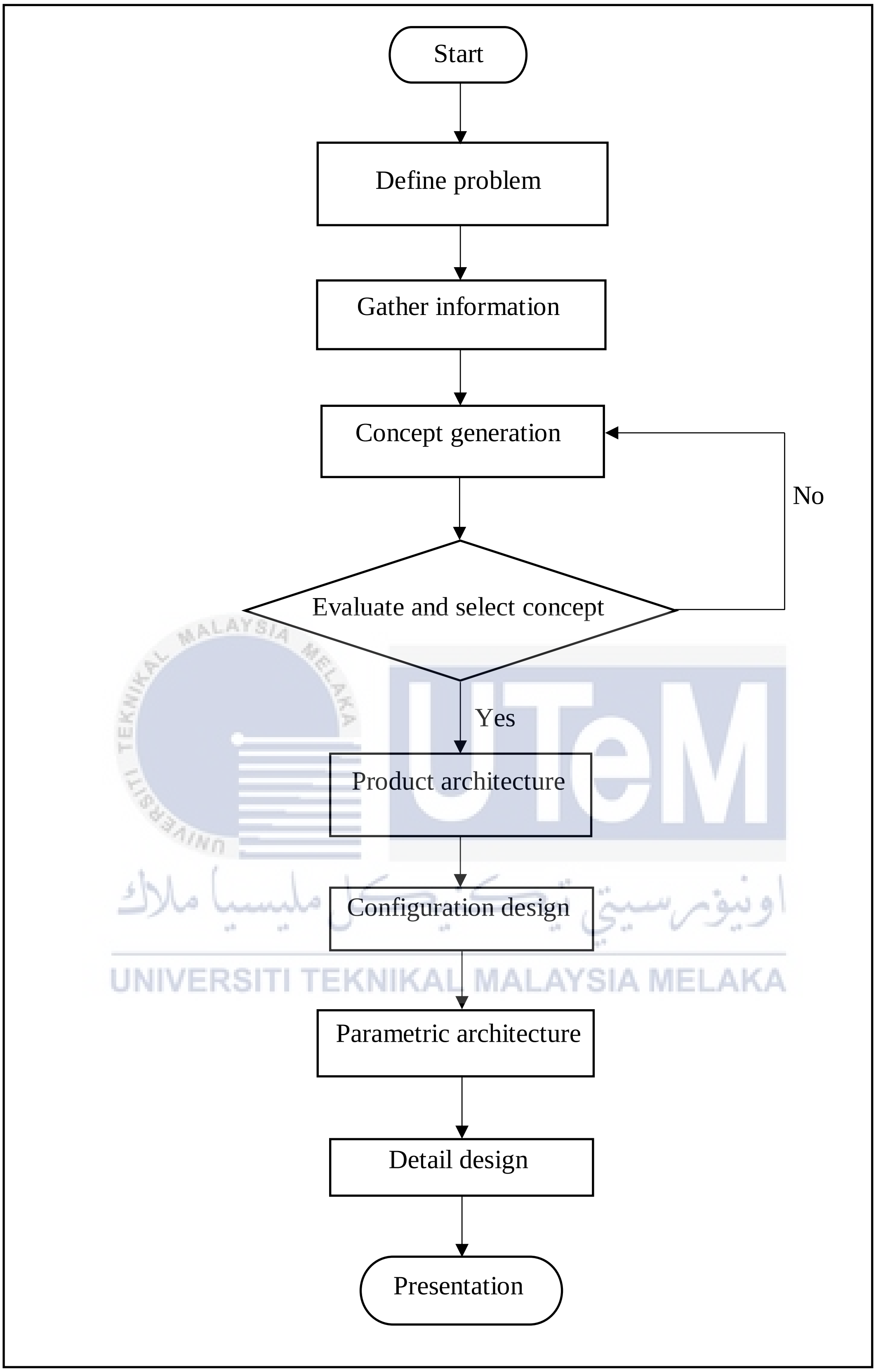


Figure 3.1: Flowchart of the Project.

3.2 Define Problem

3.2.1 Problem Statement

Before started, the first and the compulsory step in understanding the target of this project is define the problem statement. The researcher needs to understand and clear about the problem statement in order to prepare the suitable methodology. The researcher was done some investigation about the flood happened, generally in the whole world and mainly in Malaysia. The overseas' flood was investigated based on the news, journals and some articles related. While in Malaysia, interviews were held with the people who live in the area that flood always happened like the east coast state such as Kelantan and Terengganu. All the information was recorded and will be the guideline for the customer requirement.

3.2.2 Benchmarking

To get the best specification the water treatment system, the researcher was go to Bertam Water Treatment Plant to see the actual system of the water treatment process. The information gathered will be compare with another water treatment system available. The aim of this step is to determine which of the systems that have the greatest potential that will be apply into this project. All the factors related will be considered.

3.2.3 House of Quality (HOQ)

Based from the customer requirement and the information gathered from the benchmarking process, a house of quality was made. A survey also has been made to get the weight of the customer requirement. The result of this house of quality will be used to do the product design specification and concept generation.

3.2.4 Product Design Specification (PDS)

Before applying the result of the house of quality into the concept generation, the data was gone through the product design specification to get the further details of the design of the product. The obtained data was explored and expanded meticulously in order to produce the most relevant specification for the system.

3.3 Gather Information

3.3.1 Internet

Due to the fastest-growing communication medium, internet acted as the major source for this project. From the internet, many websites provide the information about water treatment process. The researcher also was gone through certain website such as YouTube to see the simulation of the water treatment process. It also contains the video about the pre-process, current process and post-process.

3.3.2 Journal

Many journal has been get from the internet. Journal is one of most the trusted source of information because it was verified and checked. From the journal, the researcher was gathered the information of the past research about the water treatment and was combine the data with the current data. The journal also serves as a reinforcement of design specification ideas.

3.3.3 Interview

The researcher was go to Bertam Water Treatment Plant to do a visit and was had an interview with the technician in charge of one of the water treatment process, refer Figure 3.1. The visit helps the researcher to understand more about the water treatment system as the researcher can see the process of the water treatment in real situation. In that interview, the researcher also had asked the technician to give and opinion and ideas to improve this project.

Figure 3.2: The Researcher with the Technician at Bertam Water Treatment Plant.

3.4 Concept Generation

The most innovative products are the result of not only remembering useful design concepts but also recognizing promising concepts that arise in other disciplines.

3.4.1 Creative Thinking Methods

To get the better design, the researcher was push the creativity think as a means to produce the design that can fulfil the specification needed. The importance of this step is to enhance the ability to develop a wide range of approaches to a problem, to provide original solution to the problem and to bring out a large number of alternative ideas. The researcher also was neglect all the mental block to get the best result. A brainstorming also had been through with the aim of generating ideas for the design. A new kind of thinking was created by providing the solution of the problems stated.

3.4.2 Systematic Methods

For this method, morphological analysis was applied. The morphological chart was bring about to achieve a nearly entire enumeration of all potential solutions for design problems. The water treatment system was divided into several parts according to the stages of the process. Several solutions and ideas was formed for each part. These well-arranged ideas were help the researcher to do the evaluation and selection in the next part of methodology.

3.5 Evaluate and Select Concept

To get the best result, the researcher has evaluate and do the concept selection neatly. This is followed by a discussion of methods for evaluating and selecting between alternative concepts.

3.5.1 Decision Making

Based from the prepared morphological chart, the researcher was chose the best idea from each part and at the end, all those selected ideas was assemble to produce a complete system. During this decision-making, the researcher was considered about risk that will be taken. The decision made was based on available and relevant facts. The most important component in the decision operation is the judgment. The researcher was carefully done the judgment according to the understanding of the realities of the situation.

3.5.2 Decision Matrix

A decision matrix is an approach of considering competing consideration by listing the design criteria with weighing aspect and scoring the degree to which every design concept meets the criterion. The researcher was done this by convert all the earlier information from the HOQ, customer requirement and product design specification obtained into consistent set of values. Using the point scale, the researcher done the scoring process. Finally, all the scoring detail was help the researcher done the evaluation and select the best concept design.

3.6 Product Architecture

The architecture is the scheme by which the functional ingredient of the product are categorize into physical chunks and by which the chunks interact. The selected best concepts of each parts were arranged neatly to perform the whole complete system. The structure of the system was set up with the suitable arrangement that will suit the functionality of each concept selected. The capability of each part also been taken into consideration. The schematic diagram of the complete system was made with a focus on ease the researcher to get a better view of the water treatment system.

3.7 Configuration Design

In configuration design, the researcher was established the shape and general dimensions of the components. To start this configuration, the researcher was reviewed the PDS and any specifications prepared for the particular subassembly to which the component belongs. The spatial constraints that pertain to the product or the subassembly being design was established. The researcher was done some sketching as alternative configuration for some parts. These sketches was important aid in idea generation and a step for piecing together the unconnected ideas into design concepts. At this moment, the researcher was identify the likely ways the part might fail in service, identify likely ways that part functionality might be compromised, identify the materials and manufacturing issues and the design knowledge base. Finally yet importantly, the researcher was done the modelling of each part and decide the sizing of the parts.

3.8 Parametric Design

In parametric design, the design variables was applied from the attributes of the component identified in configuration design. An attributes of a part whose value is under the control of the designer is the design variables. For the purpose of improving the quality of the product, improvement of the robustness was done. Robustness means fulfilling magnificent performance under the wide range of situation that will be found in service. To complete this parametric design, the researcher has taken a few steps as below:

i. The parametric design problem was formulated.
ii. Alternative design was generated.
iii. The alternative design was analysed.
iv. The results of the analyses was evaluated
v. Refinement and optimization.

3.9 Detail Design

This is the final step in this methodology. All the details of the product that will be produce must has been completed here. The researcher was decided which components need to be buy and which component will be fabricated. If the component need to be buy, the supplier of the component also has been decided. Therefore, the selection and sizing of the components has been finished. While the most selection and size of the component already decided in previous steps especially for those components with parameters deemed to be critical-to-quality, some components may not yet have been selected or designed. This situation appeared for the component that needs for test data or Finite Element Analysis (FEA). Regardless of the reason, it necessary for the researcher to complete the drawing first.

3.9.1 Engineering Drawing

The researcher was completed all the drawing for each component. The drawing includes the standard views of orthogonal projection, that is top, front and side views, the auxiliary views such as sections, enlarged views or isometric views that aid in visualizing the component and clarifying the details, the dimensions according to the standard ANSI, the tolerances and manufacturing details, such as parting line location, draft angle and surface finish. The researcher also has prepared the assembly and exploded drawing in details to get the view of the complete system. After that, the researcher was listed down the bill of material for each component according to the finalised design specification.

3.9.2 Product Design Specification

Finally, after all the above step was done, the researcher was finalised the product design specification. The comparison between the earlier PDS with the details of the concept design was taken into consideration as to get the suitable final product specification. Only the requirement that meets the characteristic of the product been taken into the report.

CHAPTER 4

CONCEPTUAL DESIGN

4.1 Introduction

This chapter will explain about the process to design the product. Before the concept generation of the product is done, the researcher has finalise the requirement and criteria that the product need to fulfil. At the end of this chapter, the researcher will come out with one conceptual design that will be the guideline for the next chapter that is Product Architecture.

4.2 HOQ

Based from the data collected from the customer requirement and the survey performed, the House of Quality (HOQ) was made as shown in Figure 4.1. A survey also has been made to get the weight of the customer requirement. Later, during the publication of product design specification and concept generation, the information from this HOQ will be used.

4.3 PDS

Before applying the result of the HOQ into the concept generation, the collected information was gone through the product design specification (PDS) to get the further details of the design of the product. The obtained data was explored and expanded meticulously in order to produce the most relevant specification for the product. The PDS is shown as below:

i. Performance

a) To perform as a combination of tools and mechanism to build a complete water treatment system.
b) Able to be portable.
c) To provide a simple and quick water treatment process.

ii. Product Dimension

Size of the system (product) must not exceeds 2.80m x 1.65m x 3.20m.

iii. Costing

Manufacturing cost should be less than RM 10000.

iv. Product Finish

a) Corrosion resistant, which enable continued usage in long term.
b) Zero pollutant release to surroundings.

v. Product Material

a) Light weight
b) Durable and not easily damage or fracture by impact

vi. Customer Range

a) People who lives in a place where flood always happen.
b) National Disaster Management Agency

vii. Quantity of output

The quantity of the clean water supply from the water treatment process should be minimum of 15 litres per cycle.

4.4 Concept Generation

After gone through all the data from the HOQ and PDS, the researcher finally has come out with one concept generation that will fulfil the entire requirement mentioned. The concept generated not only created based on HOQ and PDS, but also based on information collected during the interview session between the researcher and the technician from Bertam Water Treatment Plant. The concept generated is shown in 4.2 below.

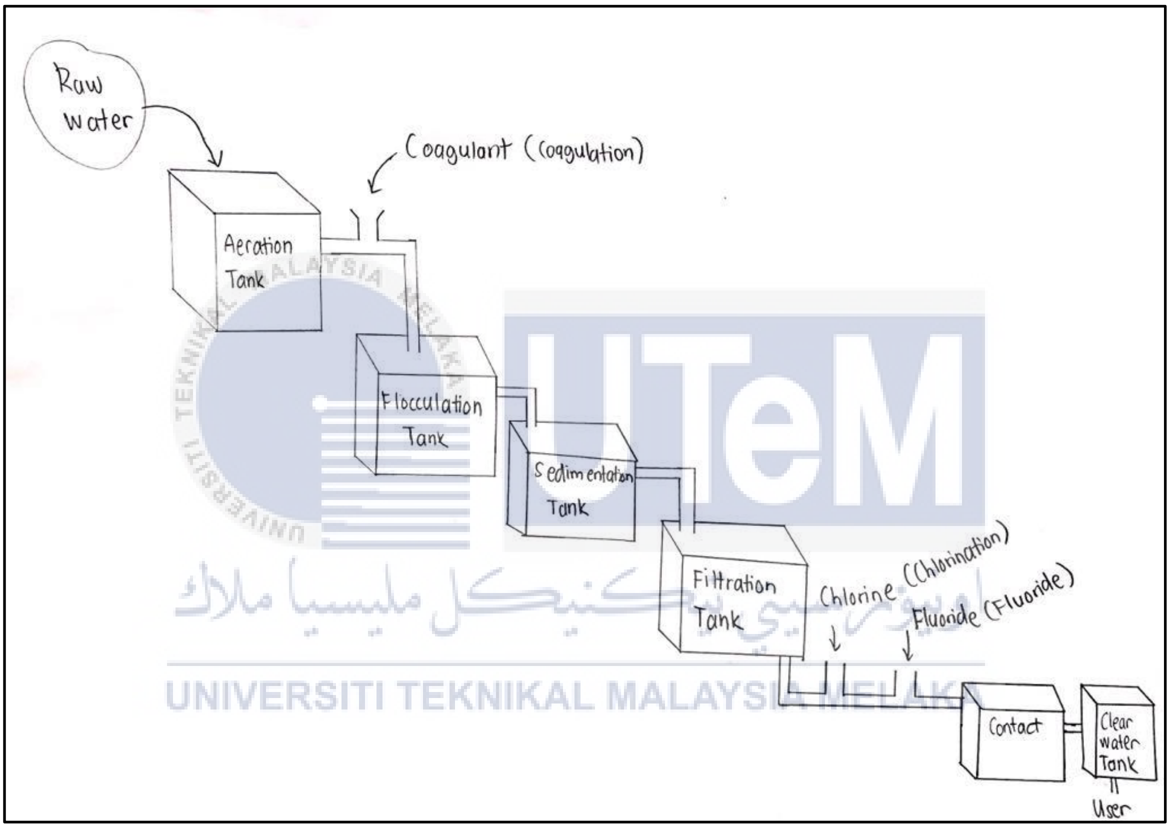


Figure 4.1: Concept Generation of the Product.

CHAPTER 5

PRODUCT ARCHITECTURE

5.1 Introduction

Product architecture is the arrangement of the physical elements of a product to carry out its required functions. The product architecture begins to emerge in the conceptual design phase from such things as diagrams of functions, rough sketches of concepts, and perhaps a proof-of-concept mode. This chapter will shows the further detail of the idea for the product or system according to concept generated previously. The researcher was elaborated the concept generation into two product architecture that contain complete system of the product. The researcher will explain in detail about the product architecture produced and later will select the best idea to proceed with the next chapter.

5.2 Product Architecture 1

Figure 5.1 below shows the first product architecture.

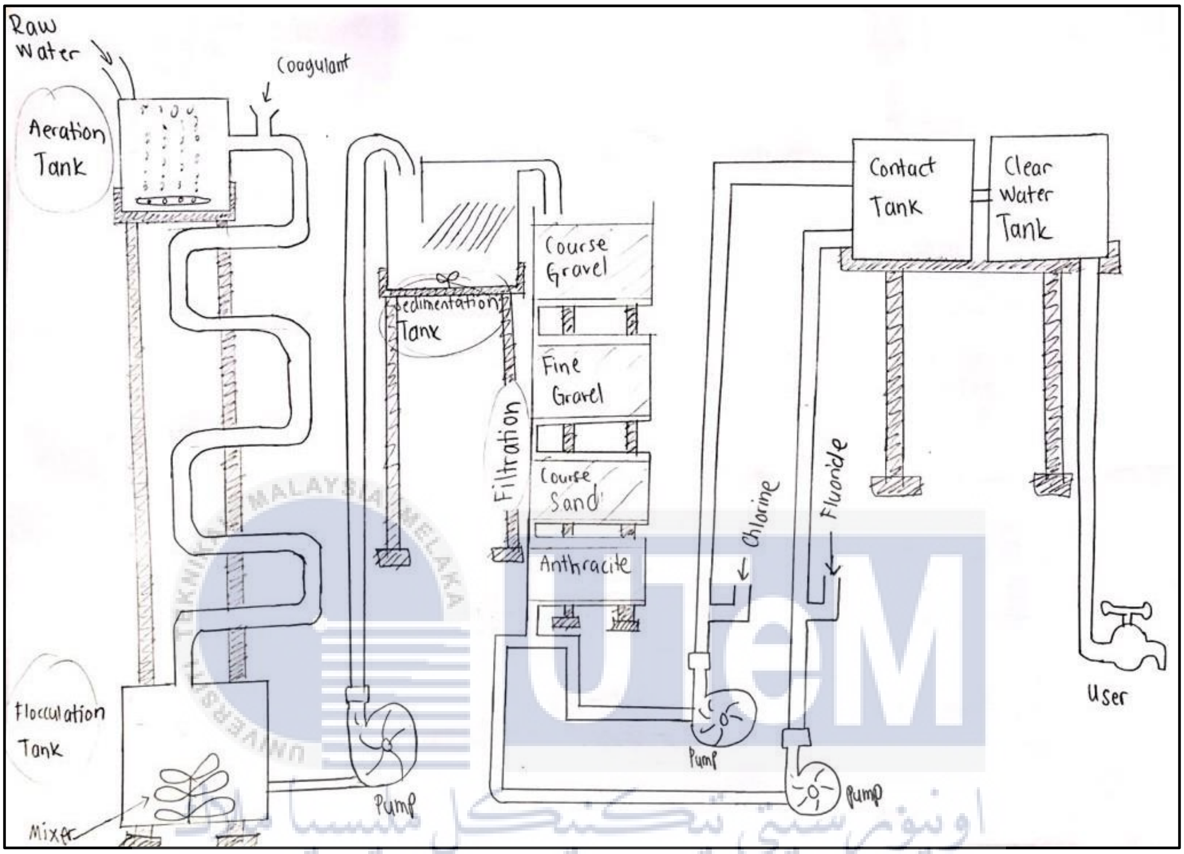


Figure 5.1: First Architecture.

For the first architecture, the tanks will arranged in different height, therefore the distance between two tanks will be longer. This is intended to provide a longer piping system in between two tanks. A longer piping will give more time for the chemical reaction of the water to complete. The movement of the water for this product architecture will be done by the help of water pump. The adjustable water pump will make the researcher able to set for the desired water flowrate. The researcher can adjust the flowrate suitable with the size of the tanks and the requirement by the chemical dosing calculation.

5.3 Product Architecture 2

Figure 5.2 below shows the second product architecture.

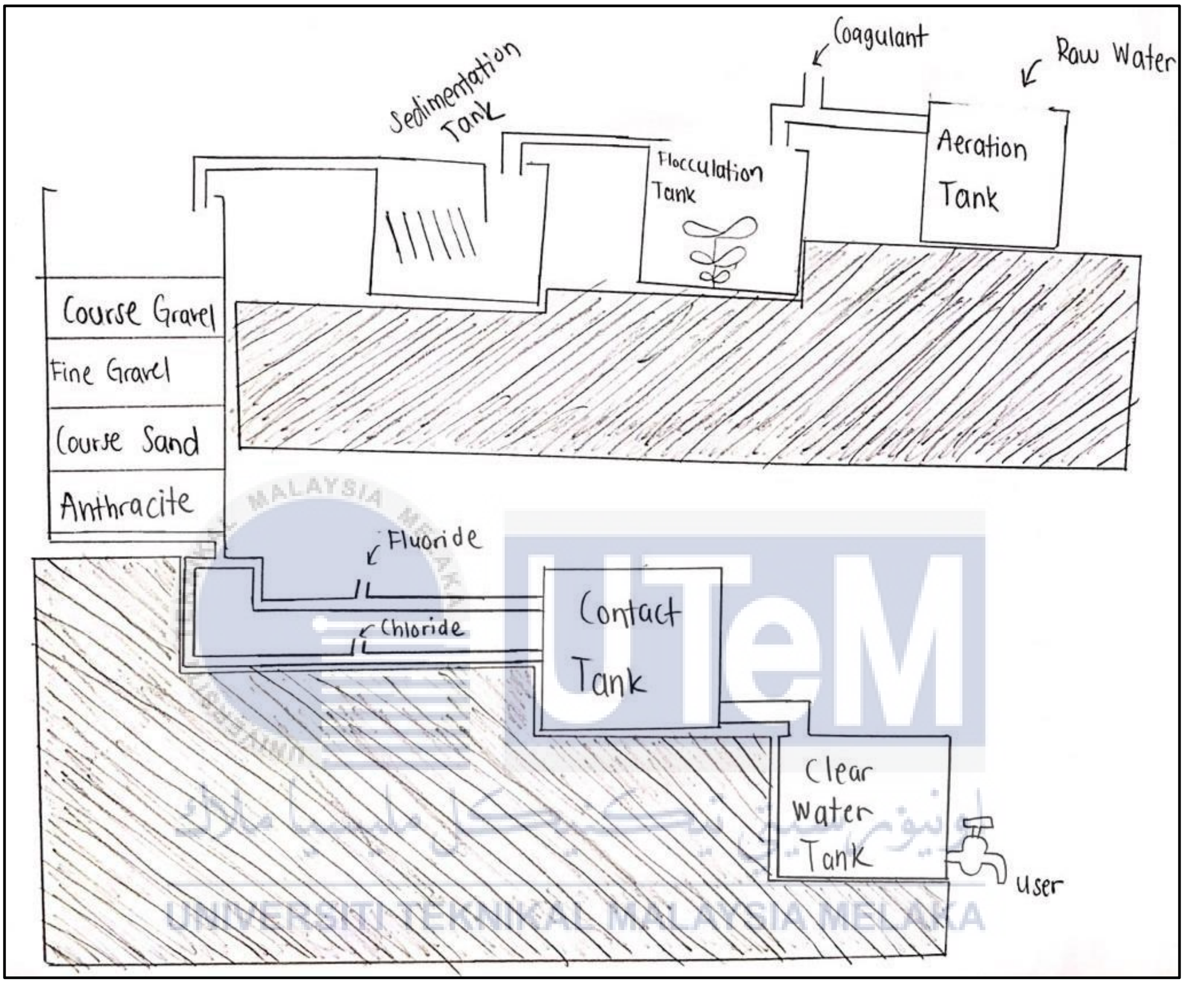


Figure 5.2: Second Architecture.

Different from the first architecture, the second architecture does not required a pump or any mechanical machine to move the water between the pumps. This architecture shows that the system will use natural gravitational force to move the water from pump to pump. When the first tank is fully filled, the water will flow into the next tank. The piping between the tanks also are shorter than the first architecture. This architecture can be consider as a lower cost than the first architecture. Unfortunately, the researcher cannot control the flowrate of the water and also cannot provide an enough time for the chemical reaction to happen.

5.4 Selection of Product Architecture

After considered all the pros and cons between those two product architecture, the researcher had chosen the first architecture as the architecture that will be used for this product. The flowrate of the water is one of the main thing in this water treatment system. The flowrate of the water must be controlled in order to make sure the system will run smoothly without any overflow. The chemical reaction also must be done perfectly to ensure the cleanliness of the water from being contaminated by any bacteria. Therefore, in next chapter, the configuration design will be done based from the first product architecture.

CHAPTER 6

CONFIGURATION DESIGN

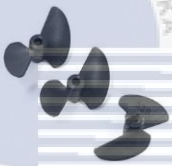
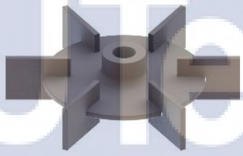
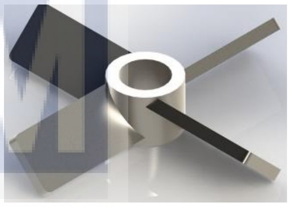
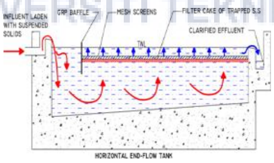
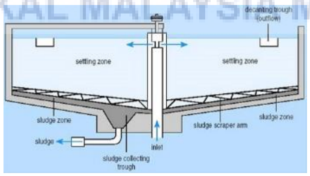
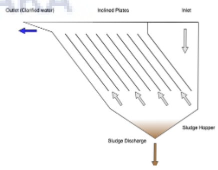
6.1 Introduction

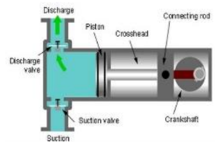
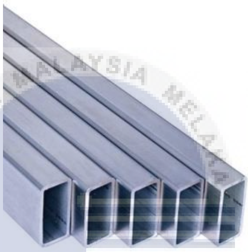
For this chapter, the researcher was established the type and size of the component that will be used for this product. A variation of potential components were provided but only the most suitable component will be selected. The variation of component and the final selection of the component were done referring to the earlier information such as HOQ and PDS.

6.2 Morphology Chart

Morphology chart was used to show the variation of component that can be used in the product. Table 6.1 shows the morphology chart.

Table 6.1: Morphology Chart

Part	Option A	Option B	Option C
Aerator	 Fountain Aerator	 Coarse Bubble Diffuser	 Fine Bubble Diffuser
Pipe	 Galvanized Pipe	 PVC Pipe	 Copper Pipe
Mixer	 Propeller (axial)	 Disk (Rushton) Turbine (Radial)	 Pitched Blade Turbine
Sedimentation Tanks	 Horizontal End Flow Tank	 Radial Flow Tank	 Incline Settling Plate Tank
Tank's Material	Plastic	Metal	Wood
Flush valve	 Stopper Valve	 Rubber Stopper	 Screw stopper

Pump	 Centrifugal Pump	 Gear Pump	 Reciprocating Pump
Filter Component	 Gravel	 Course Sand	 Anthracite
Frame Material	 Aluminium	 Steel	 Stainless Steel

6.3 Selection of Component

Based from the variation of components given, the researcher has select the suitable component. The explanation for the selection and the detail for the dimension also being stated according to the processes.

6.3.1 Aeration Process

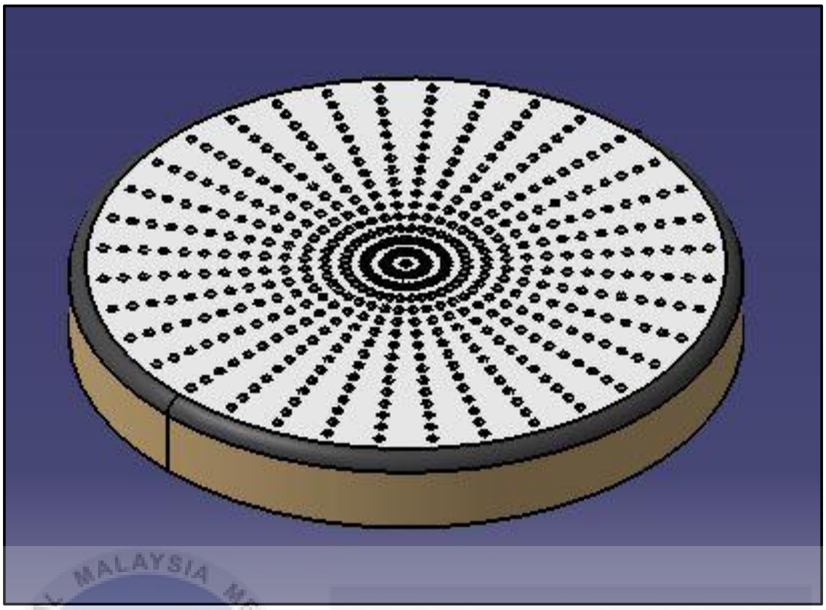


Figure 6.1: Drawing of Aerator in CATIA.

Aerator : Fine Bubble Diffuser

Explanation : Fine bubble diffusion is a subsurface form of aeration in which air is introduced in the form of very small bubbles. They exhibit high oxygen transfer efficiencies and high aeration efficiencies and can satisfy high oxygen demands. They result in lower volatile organic compound emissions than non- porous diffusers or mechanical aeration devices.

Size : 325mm (diameter)

6.3.2 Flocculation Process

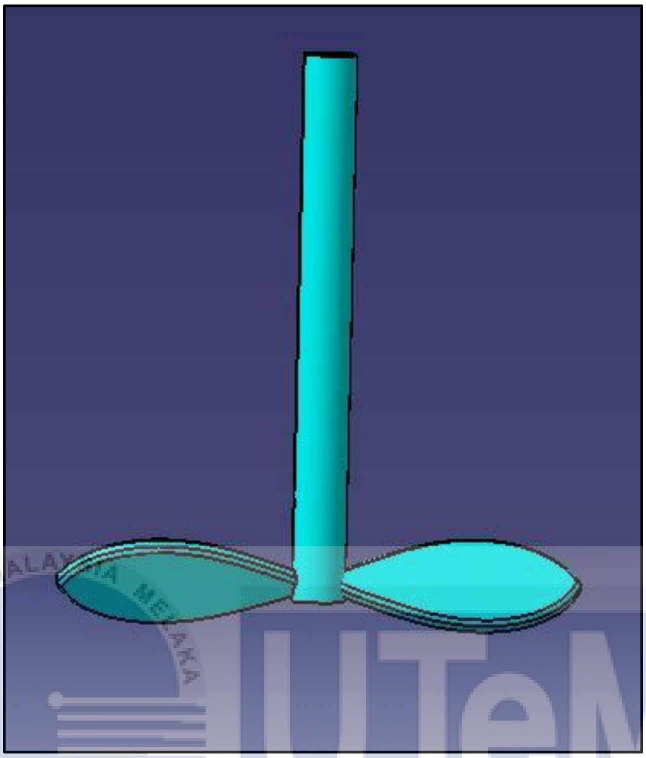


Figure 6.2: Drawing of Propeller in CATIA.

Mixer : Propeller (axial)

Explanation : It mix the water and all the substance in upside-down radial flow. It will ensure all the substance will mix equally for the entire fluid.

Size : 15.6mm (blade width), 132.08mm (blade length)

6.3.3 Sedimentation Process

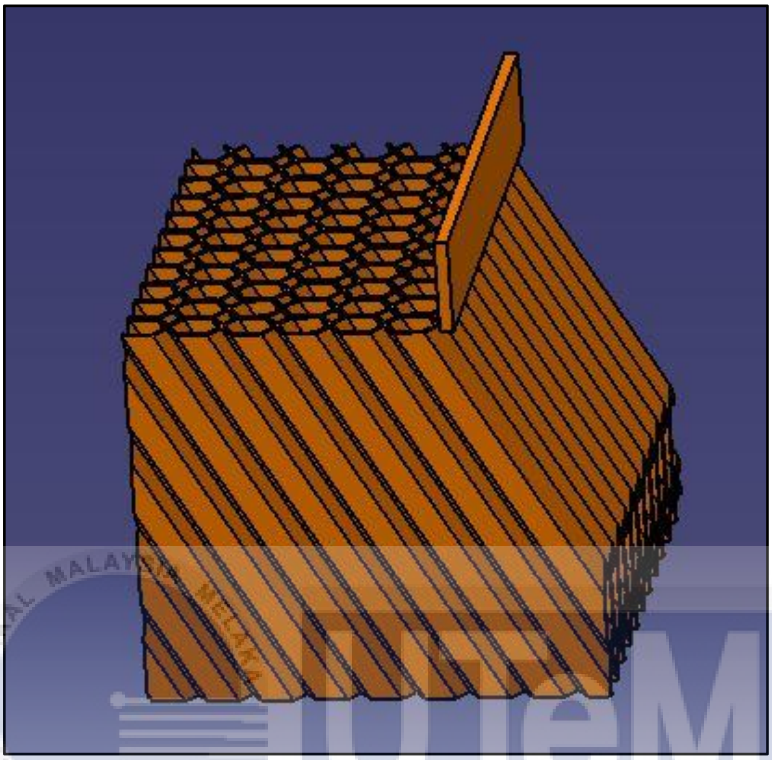


Figure 6.3: Drawing of Incline Settling Plate in CATIA.

Type of tank : Incline Settling Plate Tank

Explanation : It is the most efficient and low cost sedimentation tank. Most common use in current industry.

Size : 380mm (width), 345mm (length), 358mm (height)

6.3.4 Filtration Process

Table 6.2: Information of the Filtration Component

Component of Filtration	Size(mm)	Delph(mm)
1. Course gravel	6-15	150
2. Fine gravel	2-5	75
3. Course sand	1-2	75
4. Anthracite	0.85-0.95	400

6.3.5 Others

6.3.5.1 Piping

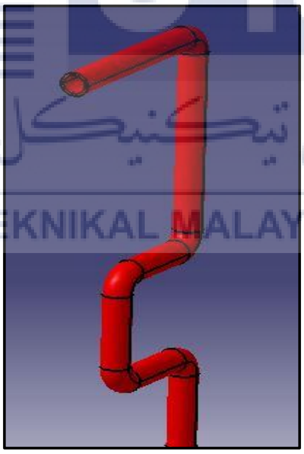


Figure 6.4: Drawing of Piping in CATIA.

Type of pipe : Polyvinyl Chloride (PVC)

Explanation : Light, stainless, low cost

Size : 25mm (inner diameter), 32mm (outer diameter)

6.3.5.2 Tank

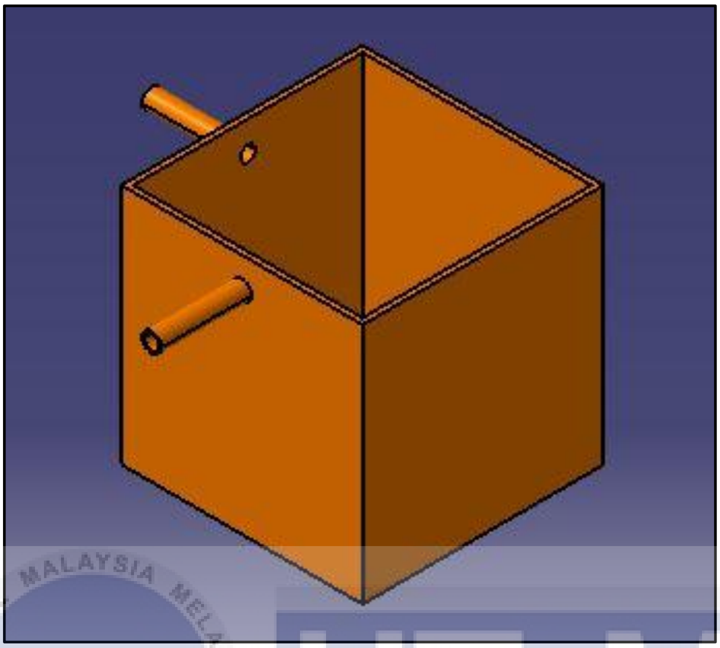


Figure 6.5: Drawing of Tank in CATIA.

Type of tank : Plastic

Explanation : Light, stainless, low cost

Size : 400mm (width), 400mm (length), 400mm (height)

10mm (thickness)

6.3.5.3 Flush Valve

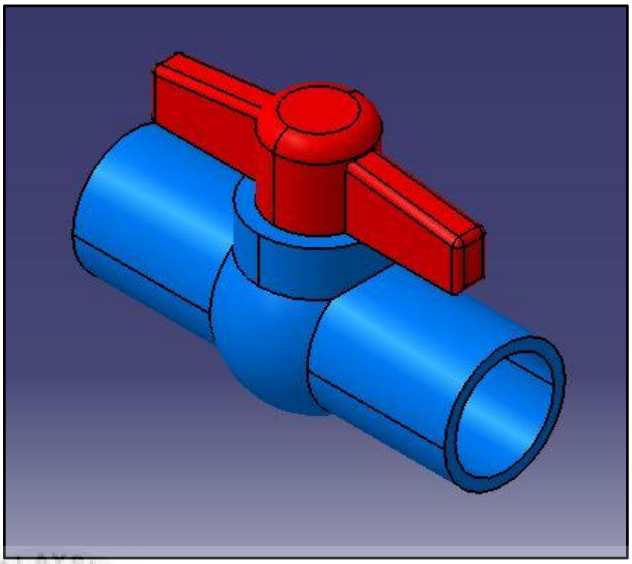


Figure 6.6: Drawing of Stopper in CATIA.

Type of valve : Stopper valve (plastic)

Explanation : Easy to handle the flush process.

Size : 32mm (inner diameter), 39mm (outer diameter), 120mm (length)

6.3.5.4 Pump

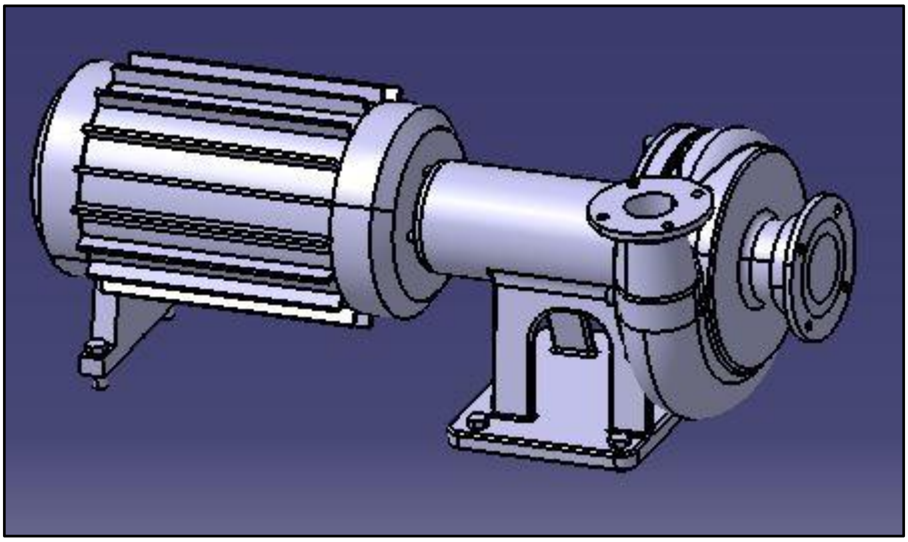


Figure 6.7: Drawing of Pump in CATIA.

Type of pump : Centrifugal pump

Explanation : Small, space saving & less capital costs, easy for maintenance.

Size : 390mm (width), 670mm (length), 390mm (width)

6.3.5.5 Frame

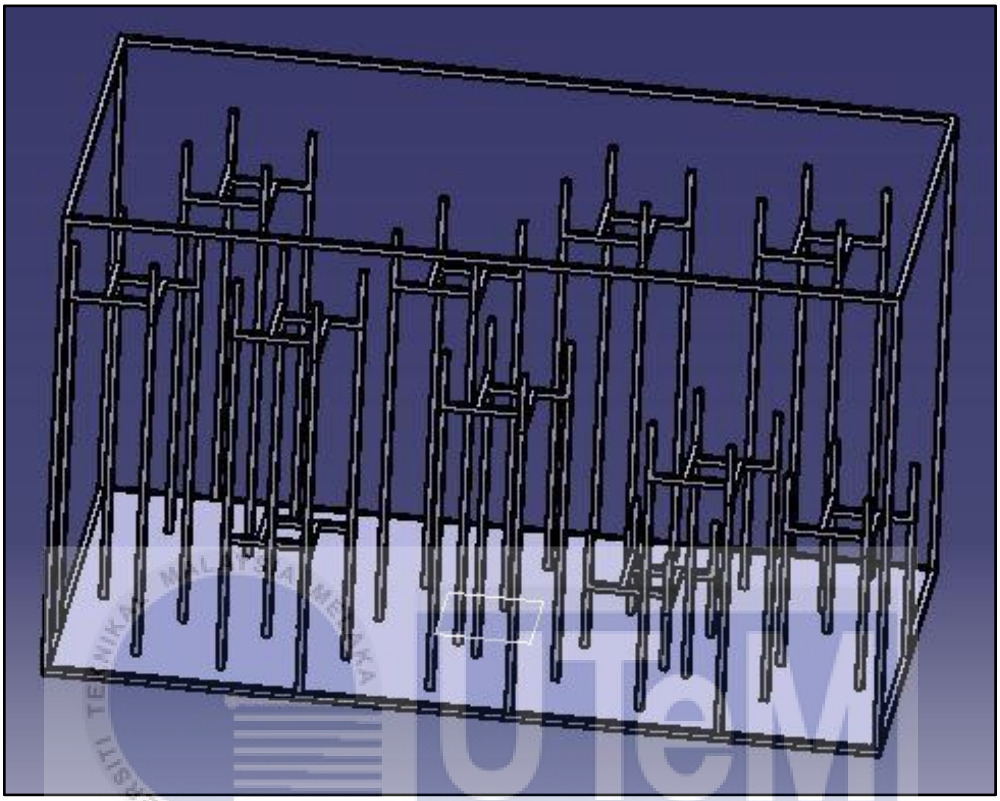


Figure 6.8: Drawing of Frame in CATIA.

Type of material : Stainless Steel

Explanation : Low cost, stainless, last longer

Size : 25mm x 25mm, 0.7mm (thickness) – For the stand

: 1500mm x 3000mm, 3.0mm (thickness) – For the base

CHAPTER 7

PARAMETRIC DESIGN

7.1 Introduction

In this chapter, the element of the design is more analytical than conceptual and configuration design. The explanations are in technical data and calculations about parameter that has been determined. The purpose of parametric design is to obtain values for the design variables that will produce the best possible design taking into account both performance and cost.

7.2 Characteristic of Pump

Table 7.1: Specification of the Pump.

Information	Specification
Model	LEO CTFG PUMP ACM75
Flow rate (L/min)	30 - 100
Size (cm)	34 x 22 x 26 (L x W x H)
Weight (kg)	13
Head rate (m)	34 - 16
Max. suction (m)	8
Power (hp)	1
Voltage (V)	220
Watt (W)	0.75

7.3 Frame's Analysis

This section will explain in details about the analysis that has ben done towards the frame of the system.

7.3.1 Force Applied

This section will show all the calculation to get the total force that will be distributed onto the frame.

7.3.1.1 Water

Density of water	: 1000 kg/m^3
Volume of water	: 0.064 m^3
Density	: $\frac{\text{Mass}}{\text{Volume}}$
Mass	: Volume x Density
	: 1000 x 0.064
	: 64 kg
Mass to Force	: 64 x 9.81 m/s^2
	: 627.84 N
11 tanks	: 627.84 x 11
	: <u>6906.24 N</u>

7.3.1.2 Tanks

1 sq ft of the tank's side	: 0.98 kg
Size of one side of the tank	: 0.16 m^2
0.16 m^2	: 1.72 sq ft
0.16 m^2	: 1.72 x 0.98
	: 1.7 kg
Full size of the tank	: 1.7 x 6
	: 10.2 kg
Mass to Force	: 10.2 x 9.81 m/s^2
	: 100.062 N
10 tanks	: 100.062 x 10
	: 1000.62 N
Anthracite tank size	: 0.4 m^2 x 0.6 m^2 x 4 + 0.4 m^2 x 0.4 m^2 x 2
	: 1.28 m^2
1m^2	: 10.7639 sq ft
1.28 m^2	: 10.7639 x 1.28
	: 13.78 sq ft
1.28 m^2	: 13.78 x 0.98
	: 13.50 kg
Mass to Force	: 13.50 x 9.81 m/s^2 = 132.435 N
Total Force from the tanks	: 1000.62 + 132.435 = 1133.055 N

7.3.1.3 Filter Component

7.3.1.3.1 Course Gravel

Density of course gravel	: 1500 kg/m^3
Volume of course gravel	: 0.024 m^3
Density	: $\frac{\text{Mass}}{\text{Volume}}$
Mass	: Volume x Density
	: 1500 x 0.024
	: 36 kg
Mass to Force	: 36 x 9.81 m/s^2
	: 353.16 N

7.3.1.3.2 Fine Gravel

Density of fine gravel	: 1500 kg/m^3
Volume of fine gravel	: 0.012 m^3
Density	: $\frac{\text{Mass}}{\text{Volume}}$
Mass	: Volume x Density
	: 1500 x 0.012
	: 18 kg
Mass to Force	: 18 x 9.81 m/s^2
	: 176.58 N

7.3.1.3.3 Course Sand

Density of course sand : 1500 kg/m^3

Volume of course sand : 0.012 m^3

Density : $\frac{\text{Mass}}{\text{Volume}}$

Mass : Volume x Density

: 1500 x 0.012

: 18 kg

Mass to Force : 18 x 9.81 m/s^2

: 176.58 N

7.3.1.3.4 Anthracite

Density of anthracite : 833 kg/m^3

Volume of anthracite : 0.064 m^3

Density : $\frac{\text{Mass}}{\text{Volume}}$

Mass : Volume x Density

: 833 x 0.064

: 53.312 kg

Mass to Force : 53.312 x 9.81 m/s^2

: 522.99 N

7.3.1.4 Pump

Mass of Pump	: 13 kg
4 Pumps	: 13 x 4
	: 52 kg
Mass to Force	: 52 x 9.81 m/s^2
	: 510.12 N

7.3.2 Finite Element Analysis (FEA)

This analysis was run in CATIA software. The analysis will calculate the total Von Mises stress produced from the force applied. The force was applied towards the product, at the frame part. All the forces was applied in different position according to force resources. From the data collected from the analysis, the researcher was calculate the safety factor of the product and decided whether the product is safe to be use or not. Figure 7.1 and 7.2 show the result of the FEA.

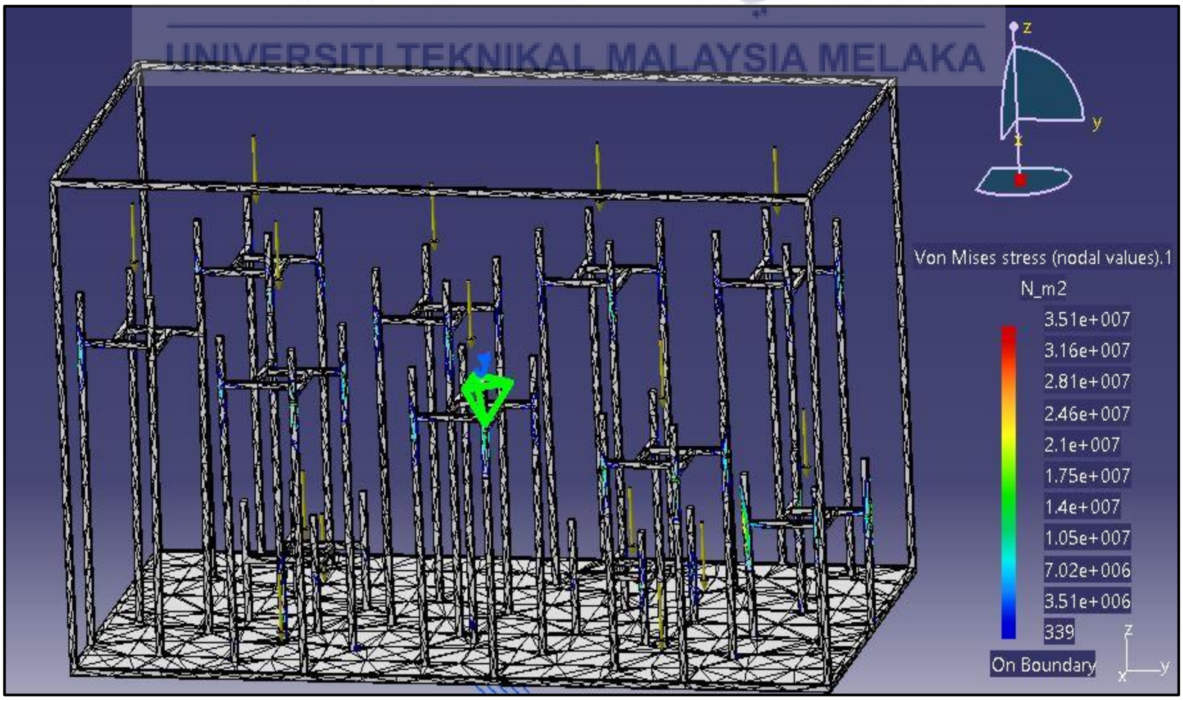


Figure 7.1: FEA Result for Von Mises Stress.

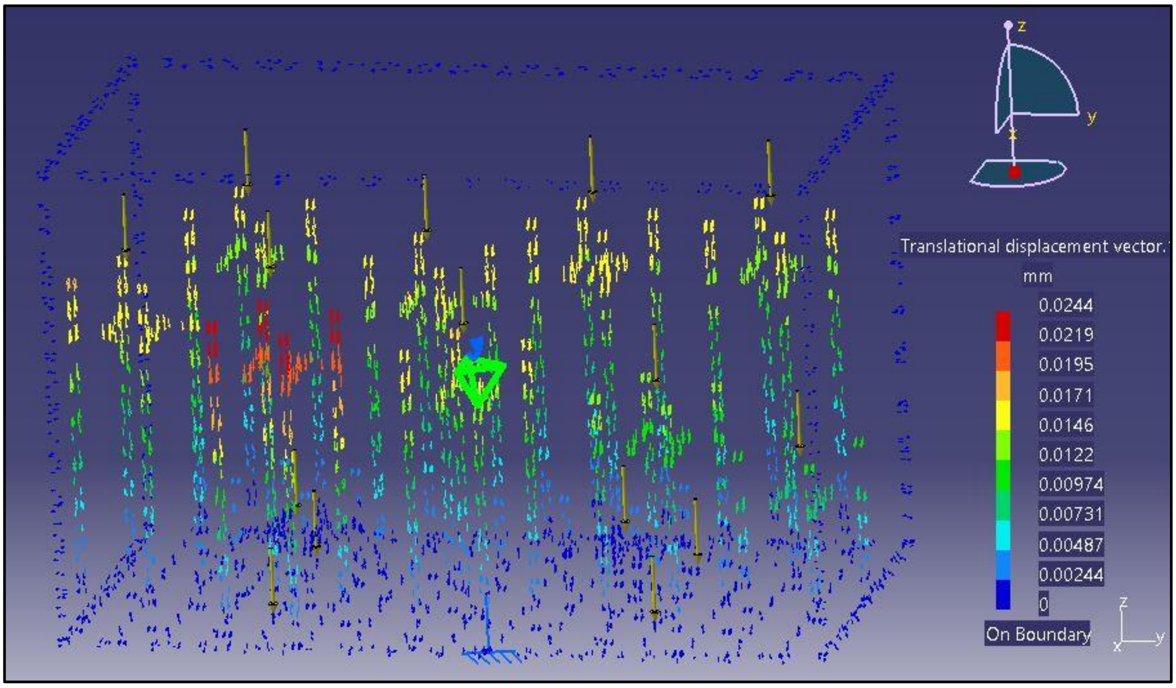


Figure 7.2: FEA Result for Translational Displacement.

Material	: Stainless Steel
Material's yield strength	: 215 MPa
Total load applied	: 9778.725 N
Von Mises stress	: 35.1 MPa
Safety factor	: $\frac{\text{Yield Strength}}{\text{Max Stress}}$
	: $\frac{215\text{ MPa}}{35.1\text{ MPa}}$
	: $\underline{6.13}$

Both of Figure 7.1 and 7.2 show that the product is still in good form after the forces were being distributed. The translational displacement value that is 0.0244mm is too small to give an effect toward the structure of the product. The Von Mises stress value that is 35.1 MPa also shows that the structure does not experience any failure or fracture. The calculated safety factor that is 6.13 shows that the structure of the product is in safe condition and it can be use as planned. This FEA also shows that the product can withstand with the amount of forces applied and it convinced the researcher that the structure of the product is strong enough to be fabricated.

7.4 Chemical Dosing

From the selected pump, the researcher will set the flow rate at the minimum value that is 30 L/min which equivalent to 1.8 m^3/hr. This lowest value is chosen because the size of the tanks was small, therefore the lower flow rate will prevent the water from overflow. This also to ensure that the process of water treatment can be work smoothly.

7.4.1 Coagulant Dosing (Coagulation)

Coagulant use : Polyaluminium Chloride (PAC)

From the jar test, the chosen value : 30 ppm.

Flowrate raw water (from pump) : 1.8 m^3/hr

Standard Gravity of PAC : 1.31

Dosing : $\dfrac{\text{Dos Optimum (ppm) x Flowrate Raw Water } (m^3/hr)}{\text{1000 x Standard Gravity}}$

: $\dfrac{30 \times 1.8}{1000 \times 1.31}$

: <u>0.0412 L/hr</u>

7.4.2 Fluoride Dosing (Fluoridation)

Target of Fluoride remains in the clear water : 0.6 ppm

Flowrate of the raw water : 1.8 m^3/hr

Concentration of Fluoride : 0.5 %

Dosing : $\frac{\text{Fluoride Balance (ppm) x Flowrate Raw Water } (m^3/hr) \text{ x } 100}{1000 \text{ x Concentration } (\%)}$

: $\frac{0.6 \text{ x } 1.8 \text{ x } 100}{1000 \text{ x } 0.5}$

: <u>0.216 L/hr</u>

7.4.3 Chlorine Dosing (Chlorination)

Balance of chlorine remains in clear water : 4.0 ppm

Flowrate of raw water : 1.8 m^3/hr

Dosing : $\frac{\text{Chlorine Balance (ppm) x Flowrate Raw Water } (m^3/hr)}{1000}$

: $\frac{4.0 \text{ x } 1.8}{1000}$

: <u>0.0072 kg/hr</u>

7.5 Costing

Since all the calculation were made and the component that will be use for the product has been finalised, the researcher proceed with the costing. The costing will be calculate based on current price.

Table 7.2: Price for Each Part of the Product.

No	Part	Price per unit *	Total unit	Total price
1	Aerator	RM 273.59/unit	1	RM 273.59
2	Propeller	RM 3.91/unit	4	RM 15.64
3	Incline Settling Plate	RM 19.54/unit	1	RM 19.54
4	Course Gravel	RM 3.91/kg	36kg	RM 140.76
5	Fine Gravel	RM 7.82/kg	18kg	RM 140.76
6	Course Sand	RM 12.66/kg	18kg	RM 227.88
7	Anthracite	RM 24.98/kg	53.312kg	RM 1331.73
8	Pipes	RM 3.00/meter	31meters	RM 93.00
9	Tanks	RM 30/kg	114kg	RM 3420.00
10	Flush Valve	RM 33.00/unit	8	RM 264.00
11	Pump	RM 214.20/unit	1	RM 214.20
12	Stainless steel square	RM 8.00/meter	91meters	RM 728.00
13	Plate (base)	RM 218.86/unit	3	RM 656.58
			Total Cost	RM 7525.68

*Note: All of the prices were based from the current market price.

CHAPTER 8

DETAIL DRAWING

8.1 Introduction

Detail design is the final phase for the design process. While most of the option and measuring of parts occurs in previous chapter, the final selection and measurement of the parts were assembled in order to form the complete product in this chapter. This chapter also will cover the bill of materials and all the related drawings.

8.2 Engineering Drawing

Engineering drawings is a technical drawing that explain more about the design of the product. It includes parts drawing, assembly drawing, orthographic drawing and exploded drawing. These drawings will interpret the position and the dimension of each parts of the product. All the drawings can be refer at the Appendix A while Figure 8.1 below shows the drawing of the complete product in CATIA.

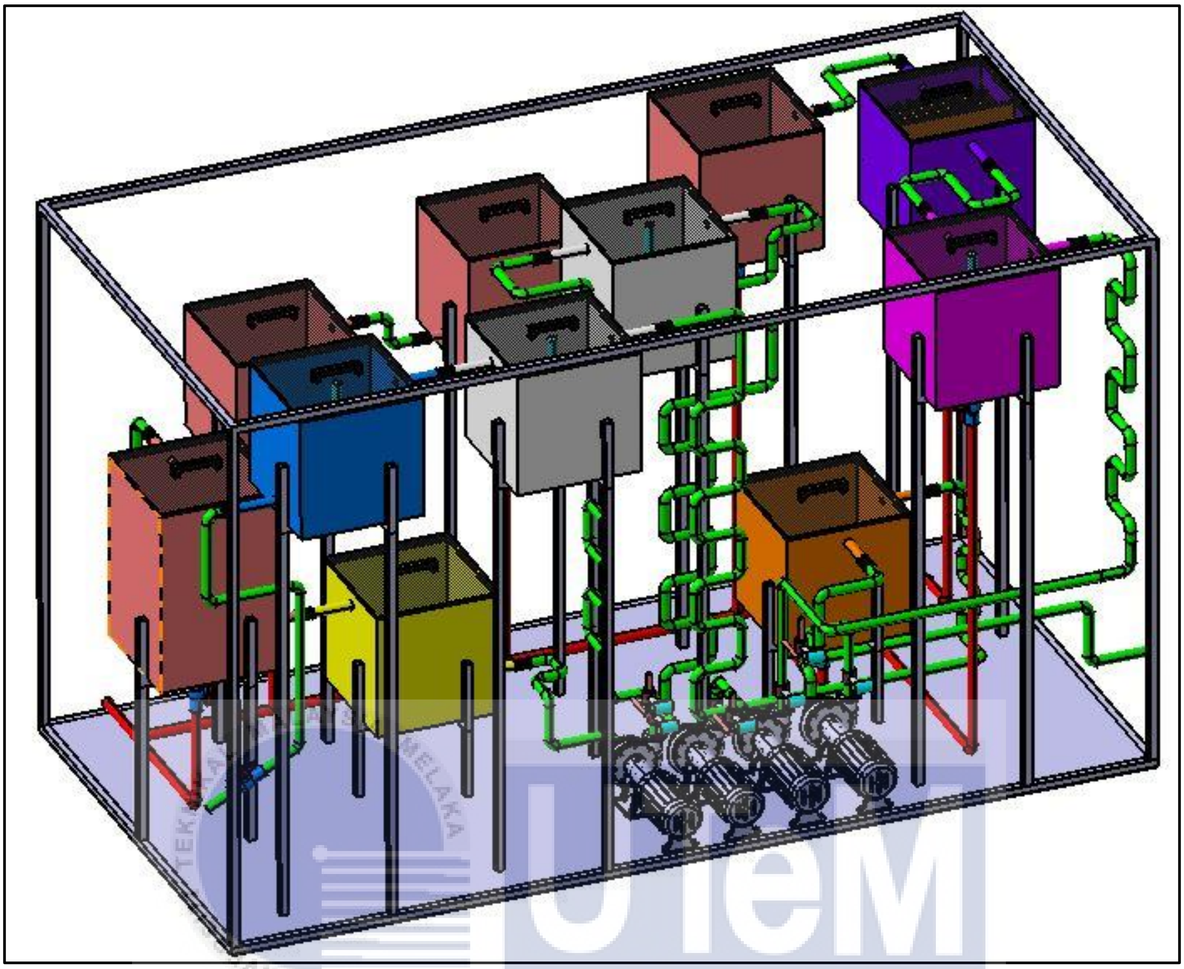
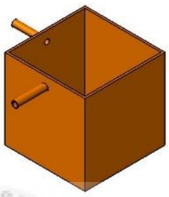
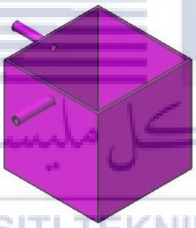
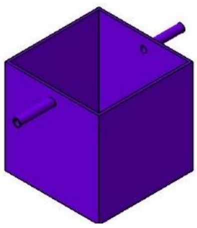


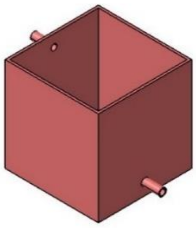
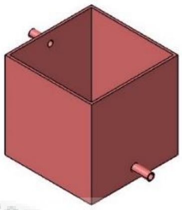
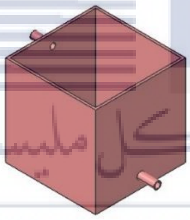
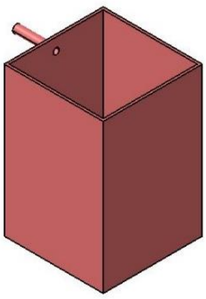
Figure 8.1: Drawing of Complete Product in CATIA.

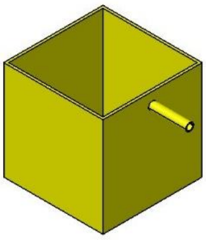
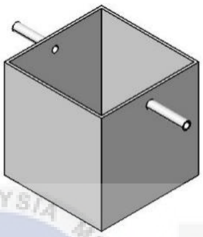
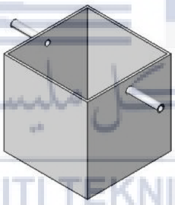
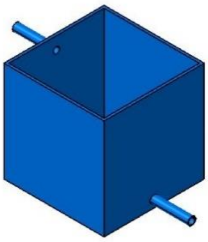
8.3 Parts of the Product

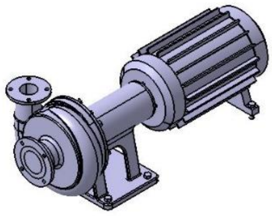
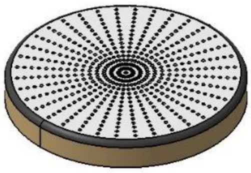
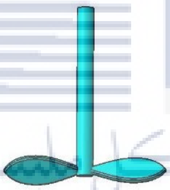
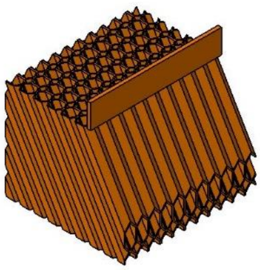
Table 8.1 below shows the functions all the parts involve to build the complete product.

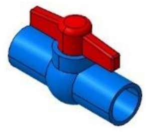
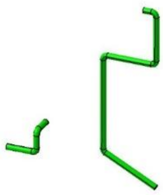
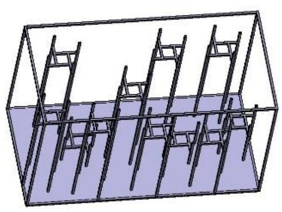
Table 8.1: Function of Each Part of the Product.

Number of Part	Part	Function
1	 Aeration Tank	Place to store the water for the aeration process
2	 Flocculation Tank	Place to store the water for the flocculation process
3	 Sedimentation Tank	Place to store the water for the sedimentation process

4	 Filter 1	Place to store the course gravel for the filtration process
5	 Filter 2	Place to store the fine gravel for the filtration process
6	 Filter 3	Place to store the course sand for the filtration process
7	 Filter 4	Place to store the anthracite for the filtration process

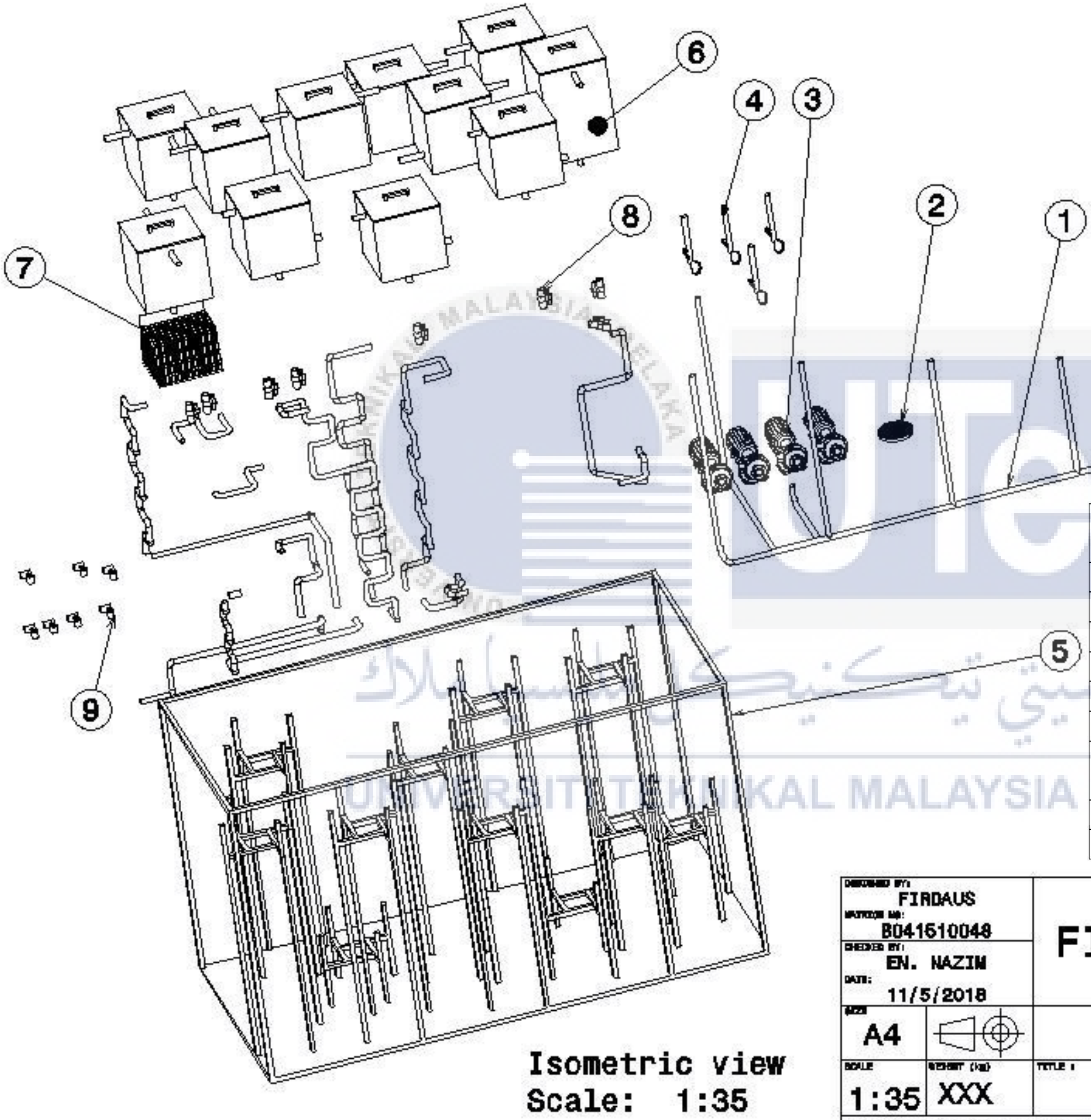
8	 Waiting Tank	Place to store the water before goes for the chlorination process
9	 Waiting Tank 1	Place to store the water after the chlorination process
10	 Contact Tank 2	Place to store the water after the fluoridation process
11	 Clear Water Tank	Place to store the clean and treated water

12	 Centrifugal Pump	To transfer water from lower level to higher level
13	 Aerator	To do the aeration process
14	 Propeller axial	To mix the water inside the tank
15	 Incline Settling Plate	Place to trap unwanted things before the water goes for the filtration process

16	 Stopper	To control the outflow of the water during the flushing process
17	 PVC Pipe	A medium for the water transfer
18	 Flowmeter	To read the flowrate of the water
19	 Frame	To hold all the parts in fixed position

8.4 Bill of Material

Bill of material (BOM) is a section that explains the individual information of each part of the product. The information includes the quantity of the part and the material of the part. Figure 8.2 below shows the exploded drawing and the BOM for the product of the water treatment system.



Part Number	Description	Quantity	Material
1	Pipe	1	PVC
2	Aerator	1	Plastic
3	Pump	4	Steel
4	Propeller	4	Plastic
5	Frame	1	Stainless steel
6	Tank	11	Plastic
7	Sedimentation plate	1	Plastic
8	Stopper	8	Plastic
9	Flowmeter	7	Steel

FIRDAUS
B041510048
EN. NAZIM
11/5/2018

FINAL YEAR PROJECT

EXPLODED DRAWING

A4

SCALE: 1:35

WEIGHT (kg): XXX

TITLE: FULL PRODUCT

SHEET: 22/22

Figure 8.2: Exploded Drawing.

CHAPTER 9

CONCLUSION AND RECOMMENDATION

9.1 Conclusion

As for the conclusion, after finished with this project, all the objectives that has been stated were achieved. The final product also has been clarified as succeed because the output of the system follow the requirement of treated water quality standard by the MOH. It is proven from the calculation and analysis that been taken into the product as mentioned in parametric design. From the analysis, the output water will satisfy the requirement of treated water quality standard when the dosing for the involved chemical follows the calculated dosing. Besides, the product also was successfully designed for portable action as mentioned in the title of this project. The product is able be move from a place to another place with the help of a lorry with 1-ton capacity.

9.2 Recommendation

For the recommendation, further study need to be carried out for the chemical dosing section. This is because the chemical dosing is the main process for the water treatment. The chemical dosing need to be done precisely and the concentration also need to be considered. Therefore, the next study might find a better way to transfer the chemical from the supplier into this water treatment system. Last but not least, a further study could find an alternative ways to run the filtration process as the current filter cost a lot. The filter component shall be replace with another component that has a same or better efficiency as the current component but with a lower cost.

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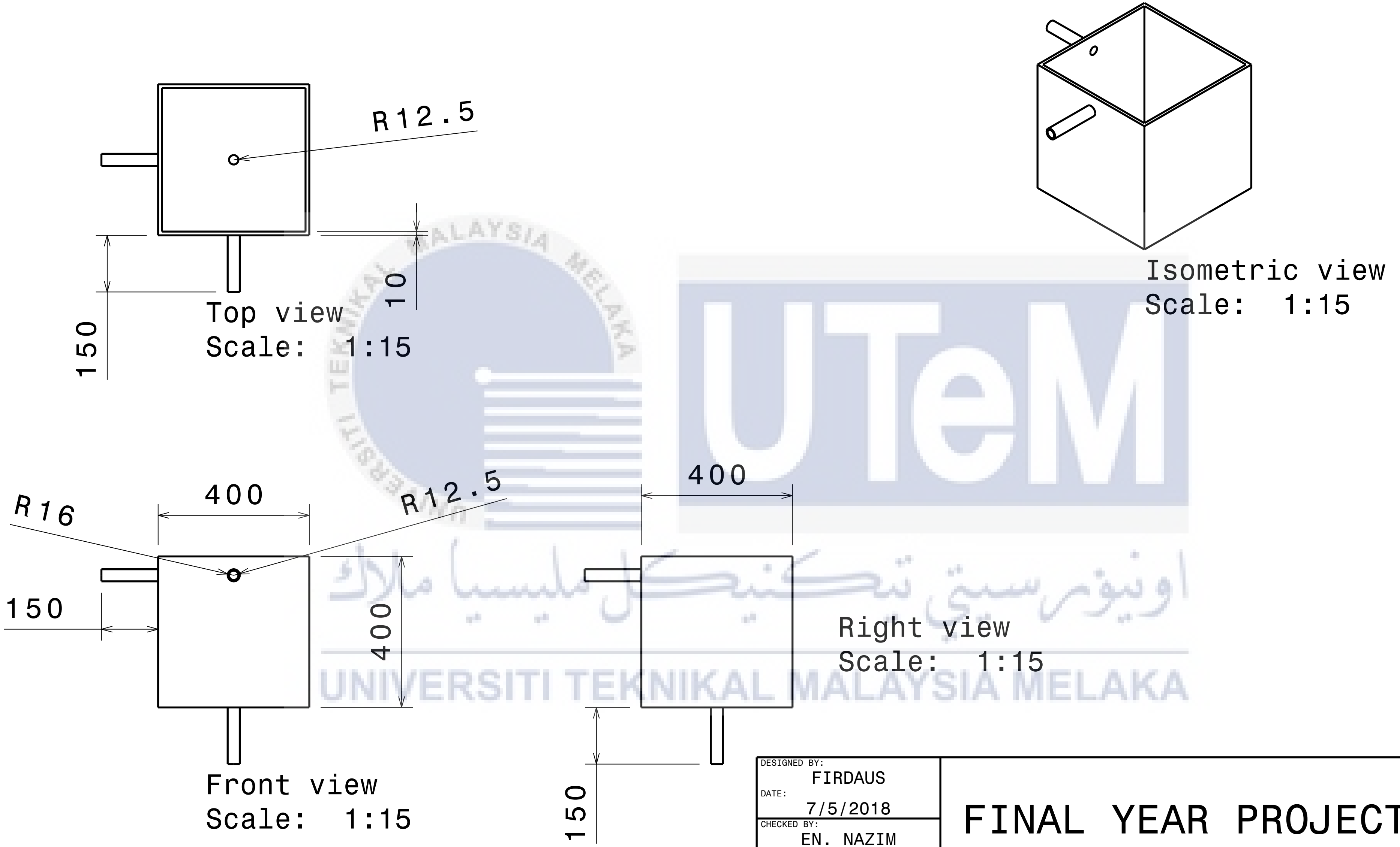
APPENDIX A



DESIGNED BY:	FIRDAUS
DATE:	7/5/2018
CHECKED BY:	EN. NAZIM
DATE:	11/5/2018
SIZE	A4
SCALE	1:15
WEIGHT (kg)	XXX
TITLE :	AERATION TANK
SHEET	1/22

FINAL YEAR PROJECT

PART DRAWING

Rev	
I	_
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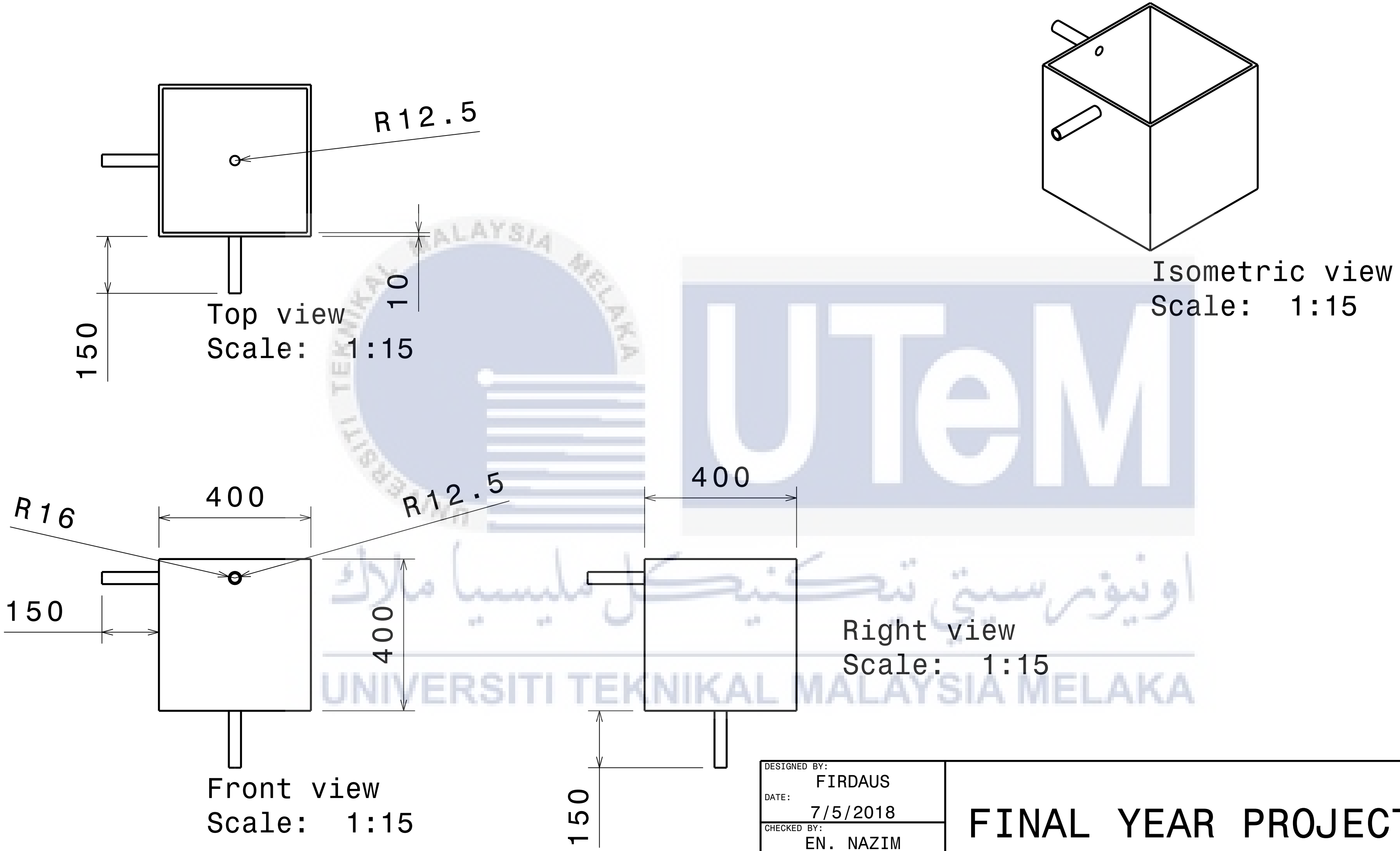
G	_
F	_
E	_
D	_
C	_
B	_
A	_



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CHECKED BY: EN. NAZIM DATE: 11/5/2018			
SIZE A4	PART DRAWING		
SCALE 1:15	WEIGHT (kg) XXX	TITLE : FLOCCULATION TANK	SHEET 2/22

I	_
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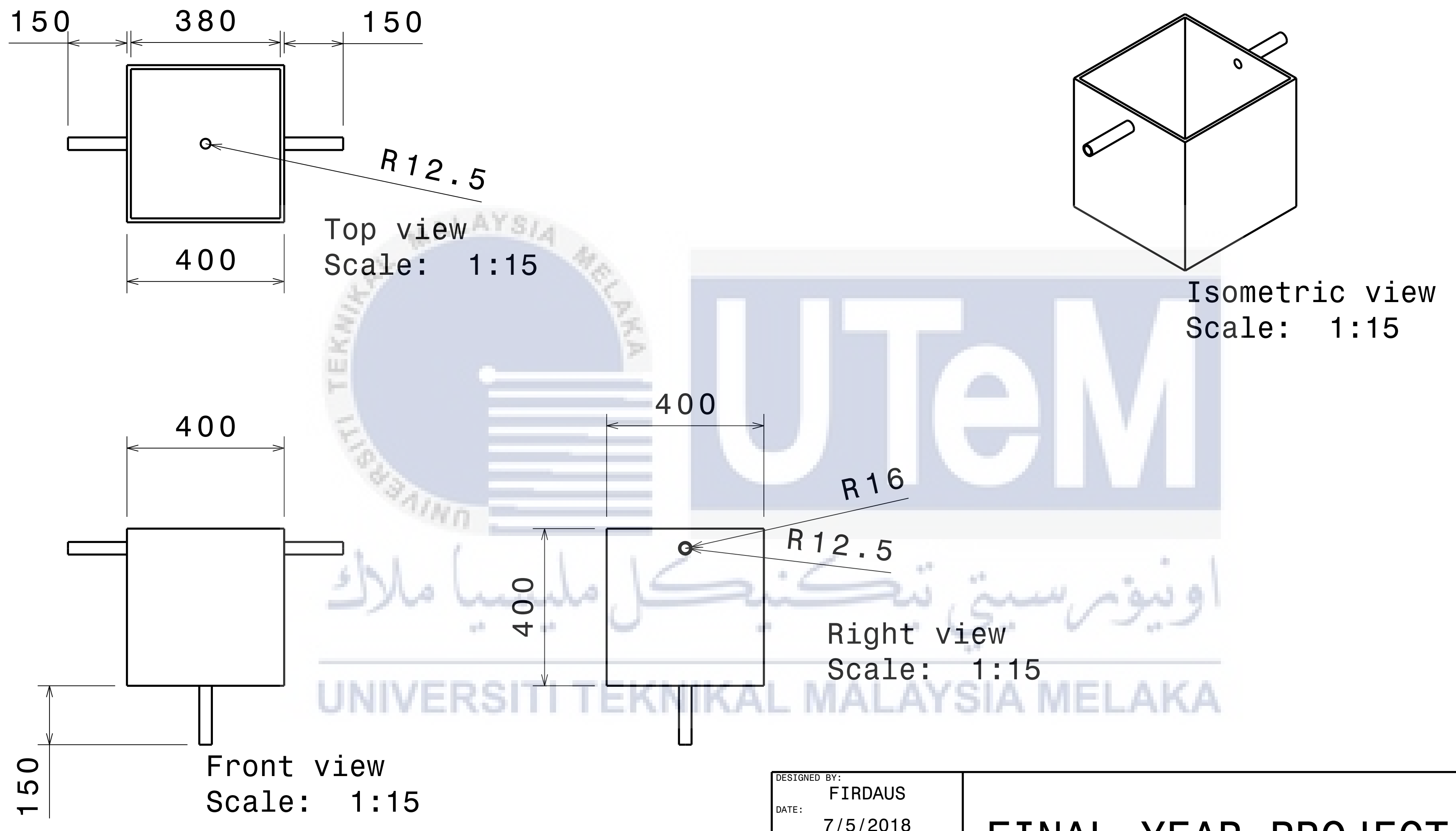
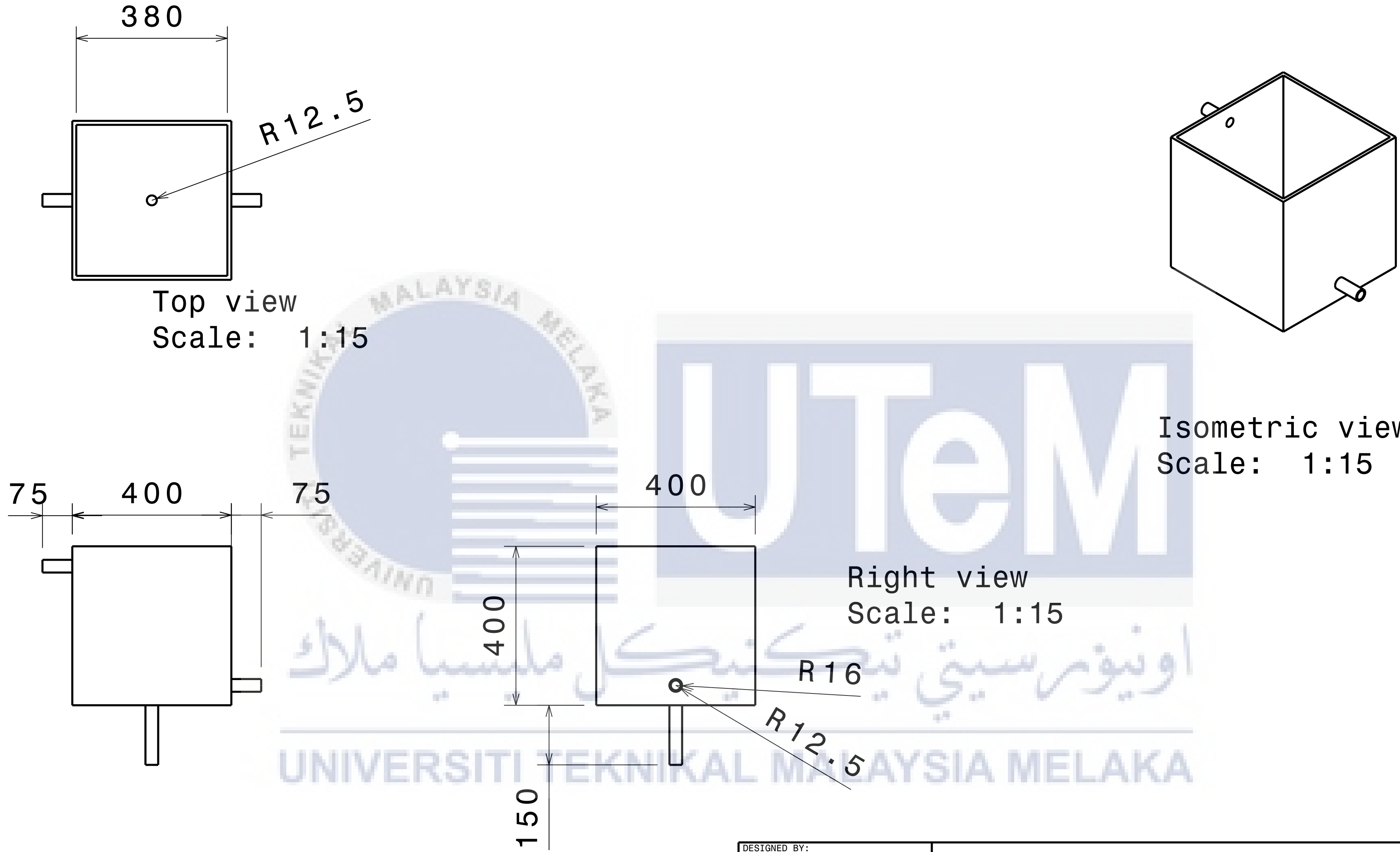
B	_
A	_



DESIGNED BY: FIRDAUS DATE: 7/5/2018 CHECKED BY: EN. NAZIM DATE: 11/5/2018		FINAL YEAR PROJECT	
SIZE A4		PART DRAWING	
SCALE 1:15	WEIGHT (kg) XXX	TITLE : SEDIMENTATION TANK	SHEET 3/22



DESIGNED BY: FIRDAUS
DATE: 7/5/2018
CHECKED BY: EN. NAZIM
DATE: 11/5/2018

FINAL YEAR PROJECT

PART DRAWING

SIZE: A4

SCALE: 1:15

WEIGHT (kg): XXX

TITLE : FILTER TANK 1

SHEET: 4/22

I	_
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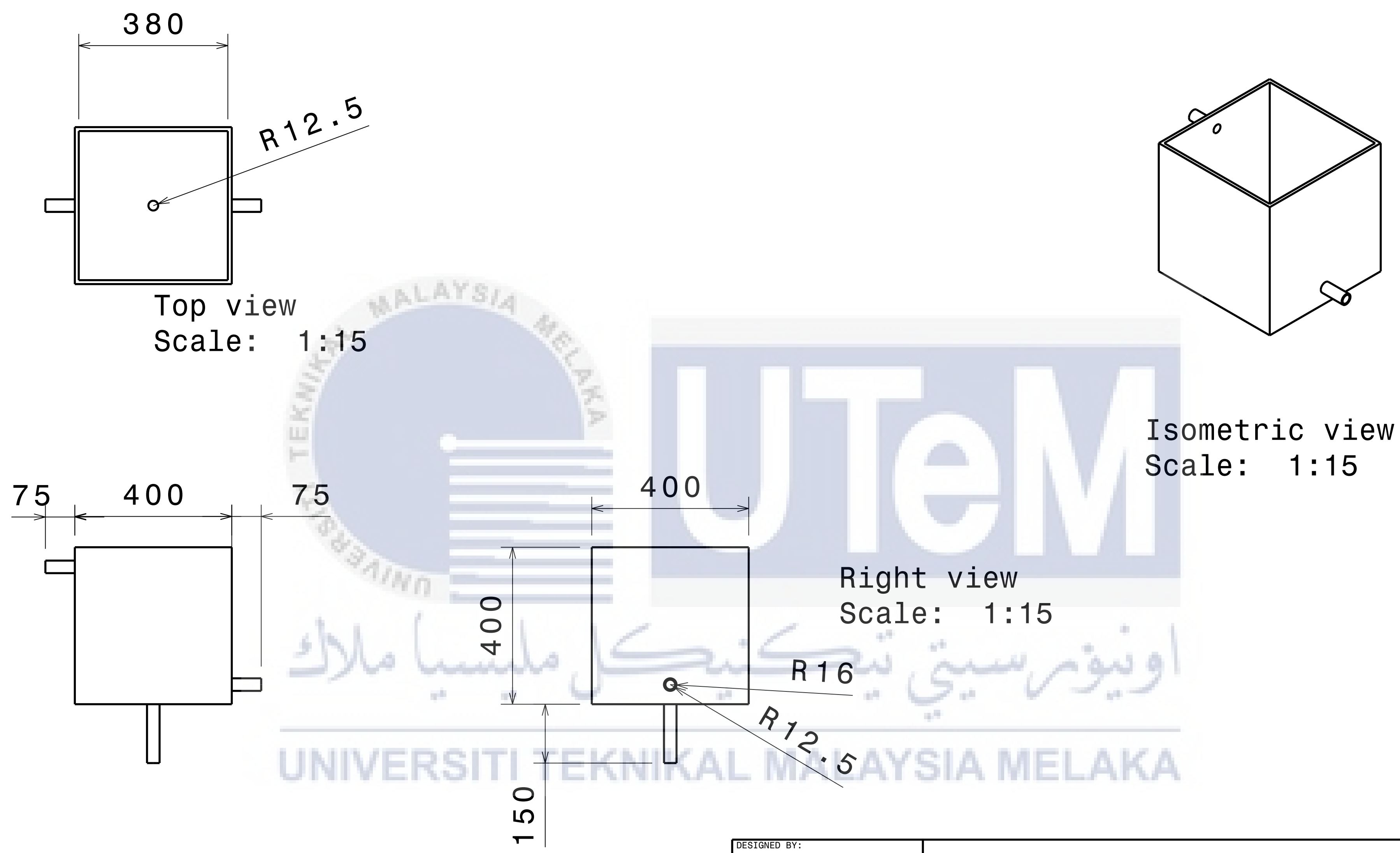

Front view
Scale: 1:15

DESIGNED BY: FIRDAUS DATE: 7/5/2018 CHECKED BY: EN. NAZIM DATE: 11/5/2018		FINAL YEAR PROJECT	
SIZE A4		PART DRAWING	
SCALE 1:15	WEIGHT (kg) XXX	TITLE : FILTER TANK 2	SHEET 5/22

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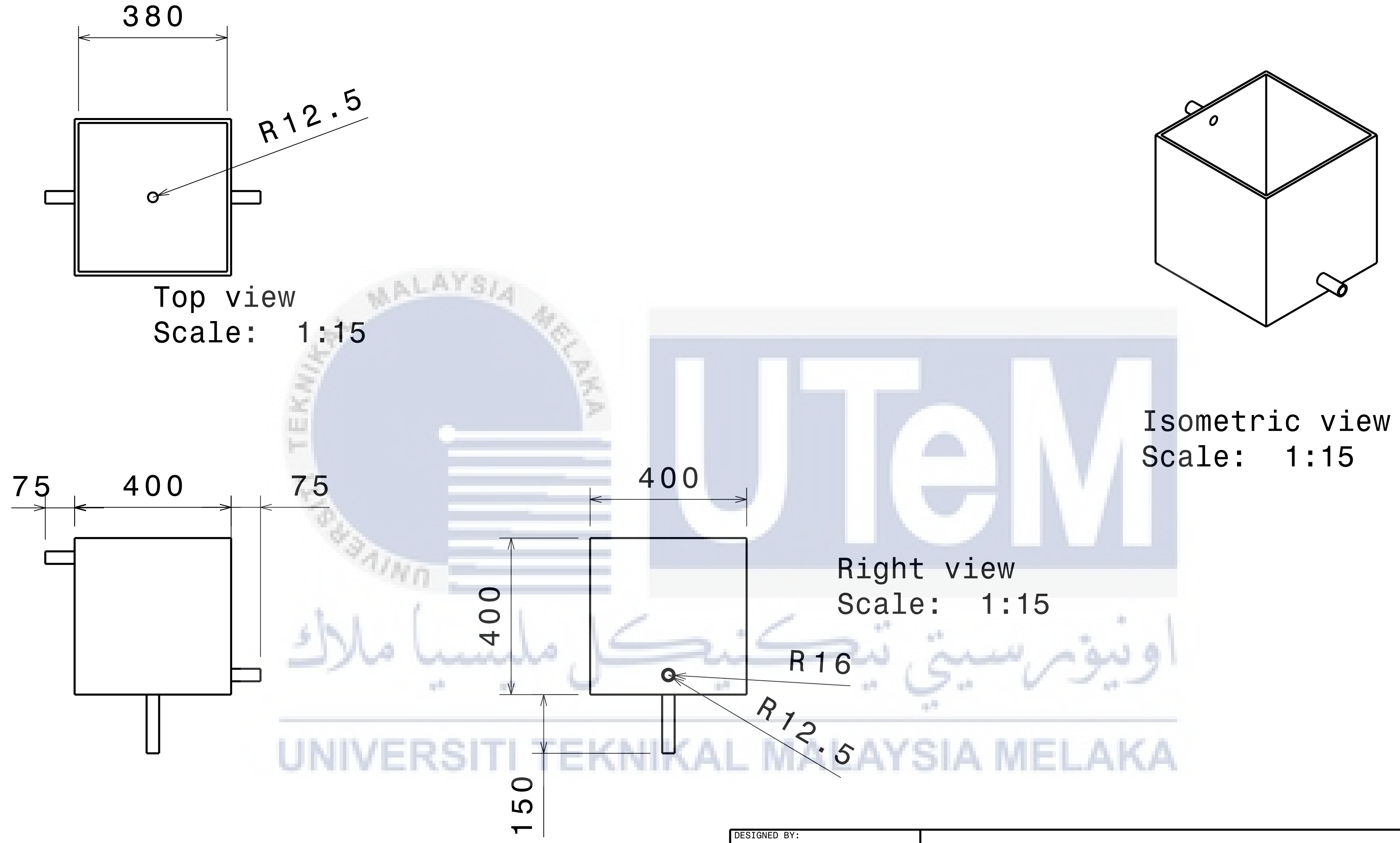

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CHECKED BY: EN. NAZIM DATE: 11/5/2018			
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SCALE 1:15 / WEIGHT (kg) XXX	TITLE : FILTER TANK 3	SHEET 6/22	

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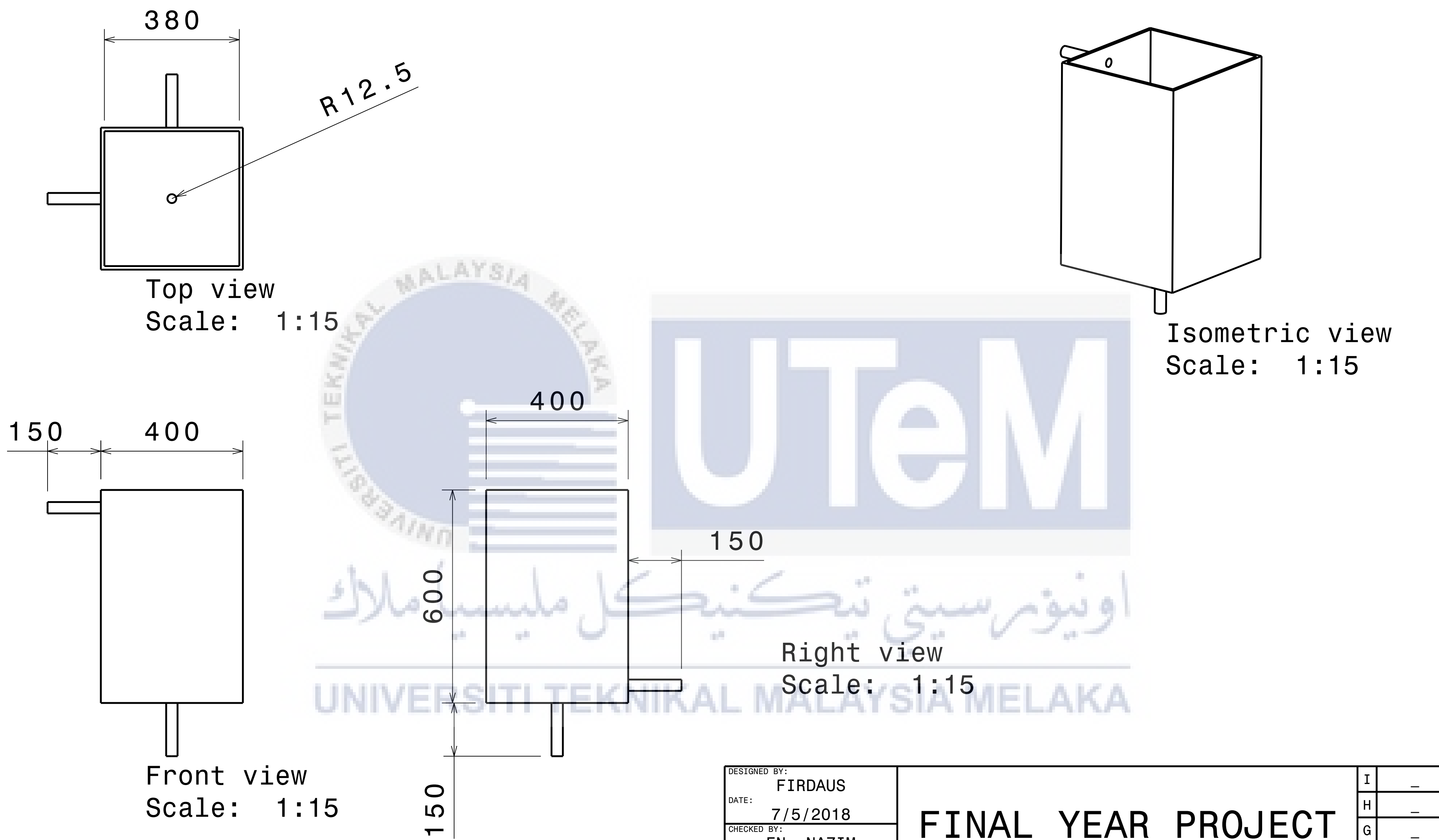
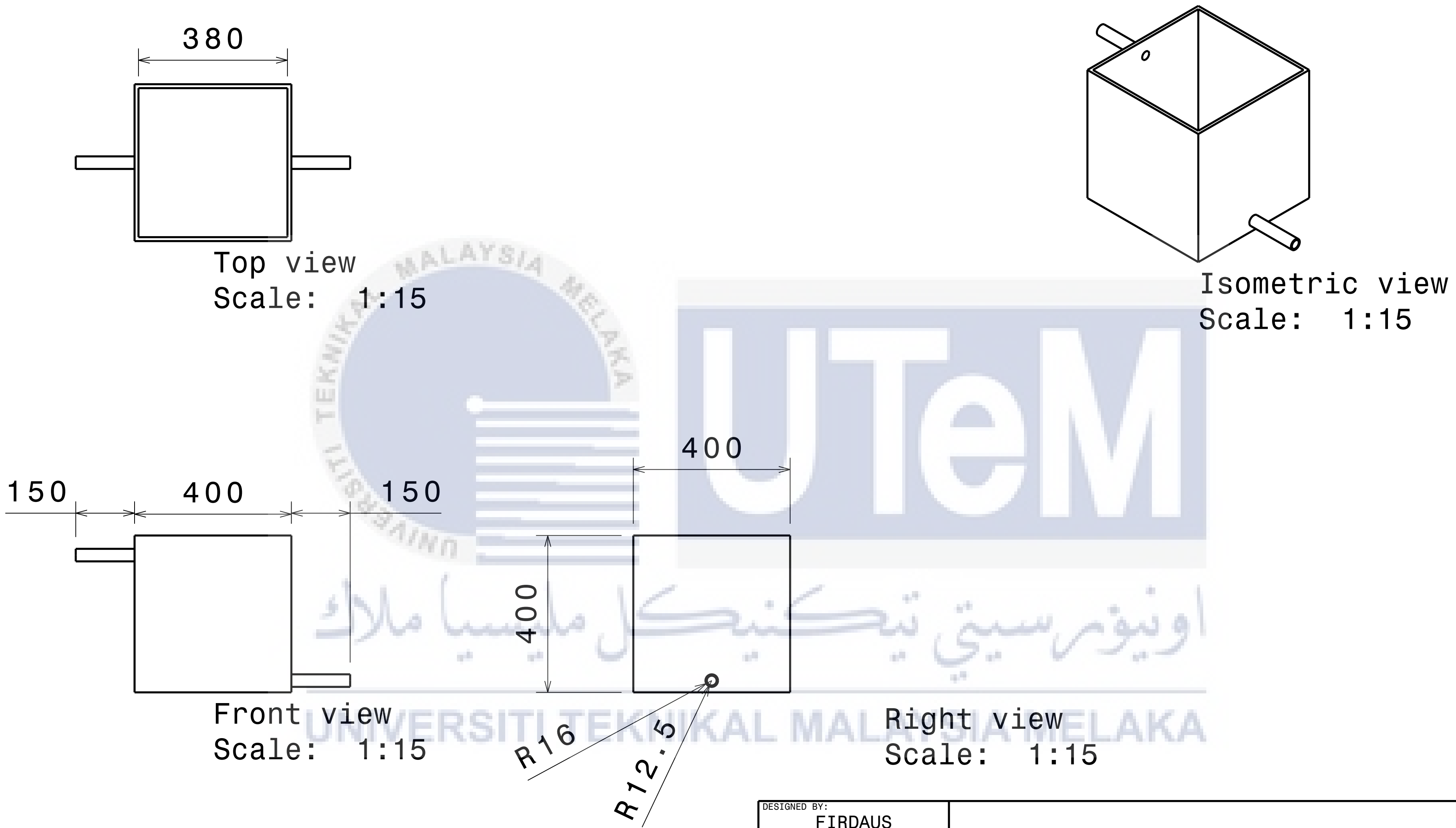


DESIGNED BY: FIRDAUS	FINAL YEAR PROJECT
DATE: 7/5/2018	
CHECKED BY: EN. NAZIM	
DATE: 11/5/2018	
SIZE A4	PART DRAWING
SCALE 1:15	WEIGHT (kg) XXX
TITLE : FILTER TANK 4	SHEET 7/22



DESIGNED BY: FIRDAUS DATE: 7/5/2018 CHECKED BY: EN. NAZIM DATE: 11/5/2018		FINAL YEAR PROJECT	
SIZE A4		PART DRAWING	
SCALE 1:15	WEIGHT (kg) XXX	TITLE : WAITING TANK	SHEET 8/22

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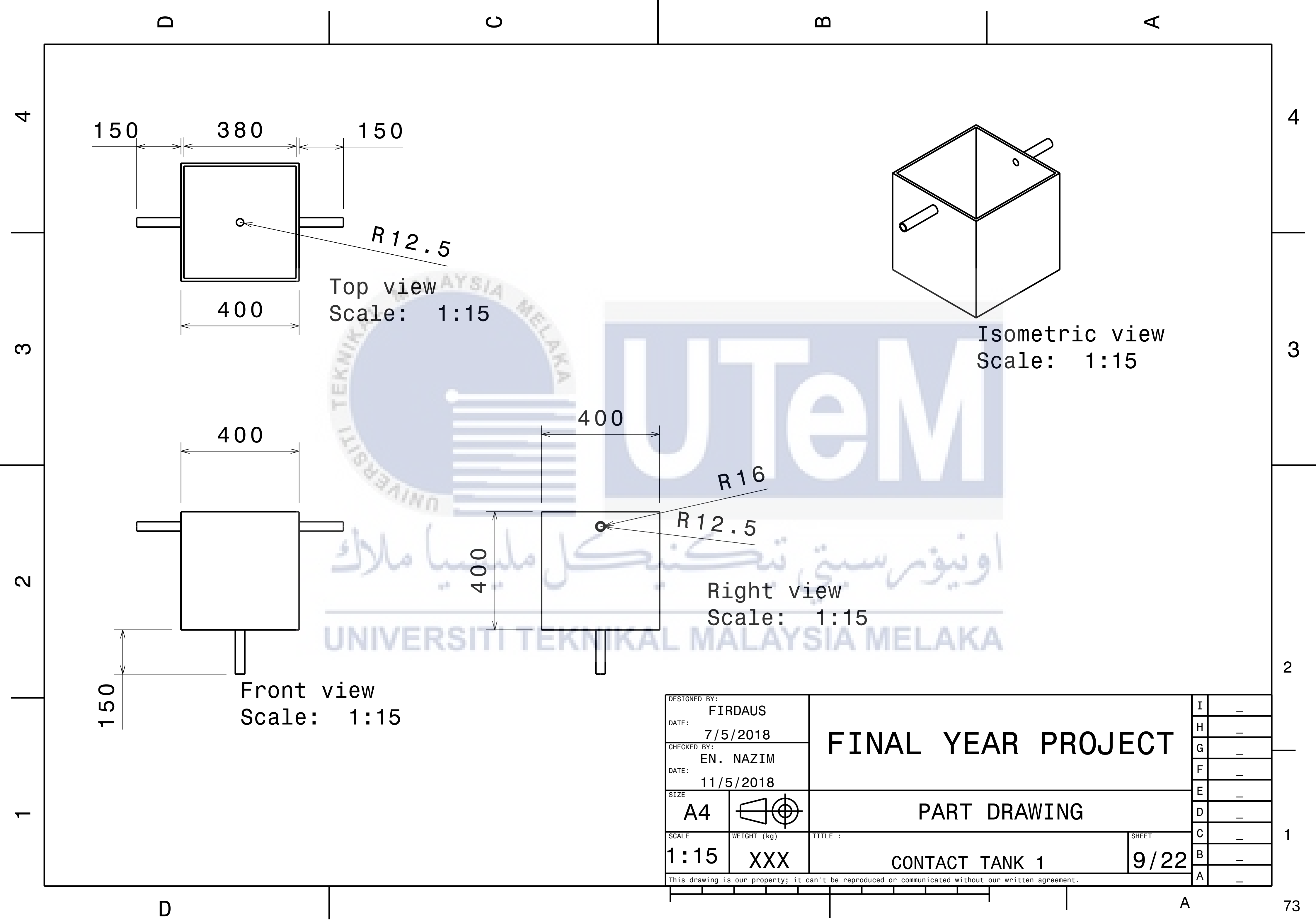
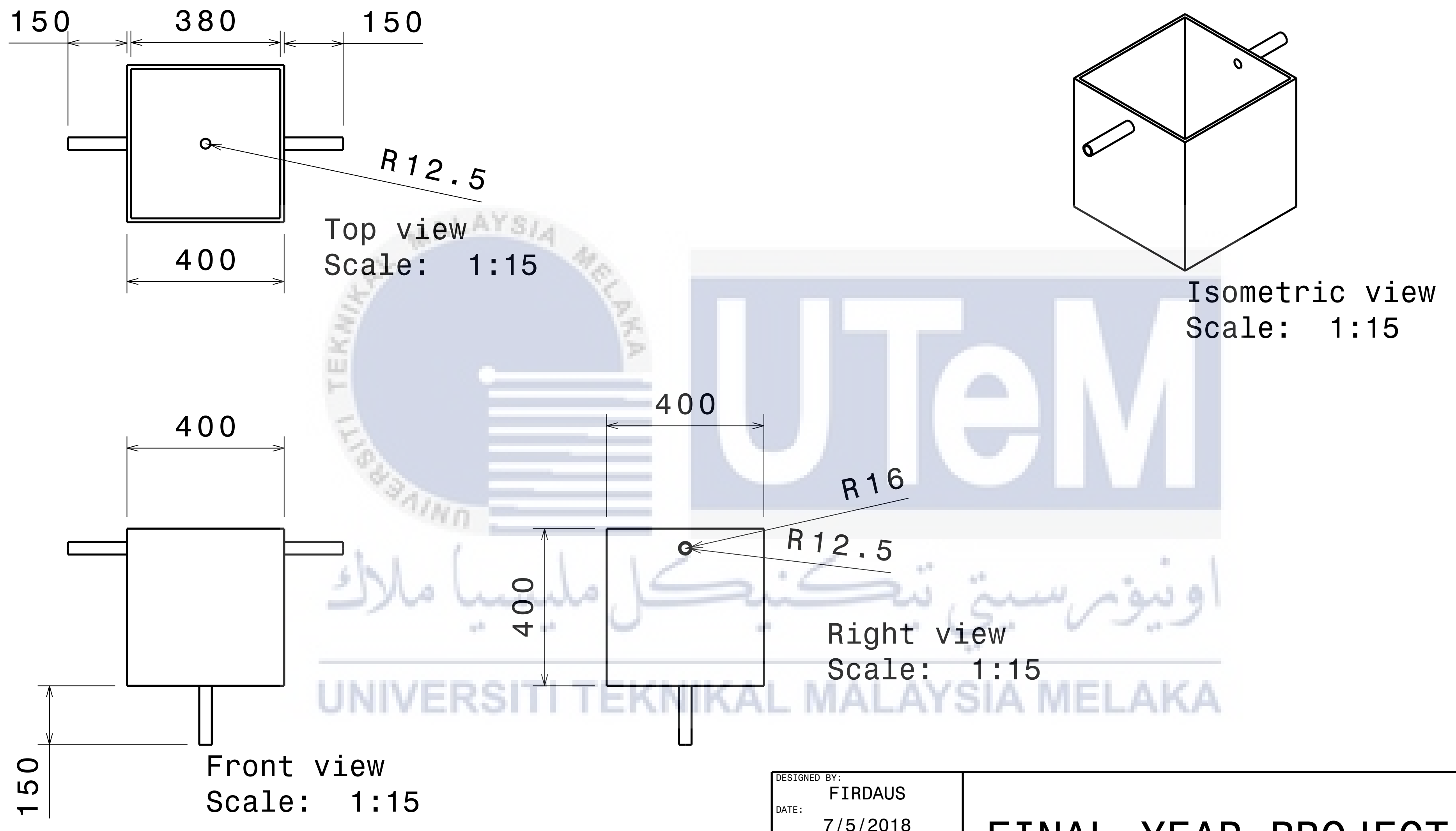
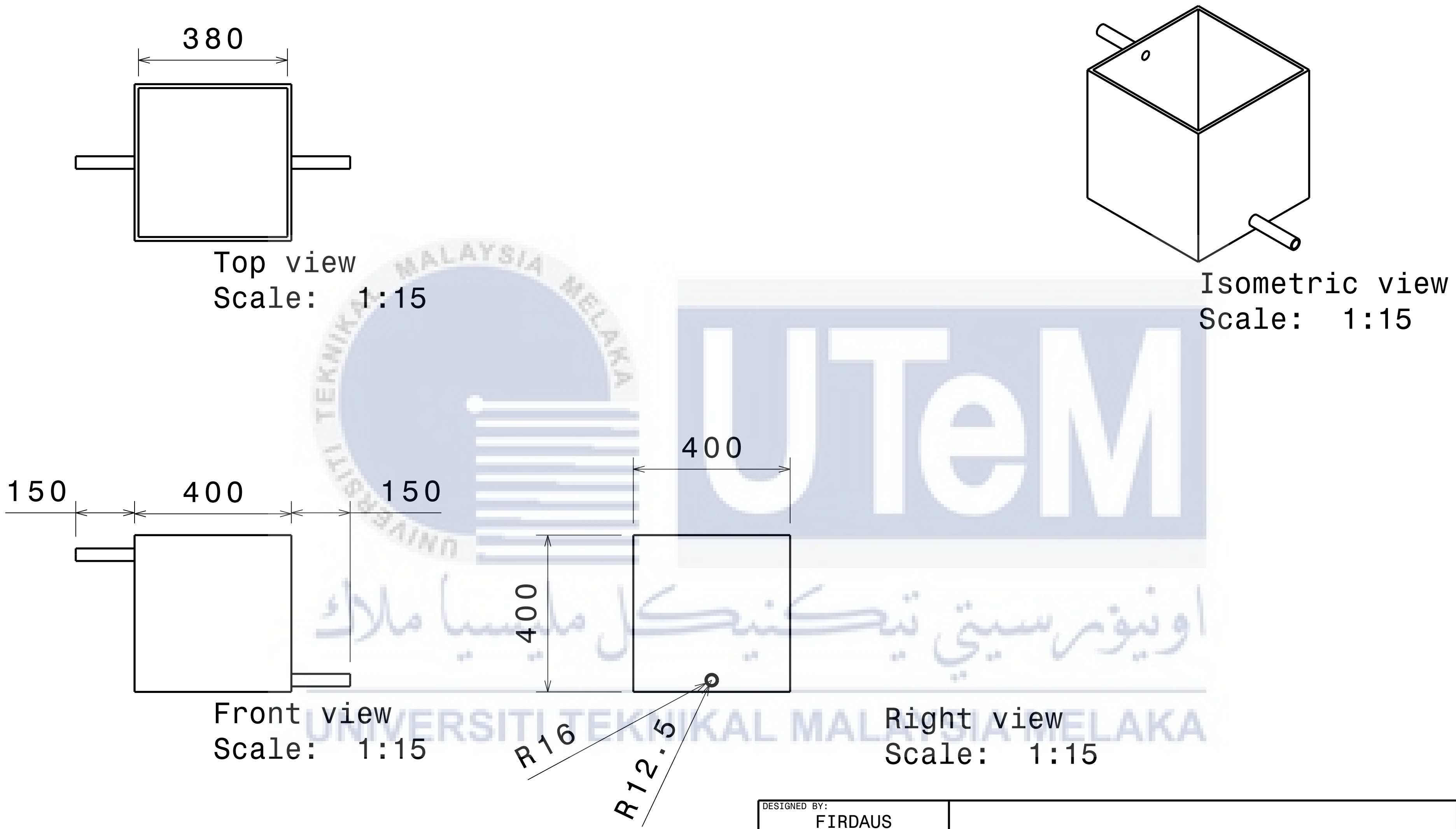


150
380
150
R12.5
Top view
Scale: 1:15
400
Isometric view
Scale: 1:15
400
400
R16
R12.5
400
Right view
Scale: 1:15
150
Front view
Scale: 1:15
DESIGNED BY:
FIRDAUS
DATE:
7/5/2018
CHECKED BY:
EN. NAZIM
DATE:
11/5/2018
FINAL YEAR PROJECT
SIZE
A4
PART DRAWING
SCALE
1:15
WEIGHT (kg)
XXX
TITLE :
CONTACT TANK 1
SHEET
9/22
This drawing is our property; it can't be reproduced or communicated without our written agreement.



DESIGNED BY: FIRDAUS DATE: 7/5/2018		FINAL YEAR PROJECT	
CHECKED BY: EN. NAZIM DATE: 11/5/2018			
SIZE A4		PART DRAWING	
SCALE 1:15	WEIGHT (kg) XXX	TITLE : CONTACT TANK 2	SHEET 10/22



DESIGNED BY: FIRDAUS DATE: 7/5/2018	FINAL YEAR PROJECT		
CHECKED BY: EN. NAZIM DATE: 11/5/2018			
SIZE A4		PART DRAWING	
SCALE 1:15	WEIGHT (kg) XXX	TITLE : CLEAR WATER TANK	SHEET 11/22

Rev	
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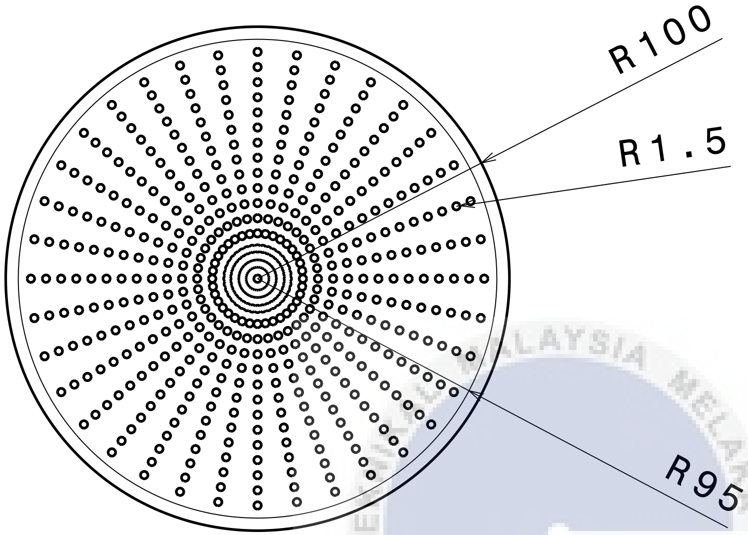

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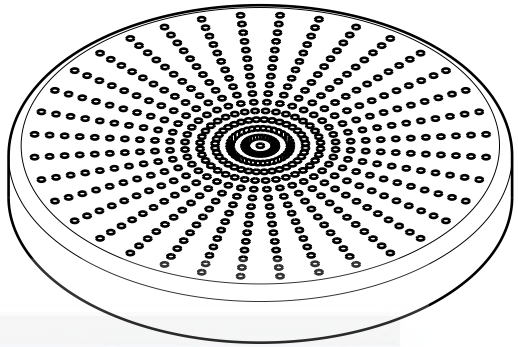
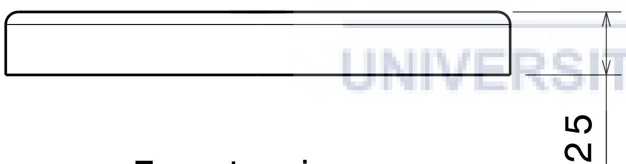


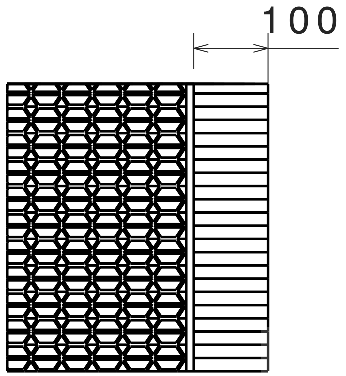
Isometric view
Scale: 1:3



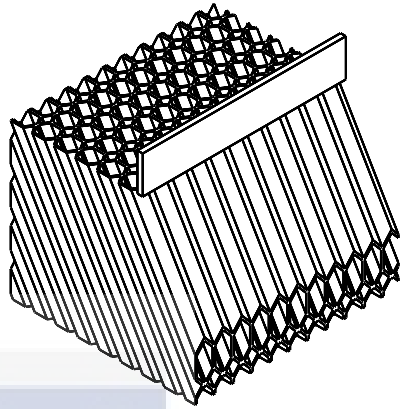
Front view
Scale: 1:3

Right view
Scale: 1:3

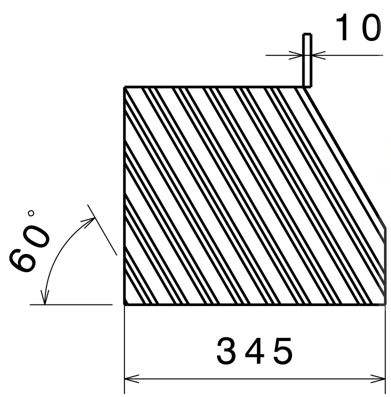
DESIGNED BY: FIRDAUS DATE: 7/5/2018 CHECKED BY: EN. NAZIM DATE: 11/5/2018	FINAL YEAR PROJECT		I _ H _ G _ F _ E _
SIZE A4		PART DRAWING	D _
SCALE 1:3	WEIGHT (kg) XXX	TITLE : AERATOR	SHEET 12/22



Top view
Scale: 1:10



Isometric view
Scale: 1:10



Front view
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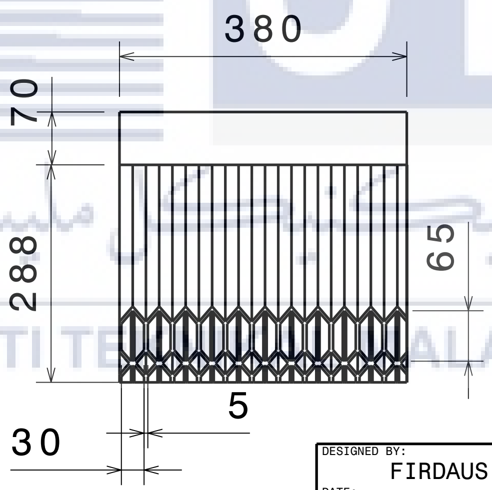
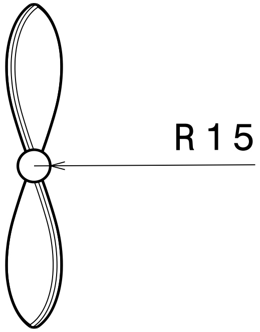
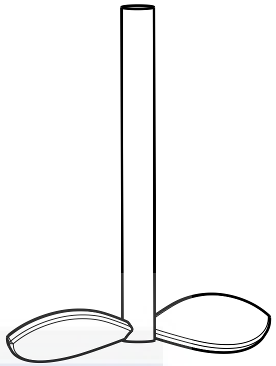


Right view
Scale: 1:10

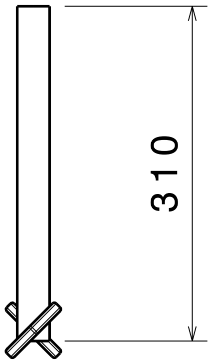
DESIGNED BY: FIRDAUS	FINAL YEAR PROJECT	
DATE: 7/5/2018		
CHECKED BY: EN. NAZIM		
DATE: 11/5/2018		
SIZE A4	PART DRAWING	
SCALE 1:10	WEIGHT (kg) XXX	TITLE : INCLINE SETTLING PLATE	SHEET 13/22



Top view
Scale: 1:7



Isometric view
Scale: 1:7



Front view
Scale: 1:7

Right view
Scale: 1:7

DESIGNED BY: FIRDAUS DATE: 7/5/2018		FINAL YEAR PROJECT		I	_
CHECKED BY: EN. NAZIM DATE: 11/5/2018				H	_
SIZE A4		PART DRAWING		G	_
SCALE 1:7	WEIGHT (kg) XXX	TITLE : PROPELLER	SHEET 14/22	F	_
				E	_
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				C	_
				B	_
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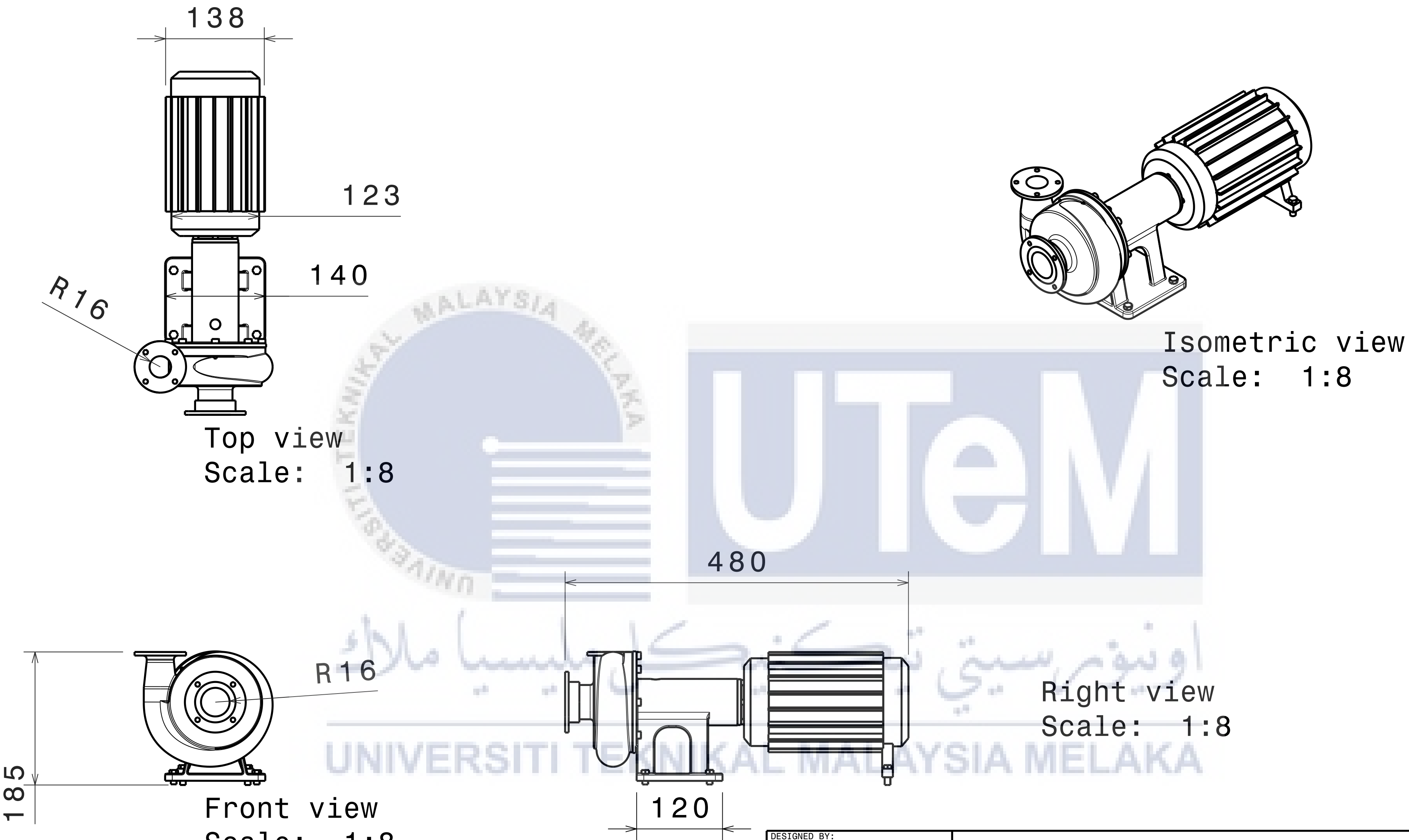

DESIGNED BY: FIRDAUS
DATE: 7/5/2018
CHECKED BY: EN. NAZIM
DATE: 11/5/2018

FINAL YEAR PROJECT

PART DRAWING

SIZE			
A4			
SCALE: 1:8	WEIGHT (kg): XXX	TITLE : CENTRIFUGAL PUMP	SHEET: 15/22

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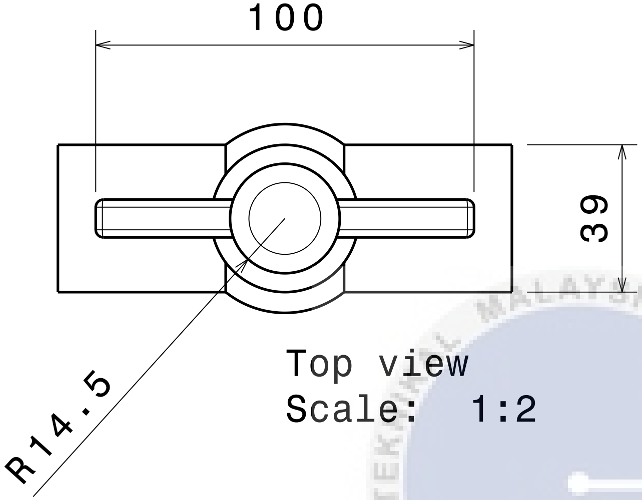
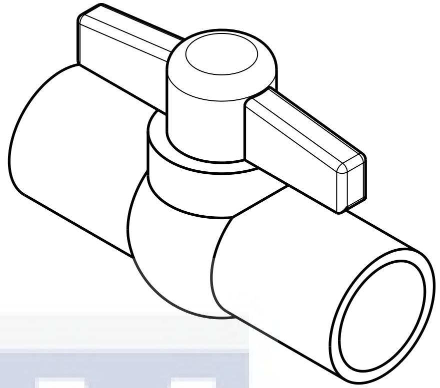
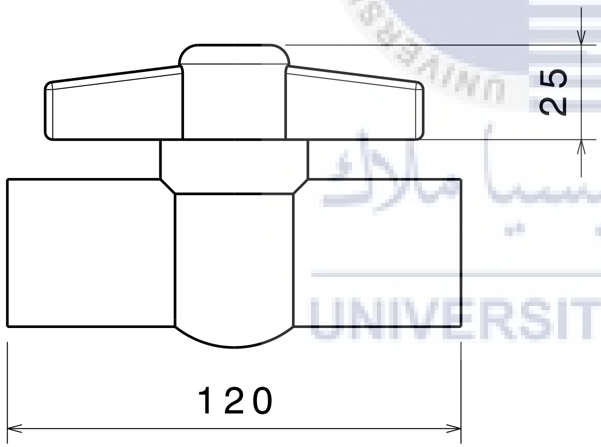
A	_



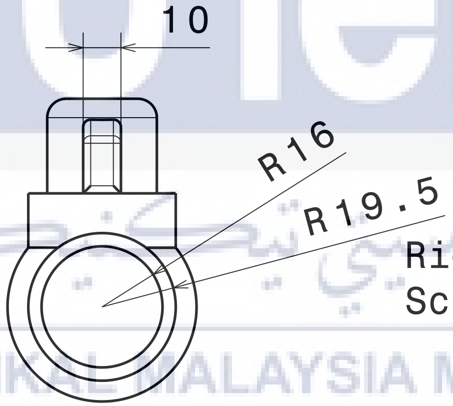
Top view
Scale: 1:2



Isometric view
Scale: 1:2



Front view
Scale: 1:2



Right view
Scale: 1:2

DESIGNED BY: FIRDAUS DATE: 7/5/2018 CHECKED BY: EN. NAZIM DATE: 11/5/2018		FINAL YEAR PROJECT	
SIZE A4		PART DRAWING	
SCALE 1:2	WEIGHT (kg) XXX	TITLE : STOPPER	SHEET 16/22

I	_
H	_
G	_
F	_
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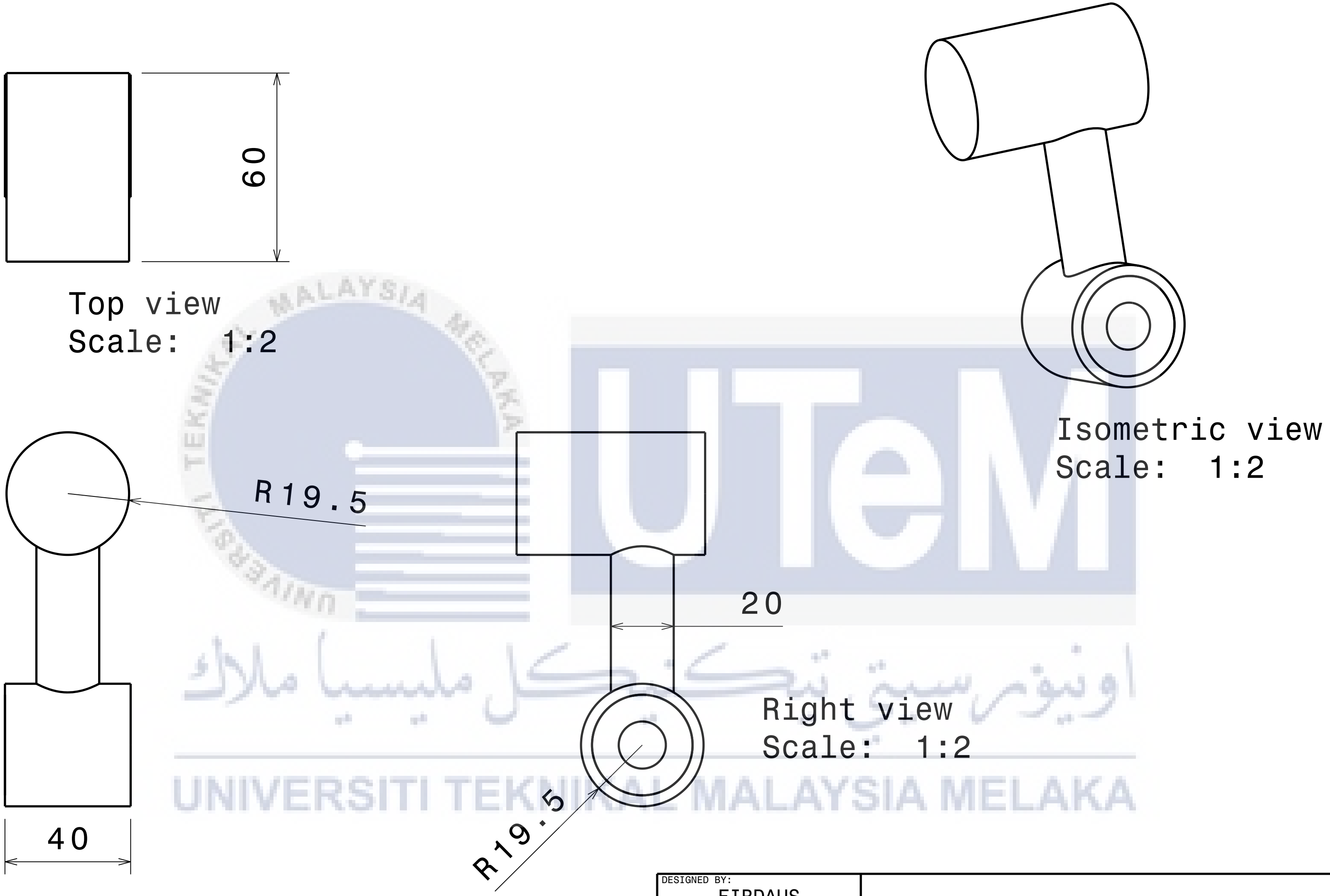
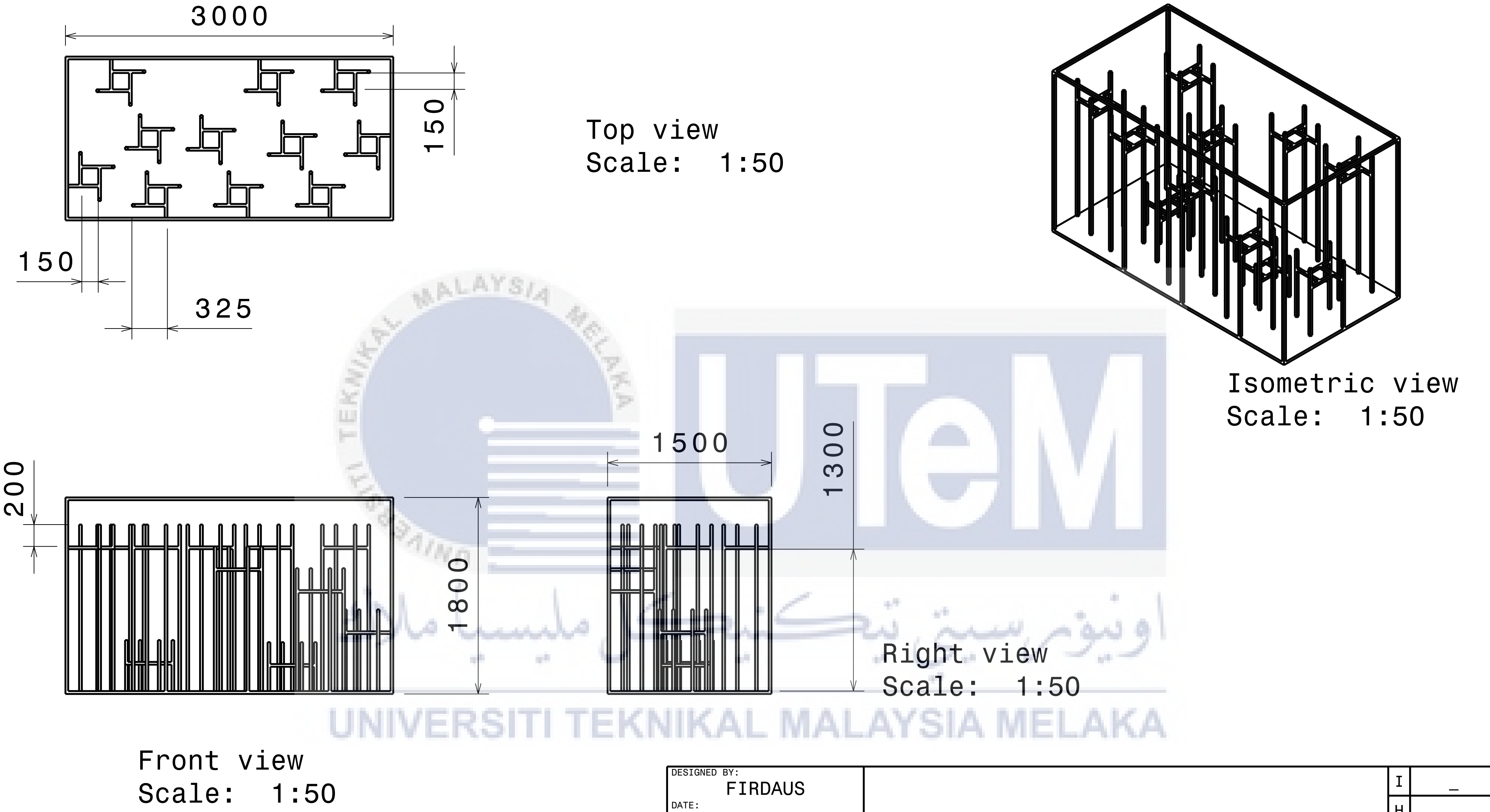


DESIGNED BY: FIRDAUS DATE: 7/5/2018 CHECKED BY: EN. NAZIM DATE: 11/5/2018		FINAL YEAR PROJECT	
SIZE A4		PART DRAWING	
SCALE 1:2	WEIGHT (kg) XXX	TITLE : FLOWMETER	SHEET 17/22



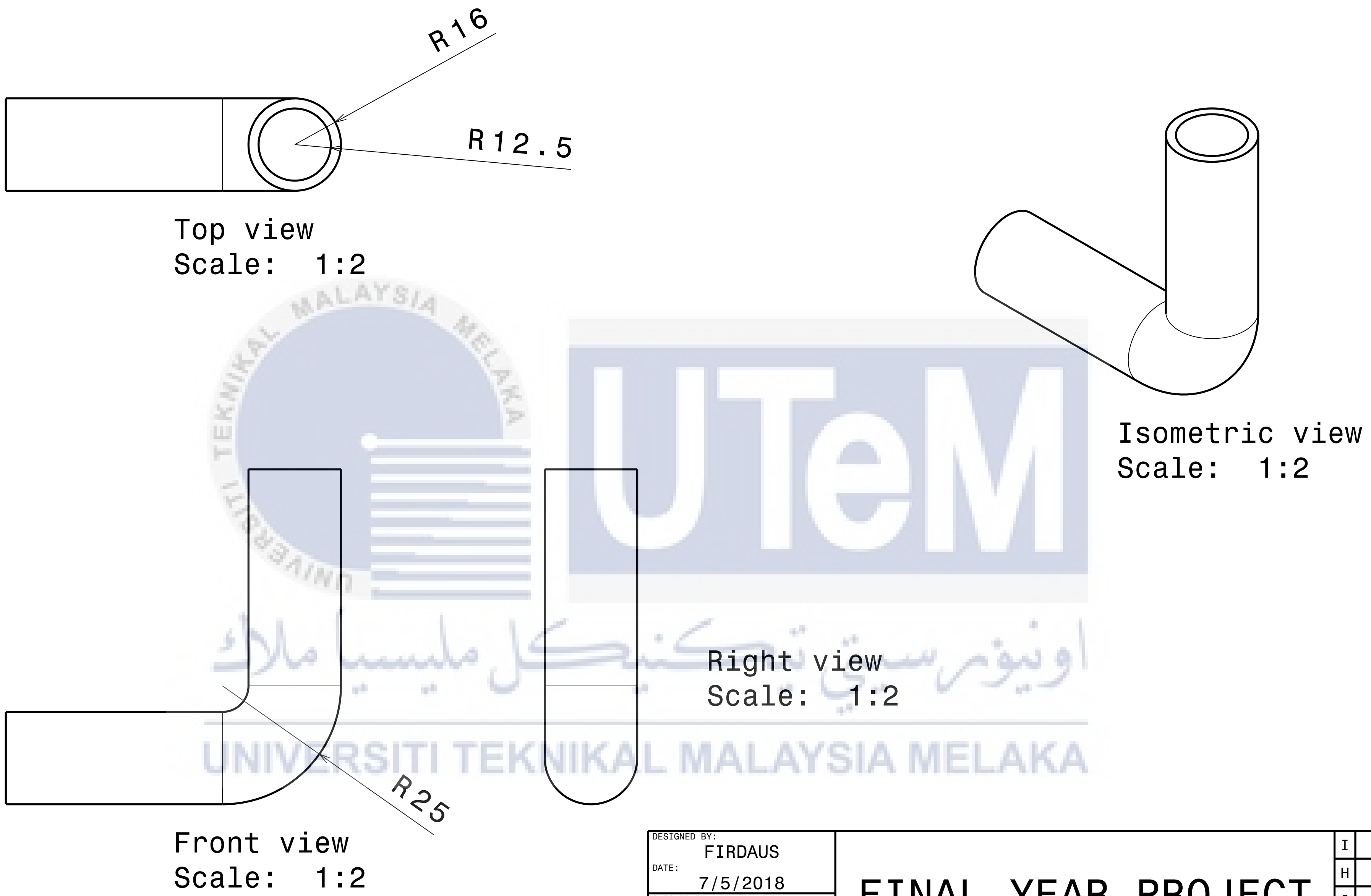
DESIGNED BY: FIRDAUS
DATE: 7/5/2018
CHECKED BY: EN. NAZIM
DATE: 11/5/2018

FINAL YEAR PROJECT

SIZE: A4

PART DRAWING

SCALE: 1:50
WEIGHT (kg): XXX
TITLE : FRAME
SHEET: 18/22



DESIGNED BY: FIRDAUS DATE: 7/5/2018 CHECKED BY: EN. NAZIM DATE: 11/5/2018		FINAL YEAR PROJECT	
SIZE A4		PART DRAWING	
SCALE 1:2	WEIGHT (kg) XXX	TITLE : PIPE	SHEET 19/22

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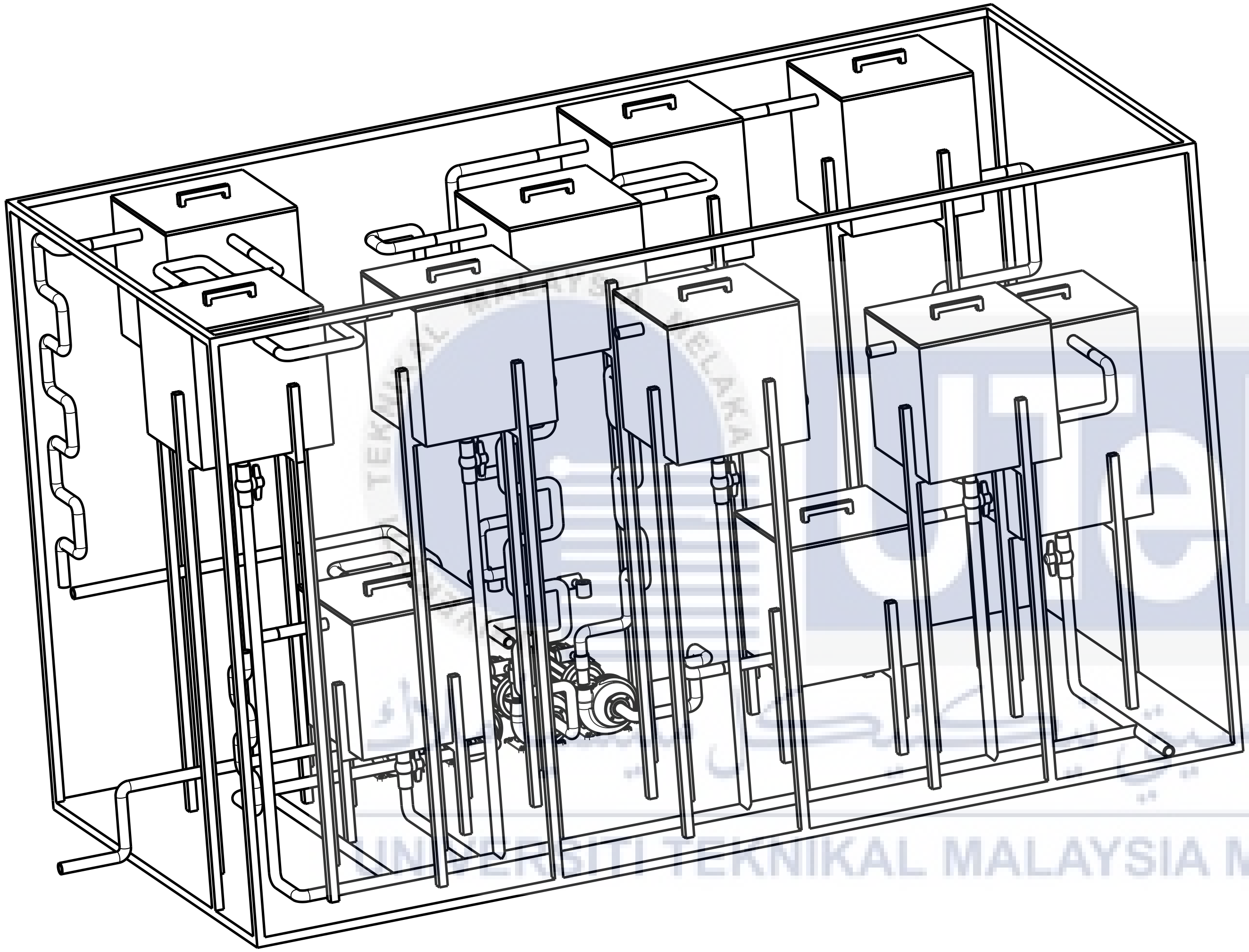
A	_



Isometric view
Scale: 1:20

DESIGNED BY: FIRDAUS	FINAL YEAR PROJECT		
DATE: 7/5/2018			
CHECKED BY: EN. NAZIM			
DATE: 11/5/2018			
SIZE A4		ASSEMBLY DRAWING	
SCALE 1:20	WEIGHT (kg) XXX	TITLE : FULL PRODUCT	SHEET 20/22

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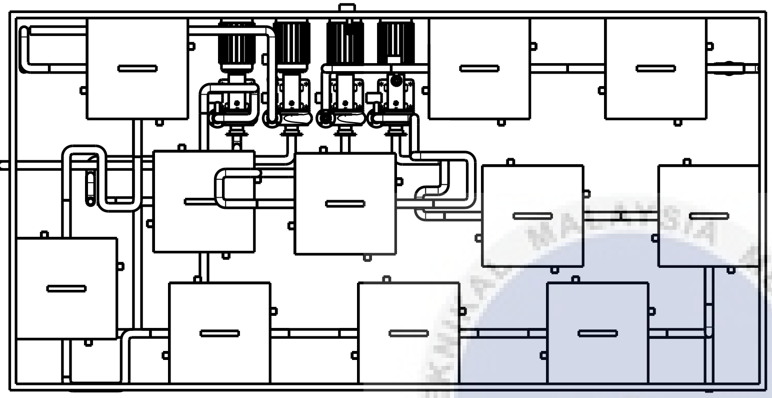
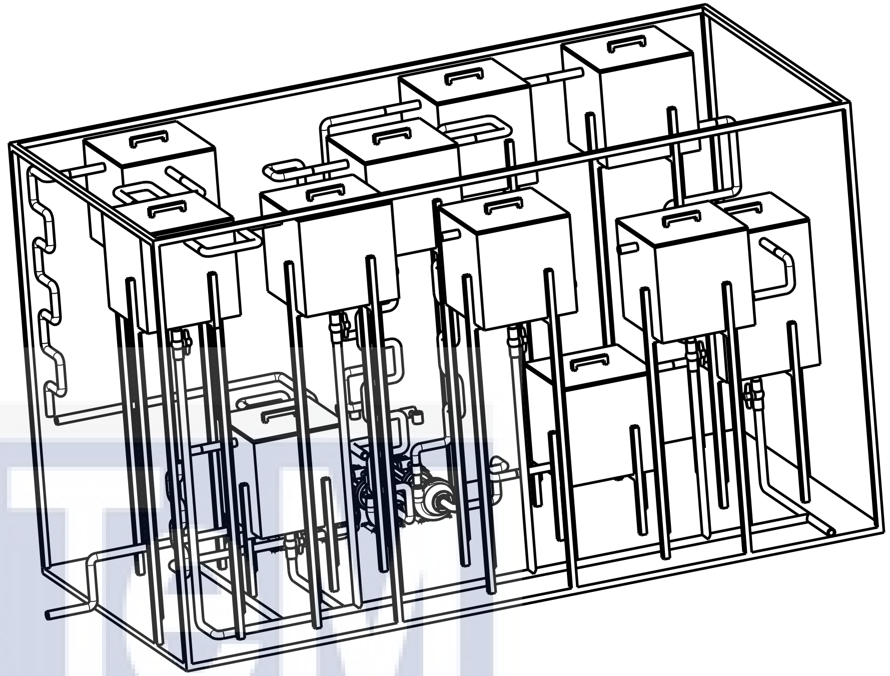
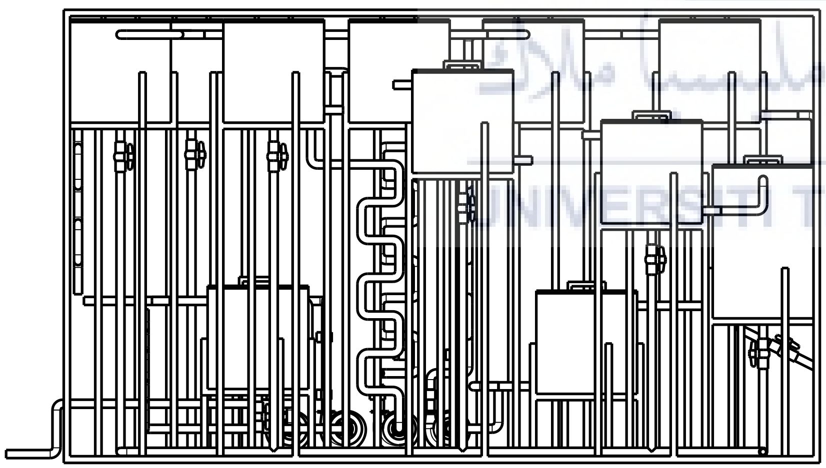


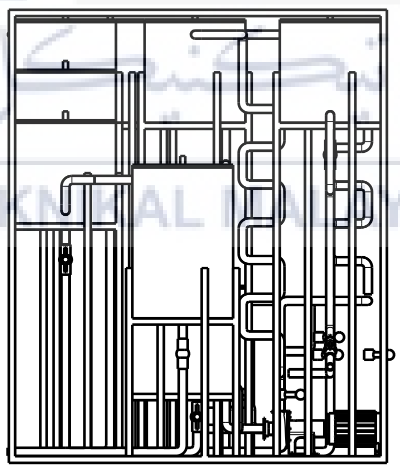
Top view
Scale: 1:30



Isometric view
Scale: 1:30



Front view
Scale: 1:30



Right view
Scale: 1:30

DESIGNED BY: FIRDAUS DATE: 7/5/2018 CHECKED BY: EN. NAZIM DATE: 11/5/2018	FINAL YEAR PROJECT	
SIZE A4	ORTHOGRAPHIC DRAWING	
SCALE 1:30	WEIGHT (kg) XXX	TITLE : FULL PRODUCT	SHEET 21/22

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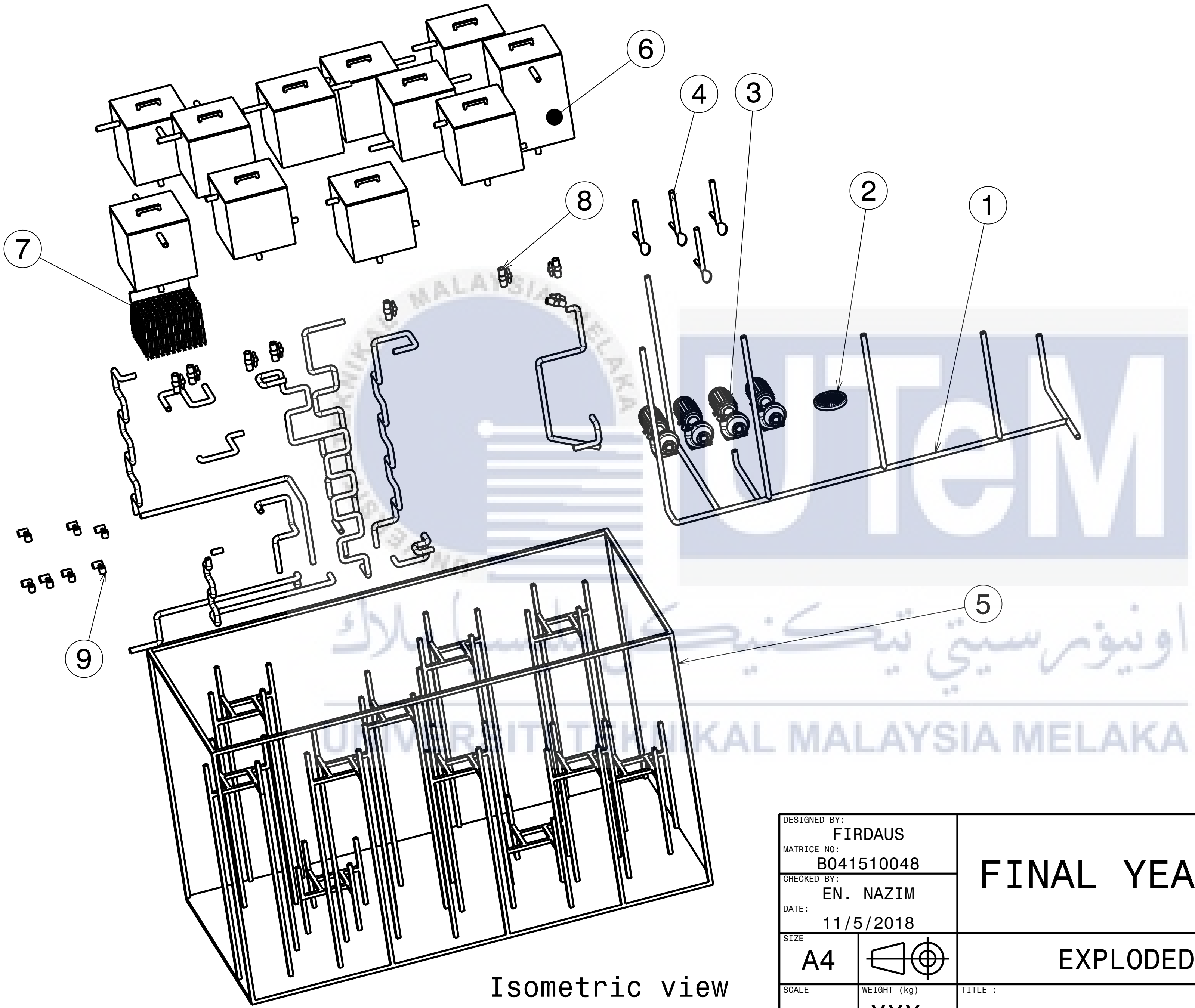
D C B A



Isometric view
Scale: 1:35

DESIGNED BY: FIRDAUS	FINAL YEAR PROJECT	
MATRICE NO: B041510048		
CHECKED BY: EN. NAZIM		
DATE: 11/5/2018		
SIZE A4	EXPLODED DRAWING	
SCALE 1:35 / WEIGHT (kg) XXX	TITLE : FULL PRODUCT	SHEET 22/22

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D A

APPENDIX B

GANTT CHART FOR FINAL YEAR PROJECT 1

No.	Task	Week													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	**Title selection**						SEMESTER BREAK								
2.	**Project briefing**														
3.	**Getting data and information about the project and literature review**														
4.	**Getting data and information about methodology**														
5.	**Produce house of quality and product design specification**														
6.	**Produce conceptual design**														
7.	**Report writing**														
8.	**Report submission**														
9.	**Presentation**														

GANTT CHART FOR FINAL YEAR PROJECT 2

No.	Task	Week													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	**Produce product architecture**														
2.	**Produce configuration design**														
3.	**Produce detail design**							**SEMESTER BREAK**							
4.	**Report Writing**														
5.	**Report submission**														
6.	**Presentation**														