SCHOOL OF ENGINEERING
TAYLOR'S UNIVERSITY

PRJ 60203
Proposal

Team 101
Vertical Rotating Shelf

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Return of student marked assessment tasks. Please check (√) the necessary column.

√	Electronically to the individual student via the University learning management system
	Collect during class, only by the student
	Collection from the school or a staff member upon presentation of their student ID card
	Collection from module coordinator, lecturer or tutor by prior arrangement

* For online assessment such as forum, quiz, test, survey and etc., return of students marked assessment tasks are published in TIMES.

CONTENT

ABSTRACT

The key purpose of this proposal is to provide complete information about the Engineering Design and Ergonomics module project. The main objective of this project is to improve student and staff experience in Taylor's University by introducing an ergonomic shelf design prototype that embodies ergonomic principles. Through our survey, research and the implementation of the Conceive, Design, Implement and Operate (CDIO) Initiative, we have selected the laboratory as our main focus and developed an idea to minimize fatigue caused by repetitive physical movements such as squatting and bending down when reaching for items in lower compartments of shelves. We tackled this issue by producing a vertical rotating shelf to allow laboratory users to easily reach for lightweight goods in any shelf compartment while standing still.

Referring to the detailed sketch of the design, we have prepared the material list and budget plan with the total cost of materials amounting to RM . Moreover, a Work Breakdown Structure (WBS) chart and Program Evaluation Review Technique (PERT) Chart have been generated to analyze required tasks and balance our workload fairly and effectively. With these two charts, we have constructed a Gantt chart showing our full work schedule to ensure the completion of our product on time. Furthermore, an organizational chart and linear distribution chart have been provided.

All in all, this module project gives us the opportunity to improve on our teamwork, time management and communication skills that we will carry forward with us in our future working environment.

1.0 INTRODUCTION

The objective of this this project is to provide an opportunity to semester 2 students to create an innovative and ergonomic product which will suit everyone's needs not only in this university but also in other regions of the world. Besides, it provides students with better understanding and improve on their project management skills throughout this project [1]. In this engineering design and ergonomics module, we are given the task to come up with a solution for a user friendly and comfortable environment in Taylor's University.

Taylor's University is one of the highly recognised university and was ranked at the top 250 in the Asia with its great achievement among the academic partners and employers, their research outputs and even achievement in internationalization. As to achieve the university's goal of becoming one of Asia's leading universities, this project is strongly beneficial as it will bring a positive outcome and success to the university [2]. When the university is well recognised, there will be a constant rise in student intake every year. Therefore, the quality of the university should be well preserved and one of the key of it will be the modernisation..

For this project, we looked into the available shelving system in the laboratory and found that it was not efficient as it could be. The standard shelves for storage purposes were not designed for maximum ease of use whereby users have to either tiptoe, squat or bend down just to reach higher and lower compartments. We found these physical movements unnecessary and inconvenient. To gain a second opinion and better understanding of the difficulties faced by laboratory users, we conducted an online survey. A total of twenty one individuals participated in this online survey and the results obtained are as shown below.

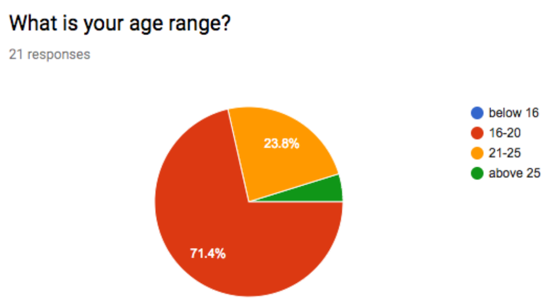


Figure 1.0 Age range

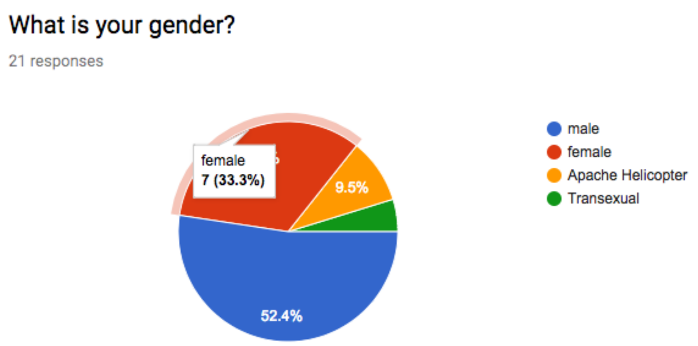


Figure 2.0 Gender category

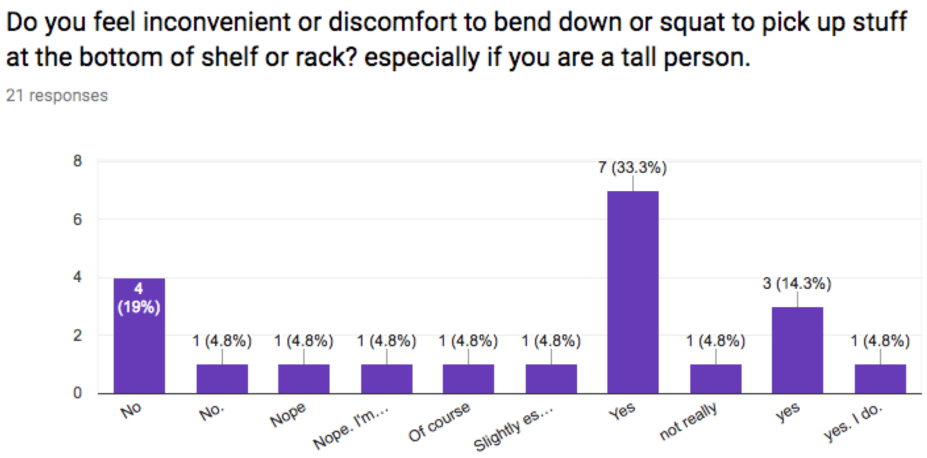


Figure 3.0 Inconvenient or discomfort when reaching the bottom of the shelf rack

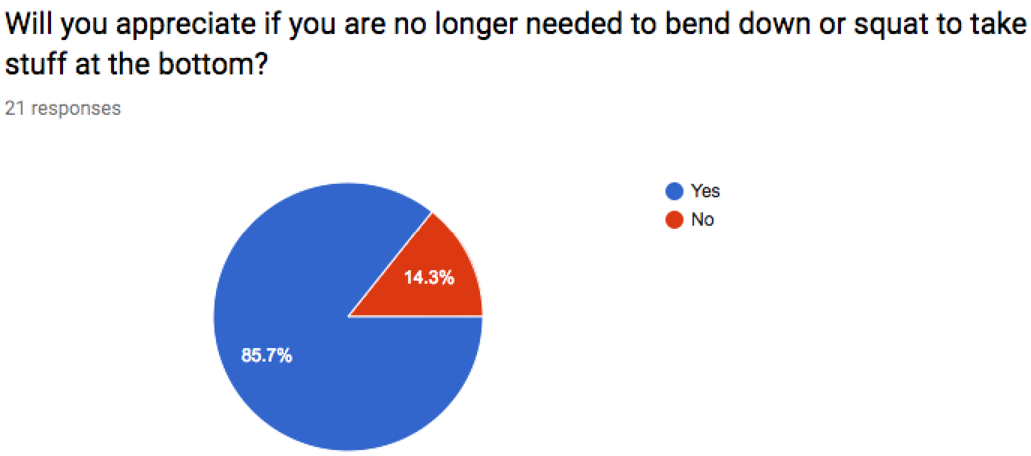


Figure 4.0 Thoughts on the need of bending down to the bottom of the shelve

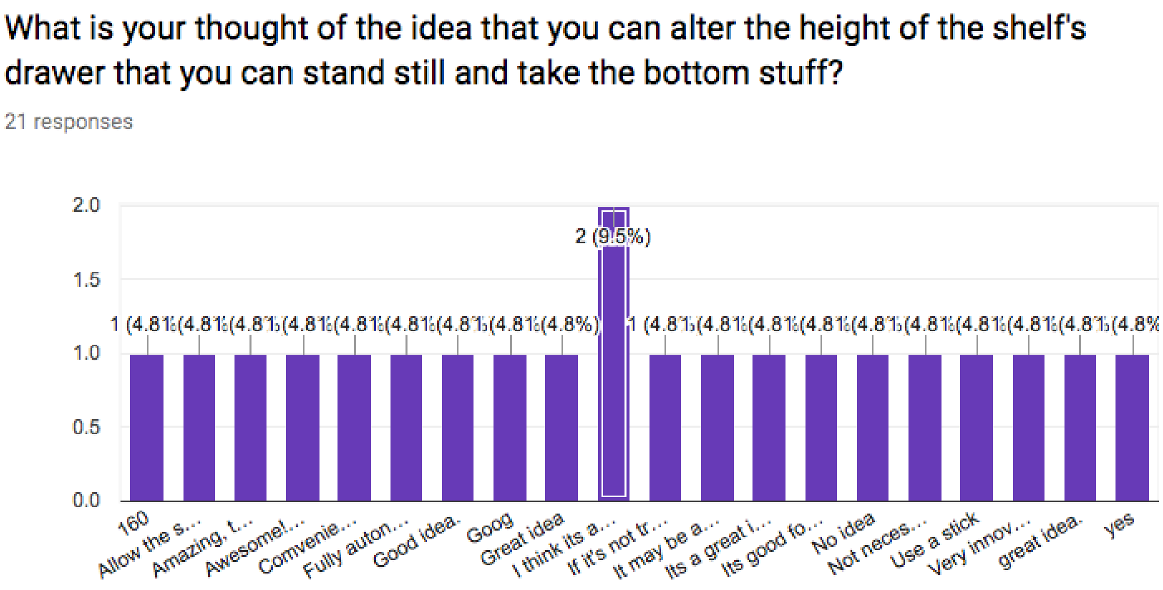


Figure 5.0 Thoughts on the idea to solve the challenges

Based on Figure 1.0 and Figure 2.0, the data shows that most of the individuals that participated in the survey are aged between 16-20 and males. Apart from that, Figure 3.0 shows that an estimated of more than 50% of laboratory users have experienced discomfort or difficulty reaching for items in lower compartments of shelves. Hence, there is a high probability that the users may have experienced backache or lower back strain when doing so. Furthermore, Figure 4.0 shows that a major percentage of 85.7% would appreciate if they no longer need to bend down to reach lower compartments in search for items. Hence, this proves that is a need for us as future engineers to think of ideas to solve this challenge. Lastly, Figure 5.0 has shown the thoughts of the users in resolving the situation. One of the participants had shared his/her idea which is to allow the shelf drawers to be elevated automatically. Besides that, a fully autonomous machine has been requested by one of the users. Apart from all the thoughts above, many of the users are satisfied with the idea (especially by the taller users) proposed by the team in order to provide a more comfortable environment for the laboratory users. From the survey conducted above, it can be concluded that the current shelving system in the laboratory can be further improved. Thus, the team members have suggested to build a vertical carousel shelf which is innovatively ergonomic and a more user friendly product. Our solution will allow users to obtain their equipments and tools without having to bend or squat down to reach the bottom compartments of shelves.

Furthermore, SWOT analysis which stands for strenghts, weaknesses, opportunities and threats was conducted. It acts as a framework to identify the thinking and philosophy which could potentially brings up a huge success in creating a product. It is also important for the team to identify the internal and external aspects of the product that will affect the future performance.

Strengths The team has plenty of knowledge and interest in the gear and pulley mechanism.	**Weaknesses** Most of the members in the team have a lack of knowledge in programming.
Opportunities The team will be able to create a complex product related to gears and pulleys system.	**Threats** The team will not be able to create something that requires the programming.

Moreover, our idea aligns with one of the fourteen grand challenges for engineering listed by the National Academy of Engineering (NAE). Our idea of redesigning a storage shelf is associated with the challenge of restoring and improving urban infrastructure [3]. Infrastructure is defined as the basic environmental or physical framework needed for the community worldwide, and this includes shelving systems because it is commonly utilized in many different areas by humans to store various types of objects in an organised manner. Our redesigned shelf is engineered to provide users easy access to any object in any shelf compartment which saves time and effort. Not only that, it diminishes adverse impacts on the environment by using fewer resources since motors are not used for this project. This eliminates the need for electricity usage as consuming less power reduces the amount of toxic fumes that power plants release, thus conserving limited natural resources and saving ecosystems from destruction. By modernizing the basic shelving units into vertical rotating shelving units without consuming energy, we are able to create a sustainable storage solution that can support the future generation.

2.0 CONCEPT

Since the theme of the project is to modify campus facilities to fit an ergonomic purpose such as, reduce human effort or increase human comfort. We have decided to improve the properties of shelves to minimize muscle fatigue by eliminating the need for physical movements such as squatting and bending down. We tackled this issue by producing a vertical rotating shelf so that we can stand still and be able to take goods in any compartment of the shelf.

Figure 6.0 Generic shelf

The figure above shows how an ordinary shelf looks like. This traditional shelf that stores goods has a weakness that requires humans to exert energy-consuming movements such as squatting or bending down. Besides, it has limitations for those who are wheelchair bound. Therefore, if the shelf compartments are able to move vertically, it will save a lot of effort and is convenient for those who with height limitations.

We unintentionally came across a rotatory automated parking system in Japan, as shown in Figure 7.0. This inspired us to produce a rotatory shelf for convenience. The concept of this system is that a shelf compartment can be rotated to the front and back of the shelf.

Figure 7.0 Rotatory automated parking system

To apply and implement this idea, an all-round completed gear system is needed for the movement function of the shelf. Basically, the gear system is the backbone of this idea. We have generated some variations of the idea and based on the decision matrix table shown below, we have chosen the best one which is the gear system with single pitched attachment chain.

Criteria	Weightage	A nailed ferris wheel shelves in a box	Gear system with rubber belt	Gear system with single pitched attachment chain
Ease to use	5	4	4	4
Safety	4	3	3	4
Value & Performance	3	2	1	5
Cost	2	3	2	4
Physical apperance	1	1	2	3
Total rate, ∑Weightages		45	41	62

After deciding on the ideal system, we proceeded to research for similar systems and designs which are already available in the market. We found similar designs but for different purposes, for example, the rolling machines in the factory to deliver stuff, a rotating shoe rack as well as a rotating storage for confectioneries. Furthermore, we came across the design which is the closest to our gear system design as shown below.

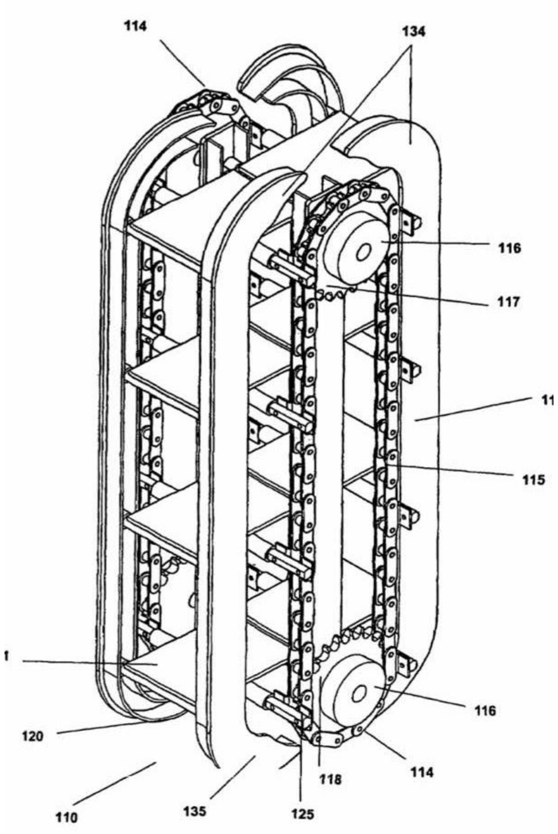


Figure 8.0 Rotating compartments mechanism

Based the APOC survey which we have carried out to investigate users' needs, and majority of them feel that it is troublesome to squat or bend to pick up items from the bottom compartments. Plus, most of them think that this idea is feasible and would appreciate if this kind of product existed.

While developing our idea, we have produced a more detailed design on each component of our system. We have found that the trickiest part that requires the most consideration in terms of cost is the four gears.

As shown in Figure 9.0, the gears are connected by long metal shafts, which is roughly 70cm apart. One pair of gears are placed on the top and the other pair are placed at the bottom, roughly 140cm apart. Two single pitched roller chains are installed on the right and left side of the shelf to be rotated by the gears simultaneously.

For the shaft attachment, a U-shaped lock will be used to secure the shaft to the wood. A long screw is penetrated through the pitch of the roller chain and screwed to the sides of each compartment.

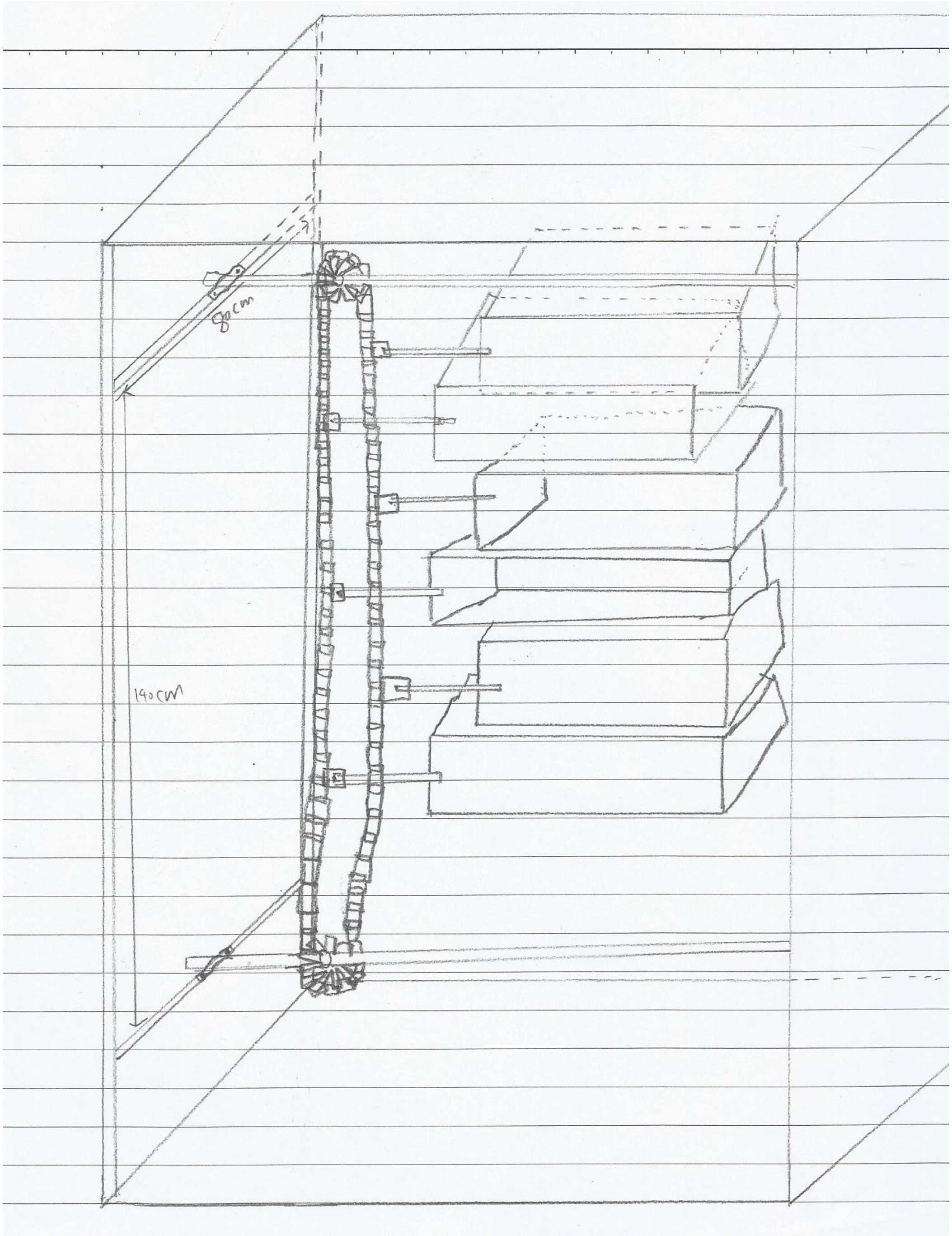


Figure 9.0 Internal mechanism design

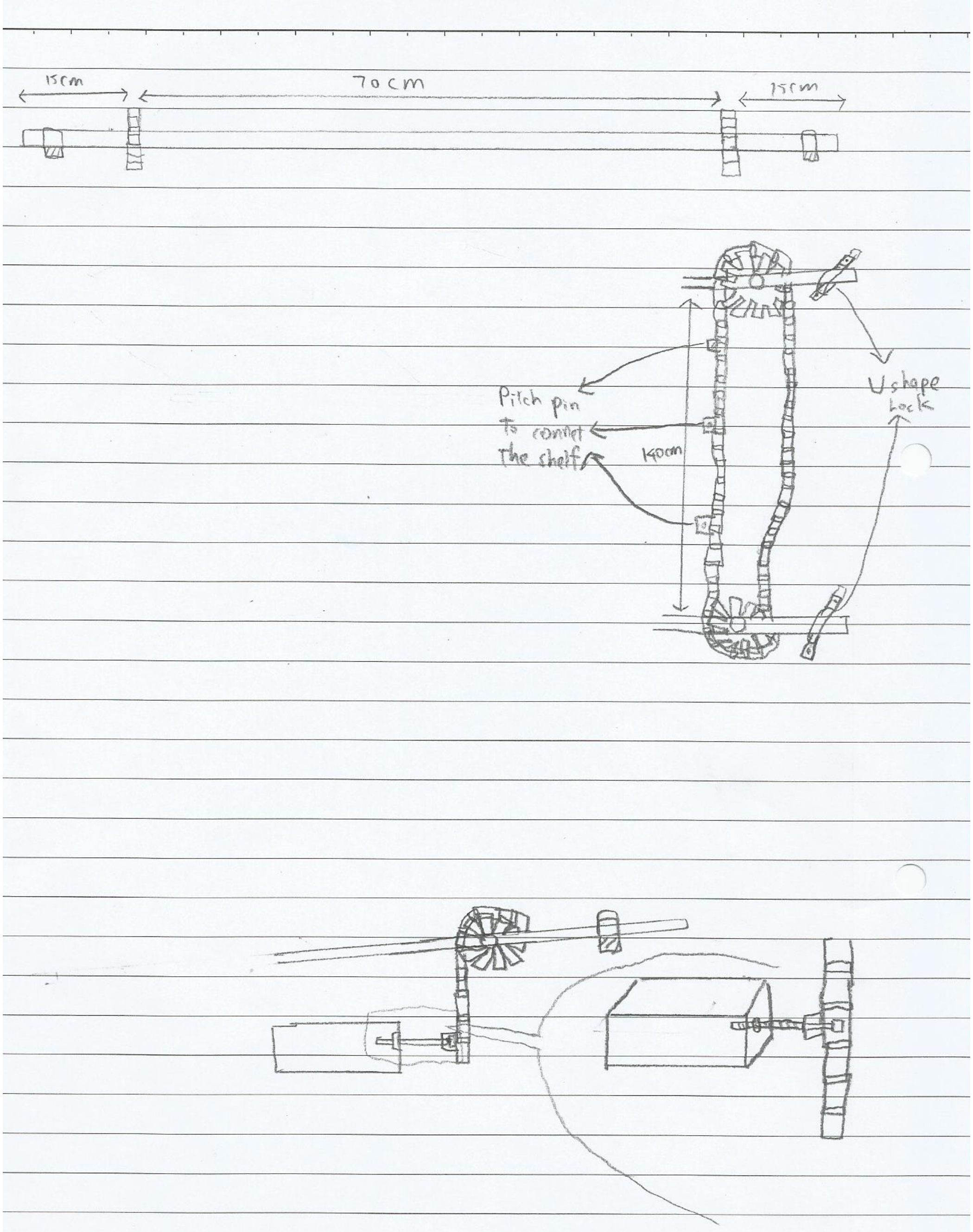


Figure 10.0 Close up view of mechanism

3.0 METHODOLOGY

Our goal is to construct a vertical rotating shelf for storage purposes in the laboratory which can reduce physical stress and muscle fatigue at a minimum cost.

For this project, the rotating shelf consists of three sub-systems; the exterior frame, internal mechanism and linkage system. The exterior frame acts as a support for the rotating shelf with dimensions 150cm in height, 50cm in width and 100cm in length. As for the internal mechanism, the rotation of the compartments (total of 6 compartments) are aided by gears and chains. Based on Figure 11.0, the dimensions of each compartment is 20cm in height, 12cm in width and 50cm in length.

Ergonomic principles have been taken into consideration. The rotating shelf is designed to work manually instead of using motors which requires electricity usage, hence it is eco-friendly. Moreover, the height of the rotating shelf is 150cm, making it easy for users to reach. Besides, the compartments can be rotated according to the user's choice without them having to bend down or climb up, helping to reduce muscle fatigue and avoid injuries in human tissues and joints.

3.1 Internal mechanism

The six compartments is made from Perspex. Perspex is light and easily acquired at a low price. Based on Figure 12.0, brackets are used to link the Perspex together so that it will be more durable. Sprocket gears and roller chains with attachments are fixed to the compartments to allow them to rotate. For every compartment, we will drill two holes at the side to attach it to the roller chain. As for the gears, they are connected with a shaft and placed at the top and bottom of the rotating shelf in such a way that will be easier for the roller chain to move or rotate.

3.2 Linkage system

According to Figure 12.0, the linkage system connects the exterior frame to the interior mechanism. The system consists of bolts and nuts connecting the shelf to the roller chain. A small hole will be drilled into the Perspex that will fit the shape and dimensions of the bolts and nuts.

3.3 Exterior frame

The exterior frame of the rotating shelf acts as a support and connects the six compartments. The frame is made from wood. The shaft is attached to the wood as shown in Figure 11.0. A lock will be fastened onto the shaft so that the gear will be fixed in place. The design for the exterior is shown in Figure 11.0.

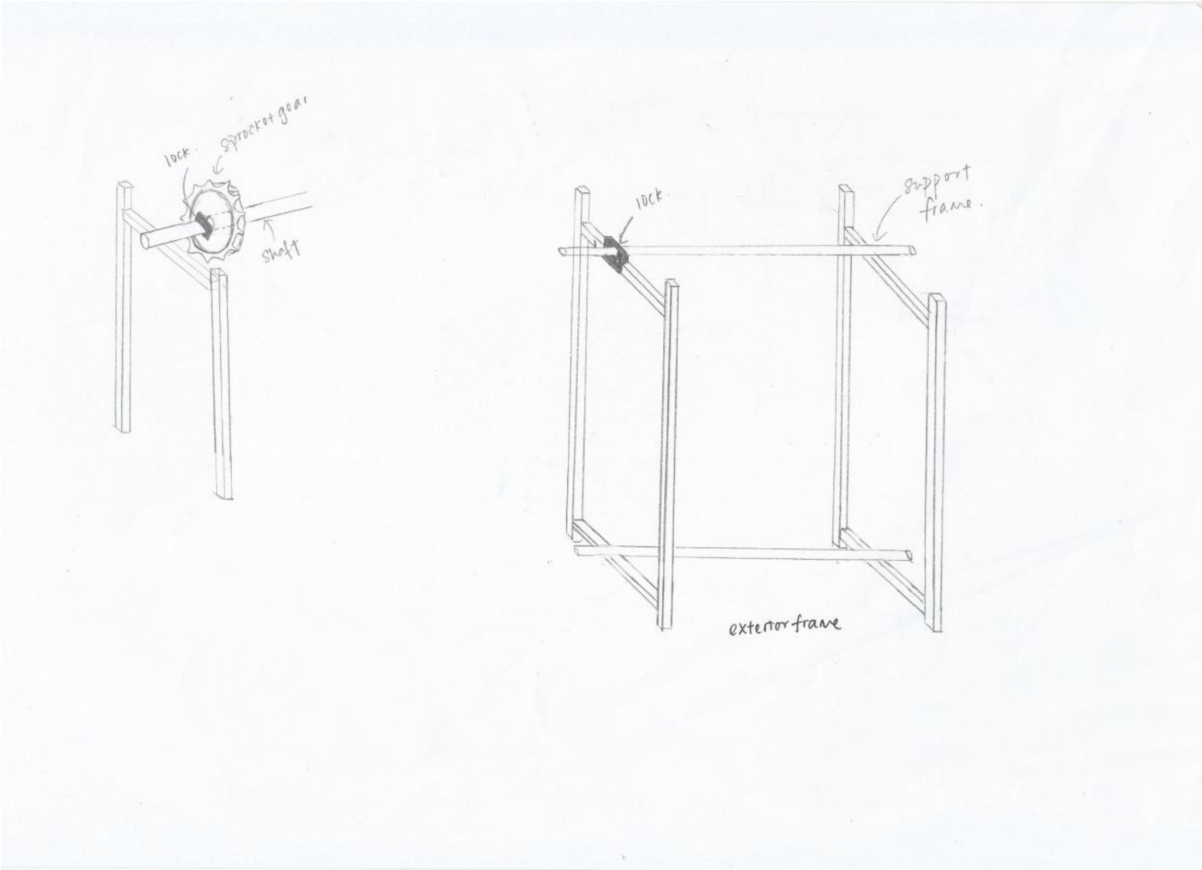


Figure 11.0 External frame design

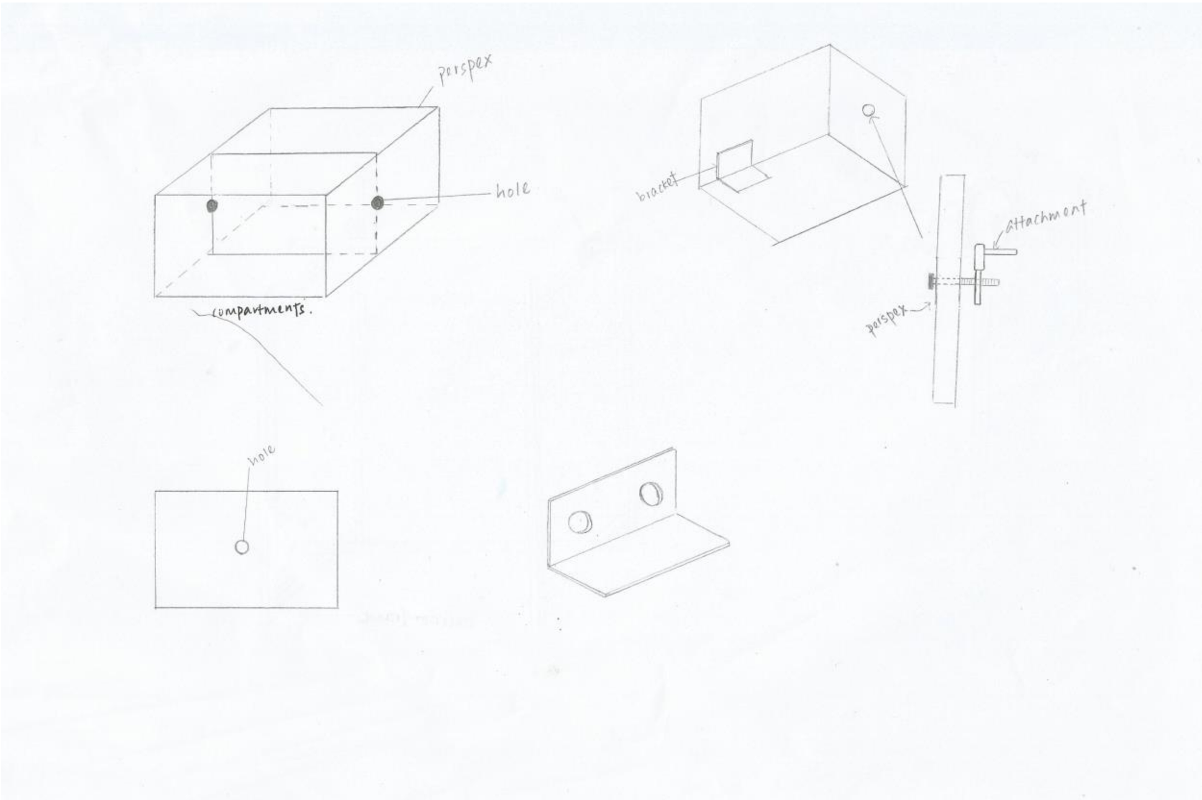


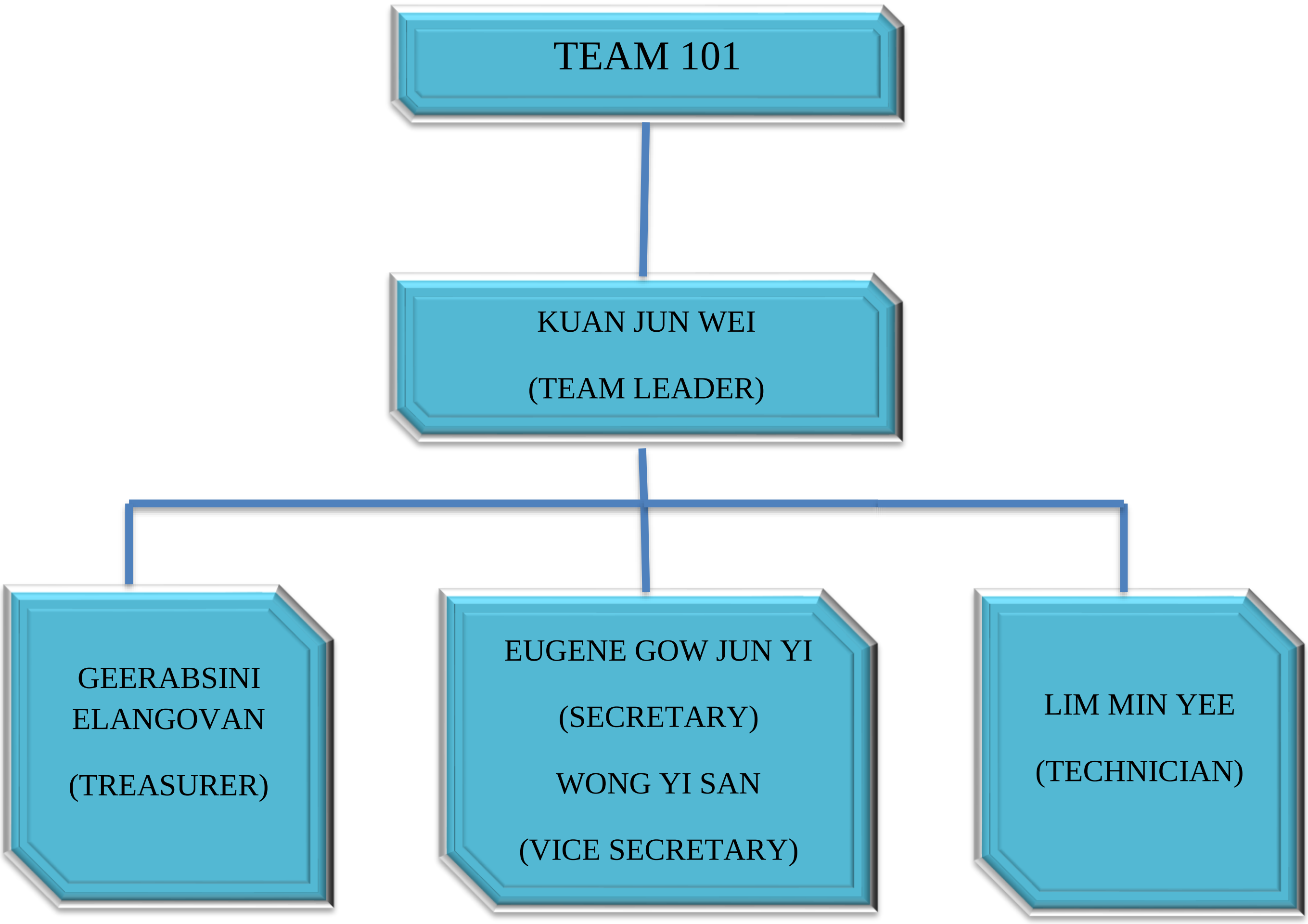
Figure 12.0 Linkage system design

4.0 BUDGET

Vendors	Materials	Dimension (mm)	Quan-tity	Unit Price (RM)	Subsidized Price (RM)	Price if purchased (RM)	Total Price (RM)
Materials & Solid Lab/ Automation and Robotics Lab	Perspex	1000 x 2500 x10	2	20.00	40.00	40.00	0
	Bracket	-	30	1.20	36.00	36.00	0
	Bolt	M4	12	0.10	1.20	1.20	0
	Nut	M4	12	0.10	1.20	1.20	0
	Shaft	1000	2	75.00	150.00	150.00	0
Eastern Electric Industrial Sdn Bhd	Woods	120 x 70 x 1500	8	7.50	60.00	60.00	0
Leong Seng Auto Sdn Bhd	Sprocket Gear	20	4	7.40	-	29.60	29.60
	Roller Chain	6096 (20 ft)	2	27.00	-	54.00	54.00
	Attachment	SA1	12	4.50	-	54.00	54.00
	Lock	20	8	12.50	-	100.00	100.00
Grand Total							237.60

We have decided to use wood and Perspex to build the shelf frame and compartments respectively. Brackets, bolts and nuts will be used for linkage. Shafts will be used to hold the gears and link the interior mechanism and exterior frame together. Perspex, shafts, bracket, bolts and nuts were obtained from the Materials and Solid Lab because the university can provide us those items for free. The locks for the shaft, sprocket gears, roller chains and the attachments were purchased from Leong Seng Auto Sdn Bhd at a good price. The wood was acquired from Eastern Electric Industrial Sdn Bhd free of charge.

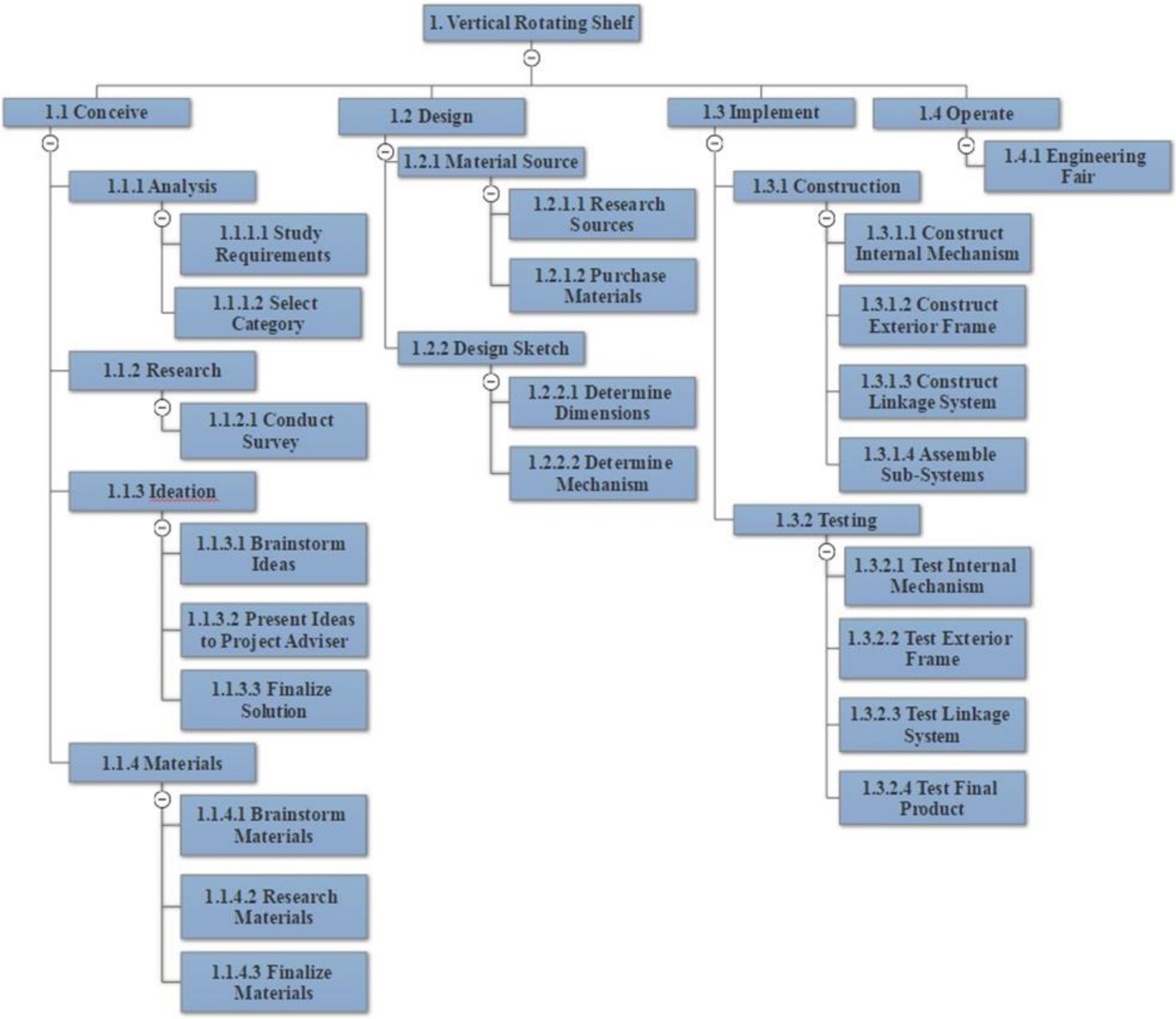
5.1 ORGANIZATION CHART



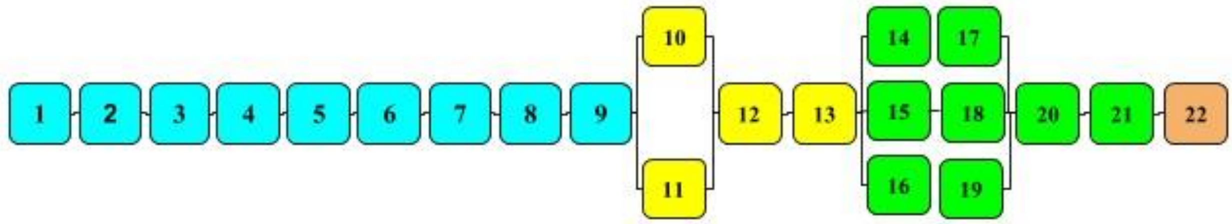
5.2 LINEAR RESPONSIBILITY CHART

WBS Code	Element	Person In Charge				
		JW	EG	MY	GE	YS
1.1	Conceive [C]					
1.1.1.1	Study Requirements	6	6	6	6	6
1.1.1.2	Select Category	6	6	6	6	6
1.1.2.1	Conduct Survey	6	6	5	4	4
1.1.3.1	Brainstorm Ideas	6	6	6	6	6
1.1.3.2	Present Idea to Project Advisor	6	6	6	6	6
1.1.3.3	Finalize Solution	6	6	6	6	6
1.1.4.1	Brainstorm Materials	6	6	6	6	6
1.1.4.2	Research Materials	6	6	6	6	6
1.1.4.3	Finalize Materials	6	6	6	6	6
1.2	Design [D]					
1.2.1.1	Determine Dimensions	5	4	6	6	3
1.2.1.2	Determine Mechanism	6	6	4	3	5
1.2.2.1	Research Sources	3	4	6	5	6
1.2.2.2	Purchase Materials	6	6	6	6	6
1.3	Implement [I]					
1.3.1.1	Construct Internal Mechanism	6	6	3	5	4
1.3.1.2	Construct Exterior Frame	6	6	6	6	6
1.3.1.3	Construct Linkage System	4	5	6	6	6
1.3.2.1	Test Internal Mechanism	6	6	6	6	6
1.3.2.2	Test Exterior Frame	6	6	6	6	6
1.3.2.3	Test Linkage System	6	6	6	6	6
1.3.1.4	Assemble Sub-systems	6	6	3	5	4
1.3.2.4	Test Final Product	6	6	6	6	6
1.4	Operate [O]					
1.4.1	Engineering Fair	6	6	6	6	6

6.1 WORK DISTRIBUTION CHART (WBS)



6.2 PERT CHART



No.	Task	Person In Charge	Duration (Days)
Conceive			
1.	Study Requirements	ALL	1
2.	Select Category	ALL	2
3.	Conduct Survey	JW & EG	3
4.	Brainstorm Ideas	ALL	2
5.	Present Ideas to Project Advisor	ALL	1
6.	Finalize Solution	ALL	1
7.	Brainstorm Materials	ALL	3
8.	Research Materials	ALL	3
9.	Finalize Materials	ALL	1
Design			
10.	Determine Dimensions	MY & GE	1
11.	Determine Mechanism	JW & EG	3
12.	Research Sources	MY & YS	1
13.	Purchase Materials	ALL	2
Implement			
14.	Construct Internal Mechanism	JW & EG	21
15.	Construct Exterior Frame	ALL	21
16.	Construct Linkage System	GE, MY. YS	21
17.	Test Internal Mechanism	ALL	7
18.	Test Exterior Frame	ALL	7
19.	Test Linkage System	ALL	7
20.	Assemble Sub-Systems	JW & EG	10
21.	Test Final Product	ALL	7
Operate			
22.	Engineering Fair	ALL	1

6.3 GANTT CHART

TASK	WEEK/DATE													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Conceive (C)			■	■										
1.1.1.1 Study Requirements			■											
1.1.1.2 Select Category			■											
1.1.2.1 Conduct Survey			■											
1.1.3.1 Brainstorm Ideas			■											
1.1.3.2 Present Ideas to Project Advisor				■										
1.1.3.3 Finalize Solution				■										
1.1.4.1 Brainstorm Materials				■										
1.1.4.2 Research Materials				■										
1.1.4.3 Finalize Materials				■										
Design (D)					■									
1.2.1.1 Determine Dimensions					■									
1.2.1.2 Determine Mechanism					■									
1.2.2.1 Research Sources					■									
1.2.2.2 Purchase Materials					■									
Implement (I)						■	■	■	■	■	■	■	■	
1.3.1.1 Construct Internal Mechanism						■	■	■	■					
1.3.1.2 Construct Exterior Frame						■	■	■	■					
1.3.1.3 Construct Linkage System						■	■	■	■					
1.3.2.1 Test Internal Mechanism										■				
1.3.2.2 Test Exterior Frame										■				
1.3.2.3 Test Linkage System										■				
1.3.1.4 Assemble Sub-Systems											■	■		
1.3.2.4 Test Final Product													■	
Operate (O)														■
1.4.1 Engineering Fair														■

7.0 CONCLUSION AND RECOMMENDATION

As a conclusion, the idea of a vertical rotating shelf has been designed in detail and will be built as a prototype in order to meet the requirement of this module project which is to create an ergonomic product that provides a more comfortable environment to the staff and students of Taylor's University. In this case, the design of our vertical rotating shelf was built with ergonomic principles in mind, allowing each shelf compartment to rotate in an upward or downward motion. This makes it convenient for laboratory users to obtain equipments and other related items located at the bottom compartments of shelves. With our design, laboratory users do not need to squat or bend down which may be unnecessary and troublesome for them to do, especially for taller individuals and people experiencing backaches when bending down. Apart from that, the design of this project will be built within the budget of RM400 and as for now we have spent a total amount of RM237.60 with some of the materials obtained from the Automation and Robotics Lab and also the Materials and Solid Lab in Taylor's University. Through this project, we have learnt to think out of the box and innovatively to create an ergonomic product that suits everyone's needs. Besides, we also strongly believe that this prototype design can be utilized in the real world in the near future.

Lastly, to improve the efficiency and quality of this product, it is recommended to add on a feature; an automated compartment locator, where the user is only required to press a button which summons a specific shelf compartment directly to the user's level.

8.0 REFERENCES

1. 2017. [Online]. Available: https://times.taylors.edu.my/pluginfile.php/2749508/mod_resource/content/1/Handbook%20%20Ergonomics_Aug2017.pdf. [Accessed: 20- Sep- 2017].

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