



KEMENTERIAN PENGAJIAN TINGGI



**LAPORAN AKHIR  
PROJEK 2  
SESI JUN2020**

**JABATAN KEJURUTERAAN MEKANIKAL**

**THE CRAWLING LADDER**

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## **Abstract**

Today our world is no stranger to progress in terms of development facilities. Studies have been conducted to identify and also improve the design of ladder according to the passage of time. Thus, a ladder has been improved to meet the set standards. Studies on ladder have given rise to ideas in their creation of "Crawling Ladder" and we have taken advantage of these ideas by adding some additional features as well as innovations in improving the use of ladder. There are several procedures that have been planned and will be followed so that this project can be completed earlier than planned. The Gantt chart has been designed so that the project runs smoothly. The findings of the study have shown that many people agree that this "Crawling ladder" is very useful to do various types of work, especially maintenance work because this ladder is able to make the work easier and can save time and manpower. The existing ladder in the market are quite difficult for consumers because they have to go down the ladder to move the ladder from one place to another. This innovation we designed can solve the problem because these ladder can move from one place to another without go down the ladder. In terms of safety, we use the arduino uno as a signal transmitter, a buzzer as a warning and a motion sensor as a tool to detect the movement of passers-by near the ladder. When the ladder is in use, if someone passes by near the ladder, the motion sensor will detect the movement and send a signal to the arduino, then the arduino will send a signal to the buzzer sounding the alarm to warn the ladder user.

## ABSTRAK

Hari ini dunia kita tidak asing lagi dalam kemajuan dari segi kemudahan pembangunan. Kajian telah dilakukan untuk mengenal pasti dan juga memperbaiki reka bentuk tangga mengikut peredaran masa. Oleh itu, tangga telah diperbaiki untuk memenuhi standard yang ditetapkan. Kajian mengenai tangga telah menghasilkan idea dalam penciptaan mereka bentuk "Crawling Ladder" dan kami telah memanfaatkan idea-idea ini dengan menambahkan beberapa ciri tambahan serta inovasi dalam meningkatkan penggunaan tangga tersebut. Terdapat beberapa prosedur yang telah dirancang dan akan diikuti agar projek ini dapat disiapkan lebih awal daripada yang dirancang. Carta Gantt telah dirancang supaya projek berjalan lancar. Hasil dapatan kajian menunjukkan bahawa banyak orang bersetuju bahawa "Crawling tangga" ini sangat berguna untuk melakukan pelbagai jenis pekerjaan, terutamanya kerja-kerja penyelenggaraan kerana tangga ini mampu membuat pekerjaan lebih mudah dan dapat menjimatkan masa dan tenaga kerja. Tangga yang ada di pasaran agak sukar bagi pengguna kerana mereka harus menuruni tangga untuk memindahkan tangga dari satu tempat ke tempat lain. Inovasi ini yang kami reka dapat menyelesaikan masalah kerana tangga ini dapat bergerak dari satu tempat ke tempat lain tanpa perlu turun dari tangga. Dari segi keselamatan, kami menggunakan arduino uno sebagai pemancar isyarat, buzzer sebagai peringatan dan sensor gerakan sebagai alat untuk mengesan pergerakan orang yang lewat berhampiran tangga. Semasa tangga sedang digunakan, jika seseorang melintas di dekat tangga, sensor gerakan akan mengesan pergerakan dan menghantar isyarat ke arduino, maka arduino akan menghantar isyarat ke bel yang membunyikan penggera untuk memberi amaran kepada pengguna tangga.

# **CHAPTER 1**

## **INTRODUCTION**

This final year project involves designing , fabricating a functional ladder with extra new features and some analysis. This prototype could be use by the other lecturers or students in PSA.

The project title is fabricating a “Crawling Ladder”. Tests are required to be conducted and to verify the design. This project development must be concern with material strength , type of material , connection of folding, part of the structure and safety features.

Nowadays, ladder becomes the common facilities for human . There are many types of ladder in the world wide market such as fixed ladder, extension ladder , step ladder , orchard ladder and others.

The main purpose of the Crawling Ladder is to help people to do their work especially someone who do their work alone and help them to move the ladder to wherever they want while the person are still on the ladder. It can reduce time, increase efficiency and work become easier. As the result for the needed in the community, many various type of multi-purpose ladder had been invented. Multi-purpose ladder can foldable, portable and easy to use. It also comes in many sizes and design to make customer choose which one is more suitable for them.

From the Advantages and Disadvantages of the ladder in the world



wide market, a new type of ladder is created that are better and easier for people to use.

## **1.1 PROJECT OBJECTIVE**

The objective of this project is:

- i. To design and fabricate a functional crawling ladder.
- ii. To make a ladder that can be moved by the person on the ladder just by using the leg without having them to climb down the ladder.
- iii. To meet required safety features, a buzzer or alarm is placed on the ladder to detect movement around the ladder
- iv. To make sure that the ladder pass all the test run to make sure that it is safe to be used

## **1.2 PROJECT SCOPE**

This project is about design and fabricates a new product of ladder. Design for this product is consider from the available product in the world wide market. Based on the advantages and disadvantages, one new product will be create to reduce the disadvantages and add more advantages facilities.

- 1) This product will be marketed and targeted to the people that involve in maintenance work and other related works in including painting and repairing works.
- 2) Can be use for household requirement.
- 3) This ladder needs to be concern about safety feature.
- 4) This ladder is expected to be acceptable to people

- 5) Construct a movable ladder which is it can be move by leg without having to go down the ladder
- 6) Expected to be stand safely on any surfaces.
- 7) Design for adults constrained to support up to 60kg and above.
- 8) To make motion sensor that are able to detect the movement around the ladder

### **1.3 PROBLEM STATEMENT**

- 1) The existing ladders require people to go down the ladder to move the ladder . All ladders today required the user to climb on it. People may lose their step or stability.-during climbing up the ladder especially when carrying a tools or materials. So this condition exactly will influence the users balancing and causing-the' ladder not stable and safe in design and mechanism.
- 2) The existing ladder are less stability during their application. Nowadays, ladders are less of stability during their applications. For example, people have to be careful for the whole of a job when using the ladder. They need to balance their body position on the ladder which has to limit the motions and movements It's hard to make two jobs instantaneously. This situation will increase the probability of ladder accident.
- 3) The environment around the ladder may be high risk and will makes people less sensitive and take it easy that may lead to injury. People that use ladder mostly did not aware about their surrounding because they usually only focus on the work that they are doing. This could lead into an accident and can cause serious injury .
- 4) Some work or job that use a ladder , usually need to use a lot of tools.The existing ladder in the market did not have a space to place tools . This will make the work or job to be more time consuming because people need to step down from the ladder a lot to change or take their tools. The chances for accident to happen also increase because when people step down from the ladder a lot, they might get slipped.



## **CHAPTER 2**

### **LITERATURE REVIEW**

To proceed with the final year projects, “Crawling Ladder” has been chosen. Some research has been done regarding many types of existing ladder through ages. It is important to know the history of the ladder and step ladder in order to add more specifications as well as improving the existing ladder into the new “Crawling Ladder”. Besides, nowadays ladder has becomes the common facilities for people to help people to do a work that need them to reach a higher place.

#### **2.1 THE HISTORY OF LADDER**

The ladder is an everyday object that we use to make certain work easier. The simple constructions serves its purpose and has remained unchanged since ladders was first used several thousand years ago. No one really knows where or when the first ladder was built and used, but one of the earliest recordings of a ladder exists is in a rock painting from the Mesolithic era about 10 000 years ago in Valencia, Spain.

A Mesolithic rock painting of a ladder was found in the spider Caves in Valencia. The painting depicts or shows two people using a long ladder, which appears to be made from plant fibres to reach a wild bee nest in order to harvest the honey. The ladder painted on the paint found to be a flexible ladder made up of some kinds of grasses. The paint was

estimated to be 10 000 years old.



First depiction of a ladder was discovered in Spider Caves in Valencia. It was estimated to be 10 000 years old.

Although it is the earliest evidence of the uses of ladder, most of the researchers are agree that it would be older than that. But by studying the ancient Egyptian and Hebrew cultures, the researchers have trace the root of functional design of the ladders. The two civilizations have developed and make a perfect design of the ladder. The Mesolithic rock painting shows that the ladder was an essential way to get food or some raw materials to survive or survival. Besides, nowadays the ladder has become a household essential and an ordinary everyday object.

It is not hard to imagine that some ladders were first developed in

order to harvest honey as in Mesolithic era, as this is still practised in remote tribes ( some using ladders created by fixing rungs directly into a tree trunk). Humans would have been used to reach high places under their own power, but with the help of climbing tools such as poles and branches would have made the works easier. The ladder could well have been developed to provide access in situations where there was no climbing tool to reach high places.

Over the years, various types of ladders have been designed and manufactured to suit different purposes such as a fiberglass ladder that is use to electricians, a telescopic ladder for portability, a cat ladder to clamber safely on a roof and many more.

However some old step ladders were made of ropes. These types of ladders are still found in some countries. There are also wooden ladders which are quite strong to withstand a heavy load or a person. Besides, during World War 2, these types of ladders were also used.

**Ladder made of rope**



**Old wooden ladder**



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**Fiberglass ladder**



**Telescopic ladder**



Nowadays, most of the ladder has developed in many kind of shapes, adjustable height, sizes and specific use. In our understanding, we need to know the early history of the ladder despite before it develops until a step ladder is invented. The specifications in the terms of the height, the sizes and despite safety features is the important things to be aware of.

## 2.2 PREHISTORIC MAN AND LADDERS

Prehistoric man existence long ago was very different to how we live now, there were probably no tall buildings or not much requirement to climb and reach high places independently or by their own ability (i.e. without the use of a tree or natural structures), so the ladder as a development would have change the way the people live. With their new-found ability to climb heights and access places that would have been otherwise out of reach, humans could access caves in high rock faces, scale cliffs and create more practical dwellings or environment. The modern ladder is thought to have been created in Middle East and Northern Africa by the Hebrew and Egyptian peoples and probably would have been used in building the pyramids and other related Egyptian structures.



Ancient Egyptian Soldier  
using a ladder



African Ladder



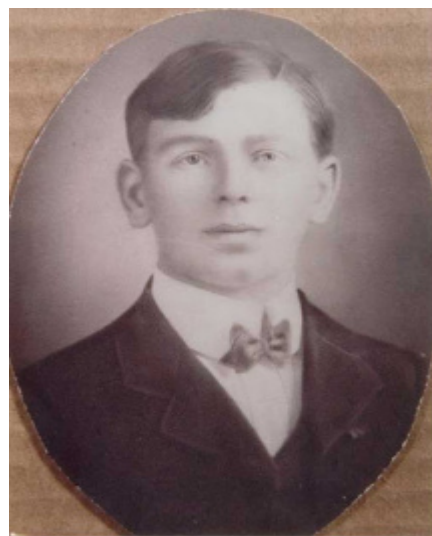
## 2.3 THE HISTORY OF STEP LADDER



John H. Balsley ( 29<sup>th</sup> May 1823 to 12<sup>th</sup> March 1895 ) was the first one who invented a folding wooden step ladder in 1862. The invention of the ladder by him became one of his significant contribution to Ohio history.

About John H. Balsley,

John H. Balsley was born in 1823 at Connellsville in Pennsylvania. His father was George H. Balsley and mother was Sarah (Shallenberger) Balsley.



John H. Balsley earned his livelihood as a carpenter. The invention of the

first folding step ladder was his greatest contribution in the Ohio history.

Step ladders were known and was also used for several years 1862. On the other hand, the patented design was looked like a step ladder rather than a conventional straight ladder, so it was named as step ladder. Like the Balsley's design, steps ladders were not easy to store, as these were not foldable. He added hinges at the top of his invented ladder. This feature allows users to fold and store it easily. We can see most of the ladders nowadays follows his design.

In our project, our "Crawling Ladder" design was designed based on this step ladder in the terms of shape. However, the special features of our ladder is it can be move without having to go down and move it from one place to another (movable). Furthermore, it can withstand a heavy weight of a person and reduce time in order to finish a work related to the height problem

## **2.4 LADDERS THROUGH THE AGES**

Ladder inventions and creations developed through the ages. The first step ladder was invented by John H. Balsley in 1862 with portability and storage among the things that influenced his design. The hinged A-frame design was made and added for portability, easy storage and the ability to use the ladder as a freestanding piece of equipment.

New materials and manufacturing processes influenced the development of the ladder structure into what we use today. As wood-working and rope manufacture became more sophisticated ( canggih ), these materials were used to make the ladders and the use of metal as a construction material that lead to the ladder made of metal.

The introduction of rubber meant that non-slip feet could be added to ladders and almost every new development in construction and engineering has been applied to ladders since that. The need to access ever more tricky and high places has led to the development of specialist access equipment and we can see that the ladder is undoubtedly one of pieces of equipment most heavily influenced by people's needs in both original design and development.

## **2.5 CHAPTER'S SUMMARY**

As to conclude this chapter, literature review is important to showcase all the studies regarding the ladder to enhance the knowledge in this project. Our “Crawling Ladder” has the same function as the normal ladder which is can be use when needing to reach something quite high and cannot be reach by a normal person.

Although the “Crawling Ladder” has been finished, the structures and also the features of the ladder must be tested in order to ensure its quality and strength can give the satisfaction to the consumer.

The study of the step ladder gave us the idea in designing this “Crawling Ladder” and the idea was benefited with some additional features. Apart from that, it is important to know the history of ladder and step ladder throughout the years because we can make improvements and and specifications to the ladder that were created earlier in order to construct the “Crawling Ladder”.

## CHAPTER 3

### METHODOLOGY

**Methodology** refers to the overarching strategy and rationale of the research project. It involves studying methods used in the field and the theories or principles behind them, in order to develop an approach that matches the objectives that has been planned. In addition, **methods** are the specific tools or procedures used to collect and analyze the data.

The general aim of the methodology are to standardize, structure and organize work methods. This helps focus all projects in the same way and allow us to repeat successfull aspects and learn from mistakes, resulting in continuous improvement process. The methodology also used to obtain certain benefits such as organizing project times, helping to manage and minimize project risks and developing the team's skills.

The Crawling Ladder has been completed based on the methodology that has been planned and prepared as shown in the Figure 3 Flow Chart below.

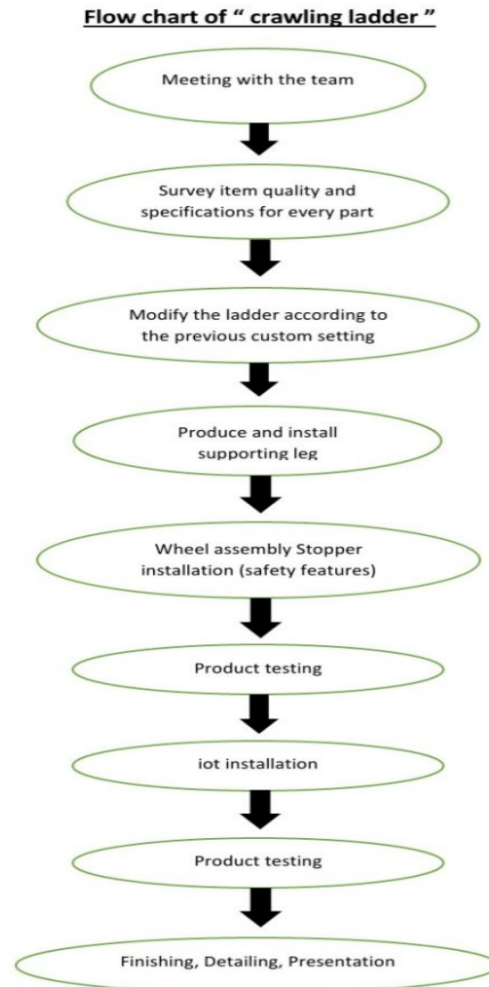


Figure 3: Project Flow Chart

A meeting with the team was held before surveying item quality and specifications for every part of the ladder. The ladder has been modified according to the planned custom setting in the workshop at Mechanical Engineering Department and other workshops. Then, the process of making the important parts of the ladder started :

1) ‘**Supporting leg**’ which is the main part of the ladder also been produced by cutting the stainless steel as shown in Figure 3.1 according to the measurements that has been measured. Grinder saw machine was used in order to cut the stainless steel precisely and carefully. The

materials is cut into two sections along 3ft and 9 inch each. Two connectors are produced along 10 cm each in order to connect the two sections. Then, the parts are welded carefully by using Metal Inert Gas welding or MIG welding. The ‘Supporting Leg is then installed to the ladder by using screw as shown in the Figure 3.2.



Figure 3.1 Cutting Material for ‘Supporting Leg’





Figure 3.2 Installation of ‘**Supporting Leg**’



The ‘**Supporting Leg**’ which is the most important parts has been carefully installed to make sure it is tight and can be moved



2) A part called safety rail was cut in order to make a space for the consumer to sit and the control the movement of the ladder. The space made should be enough for the consumer to sit comfortably as well as controlling the movement of the ladder when it is moved.

3) To allow the ladder to move and stop safely, there are four wheels that were installed to each bottom of the rails of the ladder. All four wheels was cut from its original base. Then, the wheels are planned to be welded on the other base to fit the area of the bottom of the ladder's rails. So, there were four bases that were made from a metal plate. The metal plate was cut accurately according to the size of the wheels. The wheels have the width of 1.8cm and diameter of 4.5cm. Then the metal plate that have been cut are used as bases. After that, the wheels are welded to the bases carefully to make sure the wheels are joined neatly. After the wheels are ready, the Metal Inert Gas (MIG) welding is used to joint the two base materials which are the wheels with the new bases and each bottom of the ladder's rails as shown in Figure 3.3. To allow the ladder to move safely, **rubber stoppers** also were carefully installed to the 'supporting leg'. The rubber stoppers were basically made for the chair leg but an initiative was taken to use the stoppers and installed it to the bottom of the 'Supporting Leg'.



Figure 3.3 ( Installation of **Wheels** by using MIG welding)

4) As shown in Figure 3.4, **product testing** was also conducted in order to make sure that the ladder can be moved and works according to its actual function. The testing are conducted with caution to avoid any injury when the test are carried out. The **iot installation** also has been done which is using the motion sensor as the safety features of the ladder. The software of ARDUINO is used to settings the motion sensor together with the arduino. A product testing again was carried out to observe the function of the ladder with the motion sensor. Last but not least, **finishing** was done to enhance the structure of ‘The Crawling Ladder’. Painting

process started with the first layer as shown in Figure 3.5.

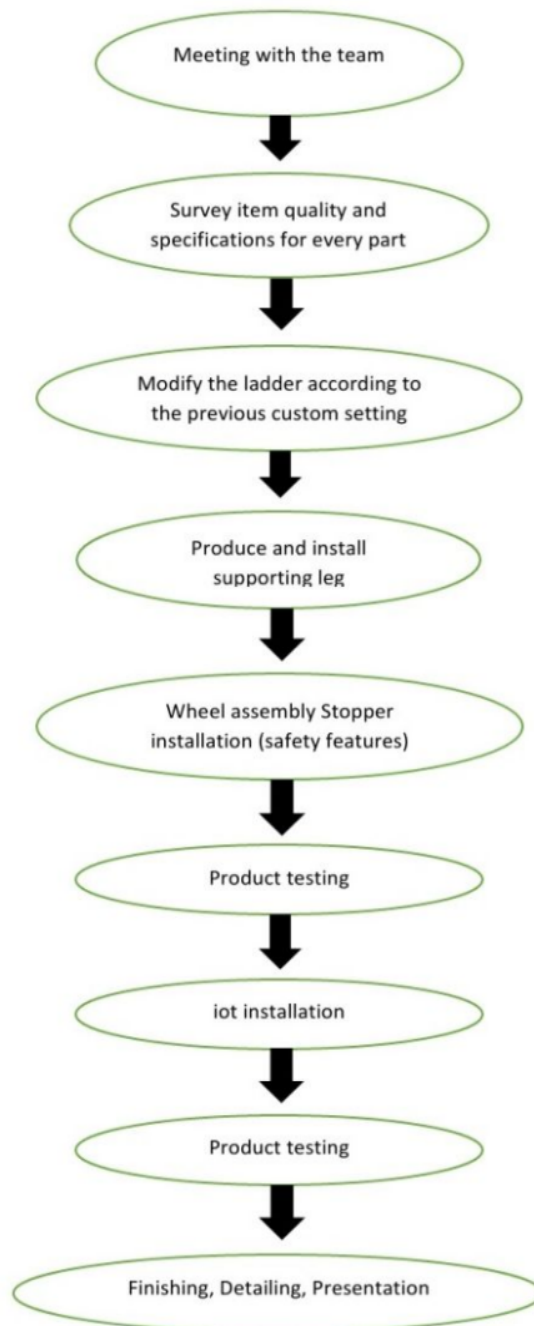


Figure 3.4 (**Product Testing** was conducted to make sure that the ladder can be moved)



Figure 3.5 First layer painting process (**finishing**)

**Flow chart of “ crawling ladder ”**



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**Project Flow Chart**

## GANTT CHART ( Project 2 )

Task / Week	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Meeting with the team include : -Discussion - Project Detail															
-Survey item quality and specifications for every part -Material purchase															
- Cutting the supporting rail to make a space to sit - Survey the material used to make the supporting leg															
- Produce and install															
- Produce and install supporting leg															
- Wheel assembly and installation to the ladder - Stopper installation to the supporting leg															
- Product testing to see whether the ladder can be function or need some improvement															
- iot installation ( Arduino, sensor, alarm ) - Coding, programming for iot															
- Testing the complete product with all the features already installed															
- Finishing including painting the ladder - Detailing															
-Presentation ( Week 10 )															
- Submit report and video															

	<u>PLANNING</u>
-	<u>ACTUAL</u>

## Budget Calculation

	Item	Quantity	Price
1	Wheels	4	RM 8
2	Paint	2	RM 7
3	Stainless Steel ( 8 feet )	1	RM 30
4	Ladder ( Body )	1	RM 90
5	Arduino Uno	1	RM 25
6	Motion Sensor	1	RM 9
7	Alarm	1	RM 5.50

## CHAPTER 4

### ANALYSIS

The “Crawling Ladder” has been finished and completed in the terms of the structure and also the movement of the ladder itself which is the most important thing to be concern of.

A ‘**supporting leg**’ was produced and installed to the ‘Crawling Ladder’. The main function of the ‘supporting leg’ is it acts as a mover or support to move the ladder.

1) **Safety features** have been added to the ‘Crawling Ladder’. The **motion sensor** is installed on the ladder that functions to detect movement around the ladder when the ladder is in use. It is installed to the ladder is also carefully set so that it can detect movement around the ladder.

2) To allow the ladder to move, it is necessary to install the **wheels** to every bottom of the rails in order for it to do so. The wheels were installed and it was found that it can withstand heavy weight up to maximum 70-80kg when it tested and can move smoothly.

3) The body of ‘The Crawling Ladder’ are made of **strong materials** such as aluminum which is the steps of the ladder and the stainless steel which is the body of the ladder to ensure it is durable, strong and can last for a long time in terms of the structure of the ladder.



4) The ‘**supporting leg**’ that are the most important part of the ladder are carefully produced with stainless steel that is able to withstand heavy weight. It was neatly installed so that the consumer can use the ‘supporting leg’ to move the ladder. This part is able to move the ladder because it is the main component of the “Crawling Ladder”.

5) The ‘supporting leg’ also has **rubber stoppers** installed at the bottom that helps the ladder to move and stop safely. The rubber stoppers are able to allow the ladder to move and to stop without any sound and problem.

### **Product testing**

The Special feature of this ladder is it can be moved without having to go down the ladder with the help of supporting legs and wheels to move the ladder. Based on the observations made during the product testing, all created parts were able to work according to its own function. Several parts of the ladder also were made of some materials such as aluminium and stainless steel. The supporting leg that has been designed and produced are also highly concerned with the suitable mechanism and has been welded carefully in order to ensure the movement of the ladder will not be interfered. The rubber stoppers also were found to be able to move and stop the ladder. The motion sensor was able to detect the movement of the ladder after it was tested for the first time after the installation. This Crawling Ladder was tested for several times before the actual presentation and the objectives that have been planned were successfully achieved and carried out.



**The product is tested to observe the ladder is strong enough to withstand heavy weight especially the consumer that use it as well as to test whether the ladder can be moved and stopped smoothly**



**The ladder is being moved to the right by pushing and pulling the steps up/down. The consumer who use the ladder can move to the right and to the left by pushing/pulling the steps up/down. It was found that the ladder was able to move smoothly on both sides.**



**The ladder stop moving and currently in the position of 'rest'.  
The consumer started to do the desired work when the consumer  
stop the movement of the ladder. ( 'rest' position )**

## **CHAPTER 5**

### **CONCLUSION AND DISCUSSION**

Based on the observations and also the data collected from the tests that have been conducted on the ladder, it was found that the ladder is strong enough to withstand heavyweight and load, especially users who weigh more than 50kg up to a maximum of 80kg. Apart from that, the ladder is also made of stainless steel and the steps are made of aluminum but must be welded using MIG (metal inert gas) welding.

The most important part is the supporting leg which serves to move the ladder is found to be able to move and be well controlled with the help of rubber stopper. This rubber stopper works to smooth the movement and stop the ladder safely during use. The supporting leg also need to be improved by changing the material to make the parts. The material used previously was stainless steel but it is feared that it will not be able to last for a very long time. However, stainless steel can be replaced with materials such as aluminum that are less corrosive, easy to machine and shaped, cast, molded and more lighter and more durable.

Next, through the test conducted the wheels are able to move and are able to carry the structure of the ladder smoothly. Each wheels are welded to an iron plate measured based on the size of each bottom of the ladder's rails. Then it is welded to the bottom of each ladder's rails carefully and thoroughly.

Moreover, the safety feature of the motion sensor works well that is

able to detect movement around the ladder at a distance of 1-1.5 meters. It is programmed using Arduino software because one of its components is Arduino Uno. However, based on the comments and opinions of some people about the motion sensor, it is found that it can be replaced or should not be placed on the stairs because the ladders are commonly used for indoors only. So, there is not too much need to put such a motion sensor.

In addition, the steps should be made of a rubber surface and not slippery to ensure that the user does not easily fall or slip. This is because it is found that during the observation, the user may easily slip because the surface of the steps is not very convincing to ensure the safety of the user.

Last but not least, the finishing of our products is from the arrangement of wires and also the motion sensor components because its position is not very well arranged and neat. This can disrupt the user as well as interfere with the movement sensor functioning properly as there may be wires or components that are open or disconnected from the ladder. However, painting work was started with the first layer which is grey colour and then continued to be painted using the desired color. The painting work was done by using spray painting type tools.

## **Conclusion**

Through this project, it helps to develop creativity in creating a project and modify existing project to be more efficient. The outcome of the project was achieved with an indication of the lessons to be learned from success and failure. While making this ladder, all sort of new things have been learned. Making this ladder has also improve our skills in welding, drilling and cutting metal. Innovation in changing the step ladder to crawling ladder has given the desired results which is can save time and energy. The ability to move the ladder without people need to step down from the ladder have proven that this ladder has met the goal which is can save time and energy. After several tests, the security system on this crawling ladder has been proven to be effective. Movement sensors can indicate people passing near stairs and arduino and alarms work well thus this crawling ladder is able to avoid any serious injury or accident. According to the review from the people who have used this ladder, this product has potential to be marketed all over Malaysia or even better, all around the world.

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