DESIGN OF A FINGER TRAINER PROTOTYPE FOR PARALYZED/STROKE PATIENTS

By

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FINAL REPORT

Submitted to the Mechanical Engineering Programme
In Partial Fulfillment of the Requirements
For the Degree
Bachelor of Mechanical (Hons.)
(Mechanical Engineering)

Universiti Teknologi Petronas
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CERTIFICATION OF APPROVAL

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Submitted to the Mechanical Engineering Programme
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Approved by:

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Universiti Teknologi PETRONAS
Tronoh, Perak
January 2008

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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AMMAR BIN AZHAR

ABSTRACT

This report introduces the background, objectives and literature review of the Finger Trainer for Paralyzed patients project as well as the methodologies in carrying out the project. The aim of the project is to come out with a prototype of a finger trainer machine used to facilitate patients in the rehabilitation program. This trainer is designed to be compact, portable and could be operated with minimum supervision from therapists. Stroke defined as a cardiovascular disease that designates the rapid loss of brain function due to an interruption in the blood supply to all or part of the brain [1], has became a big concern in the medical field as it has contributed to a big portion to the cause of death in the world including Malaysia [2]. Various types of treatments are available including the post-stroke rehabilitation process [3]. This project is an aid to ease the process of the physiotherapy programs and to reduce the involvement of third parties i.e. physiotherapists, nurses and trainers during the rehabilitation training period. This project was initiated due to the high demands of physiotherapy programs worldwide as it has became a large threat towards the health of the people all over the globe [4]. This was taking into account the insufficient amount of trainers and physiotherapists to cater this mass disease. The finger trainer will adapt the post-stroke approach using the Continuous Passive Motion (CPM) concept. It works as a medium that trains and teaches the finger nerves of its movements [5]. Simple mechanical and electrical assemblies are used in this machine to reduce the cost without having to lose the main functions of the machine.

ACKNOWLEDGEMENT

I would like to take this opportunity to acknowledge and thank everyone that has given me all the support and guidance throughout the whole period of completing the final year project. Firstly, many thanks to the university and the Final Year Project coordinators that have coordinated and made the necessary arrangements, especially in terms of the logistics, for this study.

I must also acknowledge the endless help and support received from my supervisor, Pn.Rosmawati Mat Zain throughout the whole period of completing the final year project. Her guidance and advice are very much appreciated. Apart from that, many thanks to Pn.Zunaidah, Head of Physiotherapy Department, Hospital Universiti Kebangsaan Malaysia for her advice during the consultation for the project. My thanks also go to the physiotherapists and trainers at Hospital Universiti Kebangsaan Malaysia for their help and support they gave during my visit there.

I would also like to thank the UTP Mechanical Lab technicians, especially Mr.Zamir from the EDM lab, Mr.Jani from the Mechanical Engineering Lab and Mr.Shahrul from the CNC Machining lab for their endless support in terms of the parts preparation as well as their help throughout the whole fabrication process. Their continuous support and help throughout the whole period of experiments are very much appreciated.

Finally, many thanks to my fellow colleagues for their help and ideas throughout the completion of this project. Thank you all.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The purpose of this project is to come out with a prototype of a finger trainer machine for stroke/paralyzed patients. This would be an extension study to the existing machines used for rehabilitation training programs. This machine acts as an alternative solution besides the conventional physiotherapy activities done at these rehabilitation centers. The purpose of the machine is to ease the process of physiotherapy training which are currently carried out at specific places with the aid of trained facilitators. This project is divided into two phases. During the first phase, a thorough research would be done on the current treatments available for stroke. This will take into account all the available information including the conventional physiotherapy modules as well as the latest physiotherapy machines. The concepts of these modules would be studied and the best concept that is relevant to the project will be chosen. During this period, the author will visit the rehabilitation center and also conduct studies from journals, books and searches over the internet. The second phase of the project is continued during the second semester, which is the designing and fabrication of the final prototype. The product is designed to work on a simple mechanical and electronics setup to reduce cost while maintaining its function.

1.2 Problem Statement

Patients that are attacked by stroke are considered physically impaired whereby they lose the function ability of the body [6-7]. Paralyzed patients are very dependent and have to rely on others to conduct their daily routine activities. Currently, these patients are treated through physiotherapy programs conducted by physiotherapists. However, the constraint of this current activity is that patients have to go through the training program at specific areas such as hospitals and rehabilitation centers, with the assistance from nurses/trainers. This may burden the patients and create a lot of difficulty especially for the elderly patients and for those that do not have relatives to send them to the rehabilitation centers.

1.3 Objectives and scope of study

The main objectives of this project are:

- To design and fabricate a prototype of a finger trainer for stroke/paralyzed patients
- The machine has to be portable and easy to operate

CHAPTER 2

LITERATURE REVIEW

2.1 Paralysis

Paralysis is a medical condition where affected patients or also known as paralyzed patients are unable to move one or more of their body muscles. In most cases, a person experiencing paralysis also loses all feeling in the affected area. Paralysis may be temporary, depending on the cause. If it is the result of damage to the nervous system, it is usually consistent.

Paralysis is divided into two common cases; one is the *localized paralysis* and the other is *global paralysis*. *Localized paralysis* is when only a small area of the person's body is affected such as the Bell's palsy. Typically only one side of the person's face becomes paralyzed.

On the other hand, someone who has experienced stroke may experience weakness throughout his or her body. This is rather known as the *global paralysis*[8].

2.2 Stroke

Stroke is a cardiovascular disease that designates the rapid loss of brain function due to an interruption in the blood supply to all or part of the brain. Stroke can cause permanent neurological damage or even death if not promptly diagnosed and treated [9].

There are two types of stroke namely the Ischemic stroke and the Hemorrhagic stroke. Ischemic stroke accounts for more than 80% of all stroke cases where else the remaining 17% is the Hemorrhagic stroke.

The symptoms of stroke depend on the stroke type and the area of the brain affected. Usually, Ischemic only affect regional areas of the brain where the arteries are blocked. Hemorrhagic can affect local areas, but often can also cause more global symptoms due to bleeding and increased pressure in the brain skull.

2.3 Stroke Treatment

The treatment for stroke varies according to the type and condition. One way of the treatment is called post-stroke rehabilitation. The post-stroke rehabilitation program helps the patients to relearn the skills lost due to the brain damage. Apart from that, rehabilitation also teaches the patients new ways of performing tasks to overcome any residual disabilities. It is agreed among therapists that conclude three important elements during any rehabilitation programs which are – carefully directed, well focused and done repeatedly [10-12]. The machine will be designed to comply with this type of treatment.

2.4 Available Stroke Treatments

Apart from the severity of stroke, another factor that should be considered is the stroke affected area. In order to cater the variability in both affected areas and the severity, many treatments are used. Focusing on the automated treatments, there are two machines that seem relevant to this project, which is the Continuous Passive Motion machine, and the Biofeedback machine. The difference between the two is that one involves passive training i.e. patient relaxes and does not need to do any activities and the second is the biofeedback machine which sets targets for the patients to achieve and a feedback data would be given. This machine incorporates visual and audio outputs, which acts as a motivational drive for the patients to achieve their training targets.

2.5 Manual Muscle Testing

The Manual Muscle Testing (MMT) is a module of tests used by physiotherapy practitioners to classify the severity of the stroke affecting the muscles. The tests are done by testing the amount of resistance a muscle of a particular affected area could tolerate. The test is rather subjective as to what is the standard resistance the muscle should be able to resist, but certain tests are done in prior to do so [13].

Grade	Muscle Test
Grade 5	Patient can hold the position against maximum resistance and through complete range of motion
Grade 4	Patient can hold the position against strong to moderate resistance, has full range of motion.
Grade 3	Patient can tolerate no resistance but can perform the movement through the full range of motion.
Grade 2	Patient has all or partial range of motion in the gravity eliminated position.
Grade 1	The muscle/muscles can be palpated while the patient is performing the action in the gravity eliminated position.

Table 1: The Manual Muscle Test grading

The patients then undergo treatments according to the grade severity. Most machines are designed to cater most of the MMT grading if not all. However, this project is designed to cater only a partial range of the MMT grading.

CHAPTER 3

PROJECT METHODOLOGY

3.1 PROCEDURE IDENTIFICATION

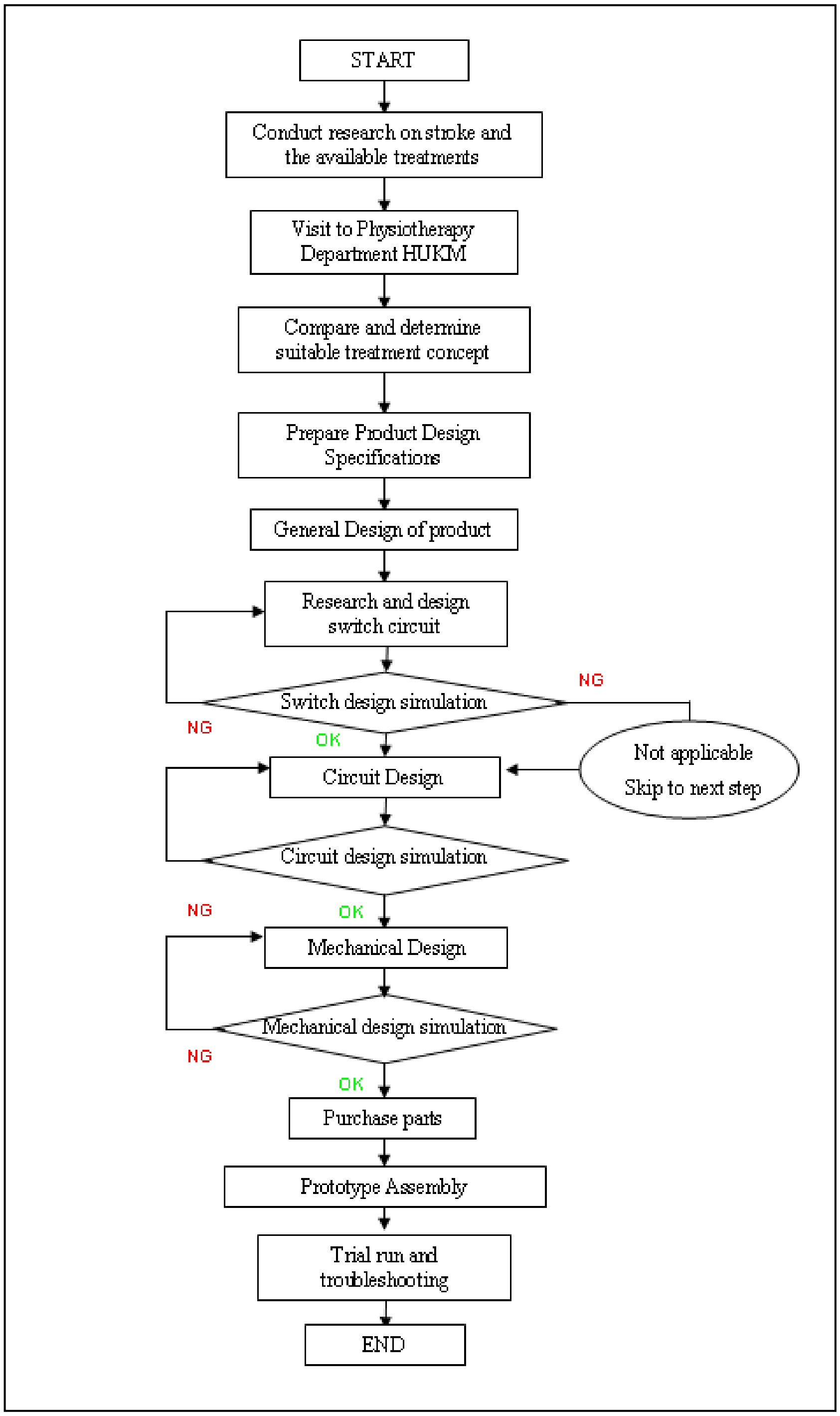


Figure 1: Project methodology flow chart

No	Detail/project work	1	2	3	4	5	6	7	Mid Semester Break	8	9	10	11	12	13	14
1	Modification of FYP I Final Report	■														
2	Research and design of switch circuit		■	■												
3	Design of prototype (Mechanical Parts)			■												
4	Circuit Design				■											
5	Submission of Progress Report I				■											
6	Develop program for touch switch					■										
7	Simulation for circuit					■										
8	Simulation using ADAMS software					■	■									
9	Order and purchase mechanical parts					■	■									
10	Purchase touch switch and electronic parts						■									
11	Start Prototype Assembly						■	■		■	■	■				
12	Submission of Progress Report II									■						
13	Poster Exhibition											■				
14	Submission of Dissertation (soft bound)													■		
15	Oral Presentation														■	
16	Submission of Project Dissertation (Hard Bound)															■

3.1.1 Study and literature review on stroke

The project is started with the literature study of stroke and paralysis and the treatments available in the market. This is to understand in general of what stroke is, the effects on the affected people and how to treat and deal with the situation. This is important to get to know what the medical market needs for these people.

A lot of the study was done from books, journals and from the internet. Apart from that, some consultations were done with doctors and physiotherapy practitioners. An interview session was done with a stroke patient and her relatives to further understand the real situation of how stroke would affect one's life.

3.1.2 Determining suitable concept for the finger trainer

In order to get the latest information regarding the available training concepts, a visit was done to the Physiotherapy Department of Hospital Universiti Kebangsaan Malaysia (HUKM), Bandar Tun Razak in Cheras, Selangor. HUKM have been operating for more than 10 years and is equipped with the latest machines and medical technologies in Malaysia. The visit was done to see the latest available treatments used and how they are conducted. On top of that, internet researches and readings were done to further understand these treatments and their functions.

Using the data and information obtained during the visit, added with study through readings and also from consultation and suggestions from the personnel from HUKM, the treatment concept was then determined. This concept is really important as it will determine the future path of the project. The concept chosen will be incorporated into the product design.

3.1.3 Product Design Specifications

Next, the specifications of the product are specified under the Product Design Specifications. These specifications are initially done to kick start the project as a guide to the designing process.

3.1.4 General Design of product

After the concept is determined, a general design of the product is brainstormed and sketched. Here, all the elements that are thought useful for the product is taken into account such as the shape, the size, the movements etc. A few drawings were obtained and using logical analysis the most suitable initial design is chosen. However, this choice is not final and is still open to modifications and adjustments.

3.1.5 Research and design switch circuit

Initially under the design specifications, a touch switch will be used to ease the usage and operation of this product. The switch circuit is designed to meet the specifications required. Besides that, justifications were done why this circuit is chosen.

3.1.6 Switch circuit design simulation

After the circuit design is obtained, it must be tested in a simulation program before the real assembly. This is to ensure that no problems would occur during the assembly phase. For this circuit simulation, Multisim 7.0 is used. This is because of the features it offers which is user friendly and easy to use as well as the variety of electronic components it has in its library. If the simulation results meet the specification, then the project will proceed, else modifications should be done and the circuit is retested in the software. However, should the simulation fail many times, the project will be preceded by modifying the concept of the circuit itself.

3.1.7 Circuit design

A circuit will be designed to operate and control the moving mechanism of the finger trainer. This circuit will include the switch design stated above.

3.1.8 Circuit design simulation

The circuit will then be simulated in Multisim 7.0 to test the function ability of the circuit design. This is important to ensure that the circuit would run well before using it to operate the machine. If the simulation fails, modifications will be done and the circuit will be retested again until it produces a positive result.

3.1.9 Mechanical design

After the circuit design simulation shows a positive result, the project will proceed with the mechanical design. The mechanical design will be divided into two parts, one is the moving mechanism design and the other is the mechanical parts. The moving mechanism is determined considering some specifications which were specified earlier. Next, the mechanical parts are determined, designed and drawn using AutoCAD 2005.

3.1.10 Mechanical design simulation

The moving mechanism will then be simulated in ADAMS 10.0. This simulation is to see whether the design and the mechanism suits the early specifications made or not. Negative results would require the design to be redone and retested.

3.1.11 Parts purchasing and ordering

After the designing phase is done, the parts are ordered and purchased.

3.1.12 Product fabrication and assembly

The last phase is the fabrication and assembly phase. The electronics part is done first. The circuit is assembled by referring to the circuit diagram in the simulation program.

The mechanical assembly requires a few processes to be done. The main body will involve cutting using jigsaw machine, drilling, filing, riveting and also painting. The moving mechanism involves cutting, conventional milling, Computer Numerical Control milling, drilling, threading and filing.

CHAPTER 4

PROJECT WORK

4.1 FINGER TRAINER WORKING CONCEPT

To cater the various grades and conditions of stroke, many types of machines were invented. However, amongst all, there were two training concepts that seem suitable for this project namely the Continuous Passive Motion (CPM) and the biofeedback machine.

The CPM concept basically trains a part of the body of its basic movements through the body Range of Motion (ROM). This training concept does not require any effort from the patient as the function of this type of training is to train and re-teach the body movements for long operating periods.

Figure 2: Example of Continuous Passive Motion leg trainer

On the other hand, the biofeedback has a different treatment approach. It concentrates more on training patients who are capable of moving, even a bit, and train them in staged progress. Visual aids and music are used to motivate the patients to strive better every time they undergo the training session.

4.2 PRODUCT DESIGN SPECIFICATIONS (PDS)

Before starting the design and fabrication of the product, a design specification was made to minimize the scope of the project. Besides minimizing the scope, it is also done to get an early concept of what the product should have and look like, as well as to obtain a rough idea of in which direction should the project be started with. The following are the product features initially specified:

1. Performance
2. Target Costs
3. Maintenance
4. Materials
5. Size and Weight Restrictions
6. Ergonomics
7. Quality and Reliability
8. Safety
9. Appearance
10. Finish

Design Brief

The finger trainer machine is designed as an alternative to the existing physiotherapy machines used to train and teach the basic movements of a finger to stroke patients. The product must be portable, not too heavy, easy to handle and operate, user friendly and comfortable for the patients. The market target are adult stroke patients ranging from the middle aged to the elderly.

1.0 Performance

1.1 The finger trainer should operate consistently at the required speed for a continuous 20 minute-session

2.0 Target Costs

2.1 The product should have an end-user cost of around RM350

2.2 The manufacturing cost should not exceed RM250

3.0 Maintenance

3.1 To be maintenance free except for light lubrication once every 3 months

3.2 Parts requiring lubrication should be accessible within 10 minutes without the use of special tools or equipment.

3.3 No special tools should be required for maintenance.

4.0 Materials

4.1 The materials used in the production of the finger trainer must be readily available, easily fabricated, and of the required properties

4.2 If electrical components are required, they must have the correct insulation or conductive properties.

5.0 Size and Weight Restrictions

5.1 Weight should not exceed 4 kg.

5.2 Length not to exceed 300 mm.

5.3 Width not to exceed 250 mm.

5.4 Height not to exceed 250 mm.

6.0 Ergonomics

6.1 The controls and switch are to be mounted in accessible positions, preferably in the top front part.

6.2 The machine should be able to be operated by the patient alone or with minimum help from others.

6.3 The finger holder is to be worn before the second knuckle of the finger.

7.0 Appearance

7.1 The machine should look easy to use, and tough enough to last

7.2 It should look robust and compact, but not too heavy to carry around.

8.0 Finish

8.1 The machine should have an attractive finish.

8.2 Metal parts should be chromed or at least polished, and the main body should be painted.

8.3 Sharp edges especially aluminum parts must be chamfered.

4.3 GENERAL DESIGN

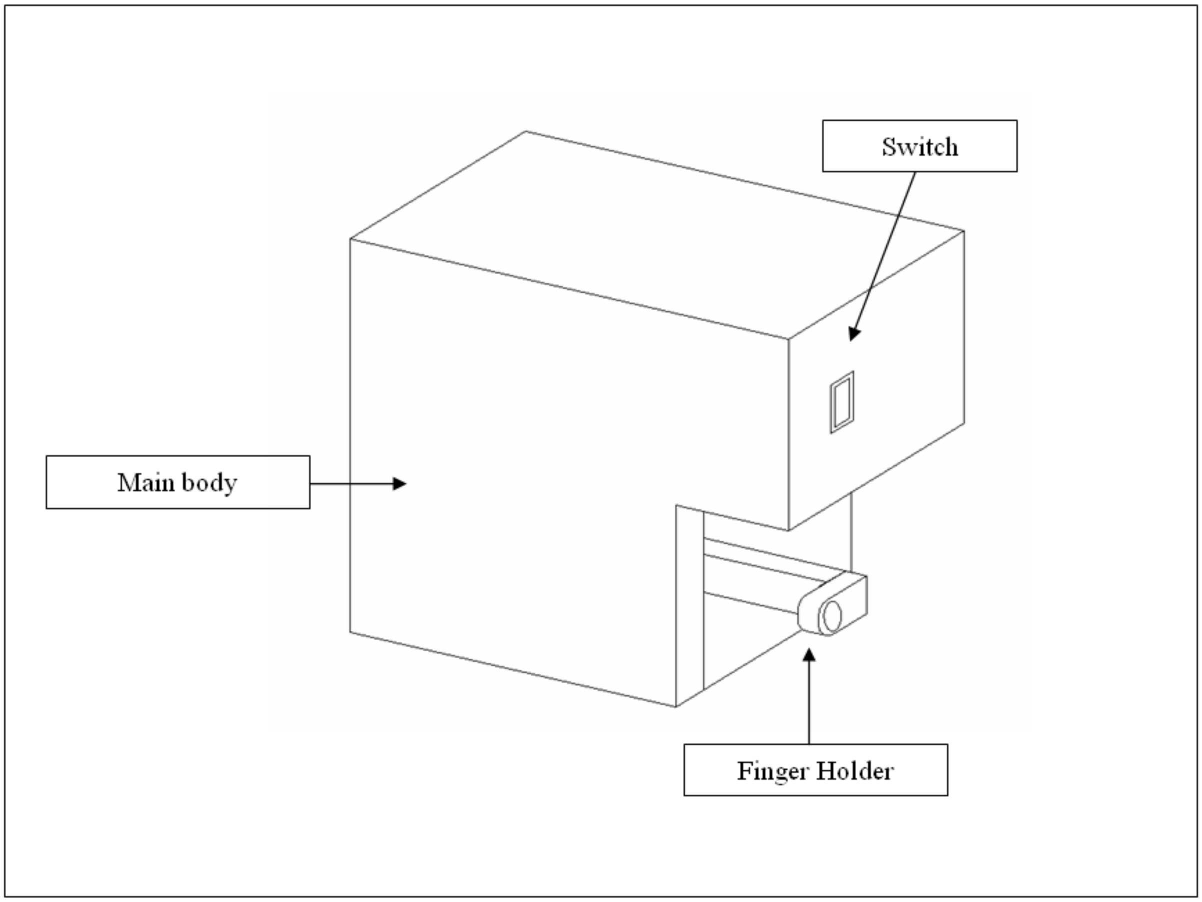


Figure 3: Circuit design drawing using Multisim 7.0

The initial general design has three main parts:

- **Main body** – acts as the container for the components and cover for the electronic circuit
- **Moving Mechanism** – the mechanism used to move the finger holder
- **Finger holder –** used to hold the finger

4.4 CIRCUIT DESIGN

The original idea was to use a touch sensitive switch to switch the machine on and control the speed of the finger holder. This was to ease the patients to operate this machine. The touch switch operates using the capacitance produced by the human body. The capacitance of the human body is able to trigger a touch sensitive switch gradually. Using flip-flop, a circuit could be switched on, and the speed of a motor or the luminance of a bulb could be adjusted by simply touching the touch sensitive switch. A circuit was modified to meet the need of this product and the drawing is done using Multisim 7.0 software.

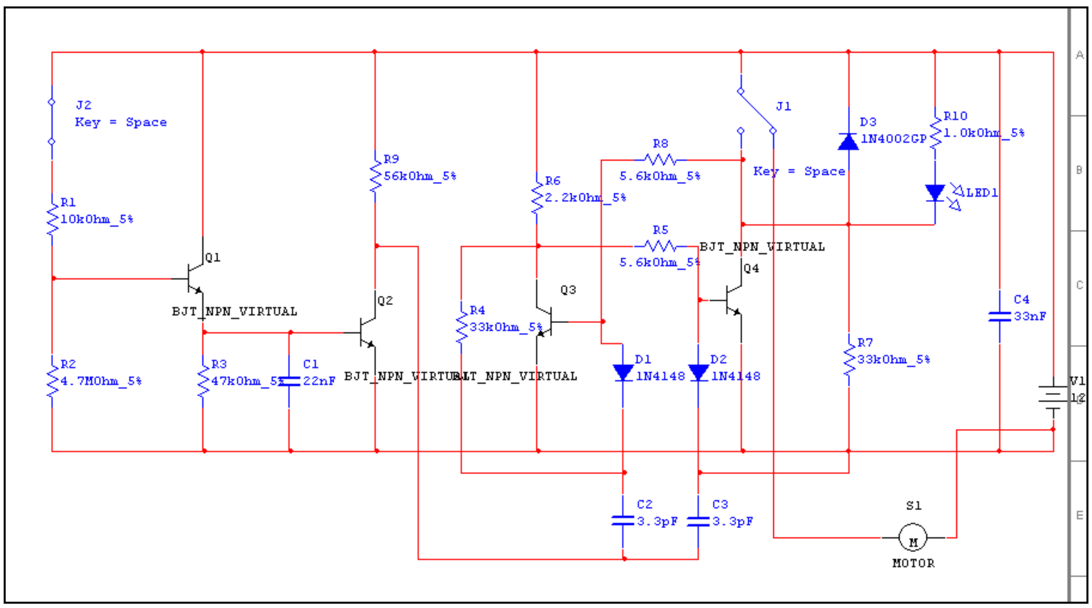


Figure 4: Circuit design drawing using Multisim 7.0

Before the circuit assembly, the circuit was put to test in the simulation software using Multisim 7.0. However, the circuit design did not work as required. Some adjustments were made but the results were still negative. Even after a few alterations and modifications, the circuit simulation still failed. An analysis was then made an eventually, the best solution was to totally redesign the circuit using a simpler concept, that is a mechanical switch. This was after considering the feasibility of the initial design, part availability as well as the cost.

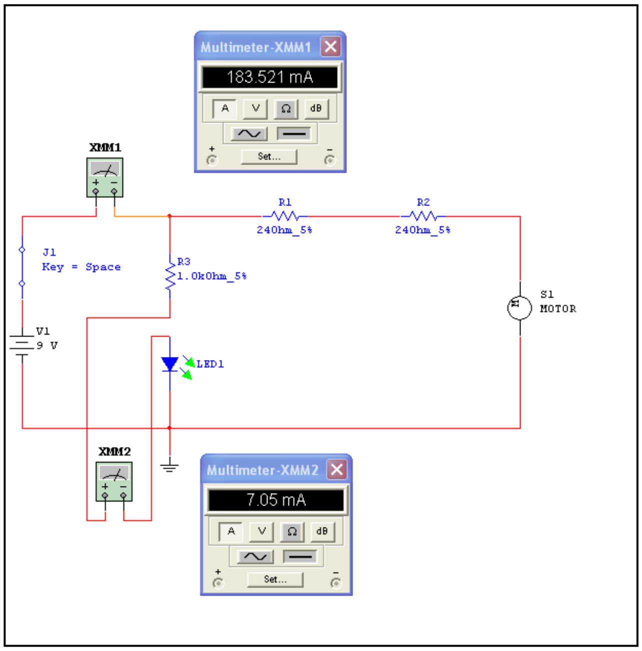


Figure 5: New simplified circuit design

4.5 CIRCUIT DESIGN SIMULATION

The new circuit design was simulated using Multisim 7.0 software.

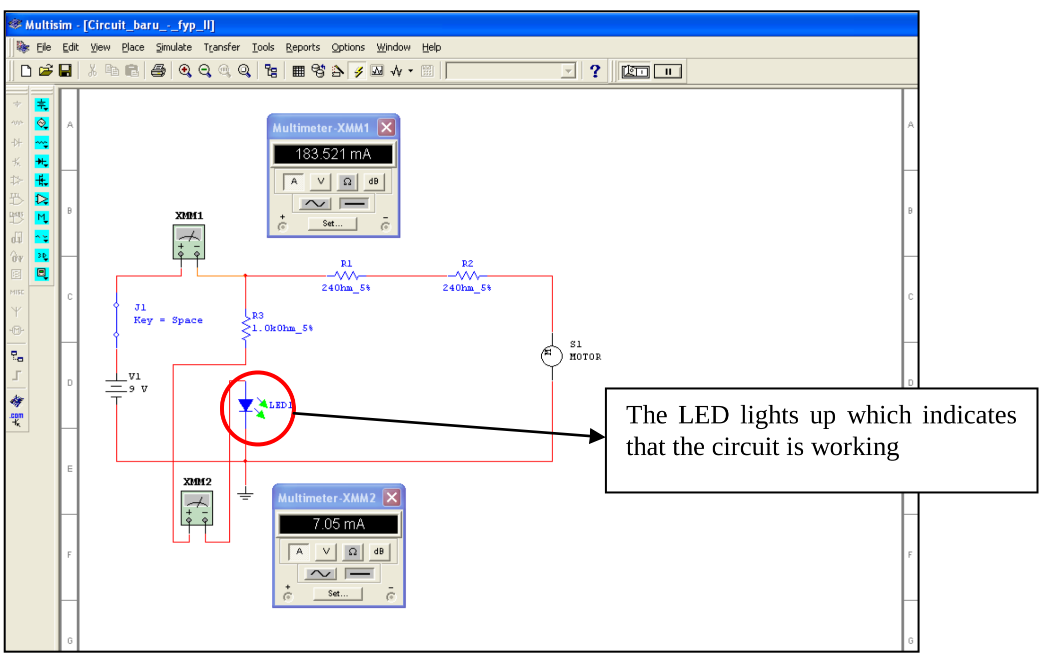


Figure 6: New circuit design simulation results

4.6 MECHANICAL DESIGN

A few general specifications were put for the mechanical design:

- Using an in-line slider mechanism
- The movement of the finger holder is 40mm upwards and 40mm downwards from the origin (the origin is in the centre of this path). This is based on the normal human finger Range of Motion (ROM) based on studies done.
- The finger holder is designed to fit most adult fingers – with a diameter of 18mm (different finger holders with various diameters will also be provided with the product)
- The design of the finger holder must also be comfortable, not to hurt the patient's finger and to keep it in place without slipping out

4.6.1 Mechanism design

i The finger holder should extend and retract approximately 8cm in total, 4cm upwards and 4cm downwards from the initial finger position.

ii The finger holder will be run by a continuous motion driven by a DC motor, thus an extend-retract motion is required (to use a cam or anything similar).

iii The design of the linkages and bars should suit the continuous movement of the motor as a DC motor is to be used.

For the mechanism design, the in-line slider crank mechanism is used. The following shows the clarification of the mechanism being chosen:

- The distance of the two extreme positions, known as the stroke is set to 80mm. The finger holder will move 40mm upwards and 40 mm downwards from the set datum (at 0mm in the figure).
- The crank pivot is located collinear with the sliding axis
- The forward and backward stroke of the mechanism takes same time to contract and retract.

• The moving profile i.e. extend and retract movement are the same which is very important as sudden jerks may injure the patients. Although the speed is not constant, but the difference in velocity is very minimum.

• The slider will take the same time to reach position +40mm to position 0mm as it takes from position 0mm to -40mm.

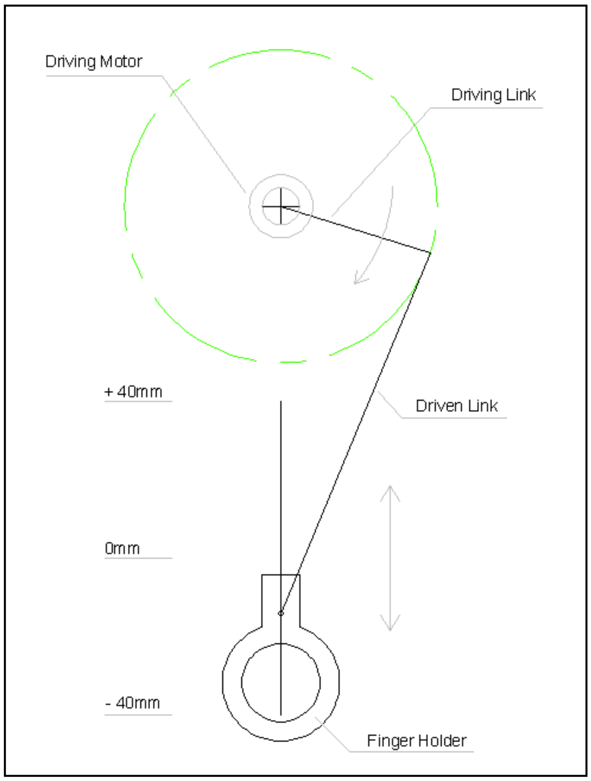


Figure 7: In-line slider mechanism

The following shows the calculation done using Excel and the in-line slider crank displacement and stroke equation [14-15]:

$\theta_3 = \sin^{-1} [(L_2/L_3) \sin \theta_2]$

$\gamma = 180^o – (\theta_2 + \theta_3)$

$L_4 = [L_2^2 + L_3^2 – 2(L_2)(L_3) \cos \gamma]^{1/2}$

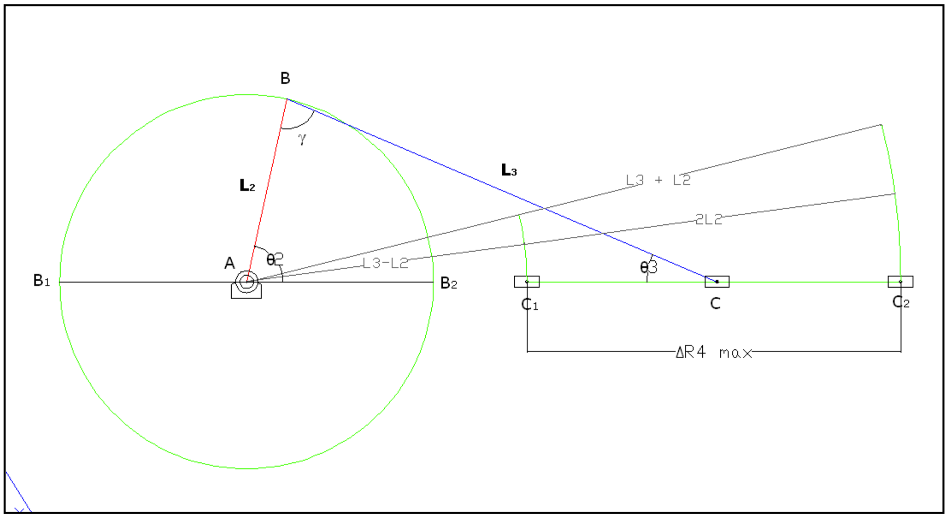


Figure 8: In-line slider mechanism horizontal view

Crank Angle, θ_2 (degree)	Slider Angle, θ_3 (degree)	Coupler Angle, γ (degree)	Stroke (mm)
0	0	180	80
45	16.4299	118.57	64.20087219
90	23.578	66.42	31.65024224
135	16.4299	118.57	64.20087219
180	0	0	0
225	-16.4299	-28.57	7.632329693
270	-23.578	-66.42	31.65024224
315	-16.4299	-118.57	64.20087219
360	0	-180	80

Table 2: In-line slider mechanism stroke calculation using Microsoft Excel

4.6.2 Mechanism design simulation

The in-line slider crank is drawn and simulated in ADAMS 10.0 software. This is to see how the design extends and retracts as well as to see the suitability of the design with the required specifications.

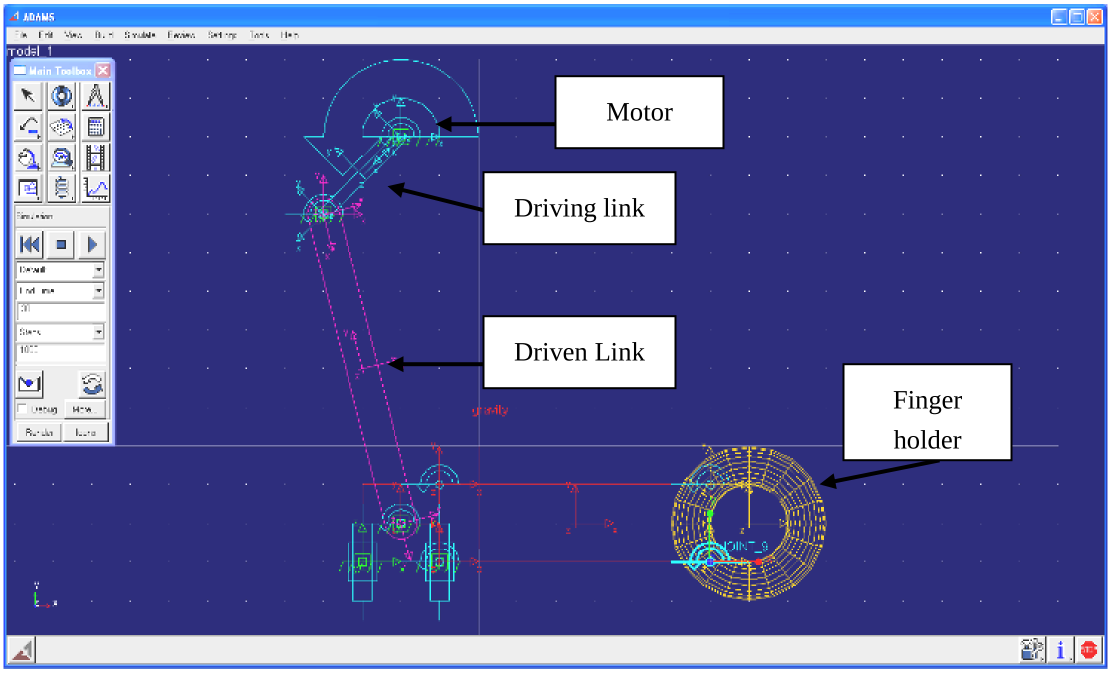


Figure 9: In-line slider mechanism drawing in ADAMS 10.0

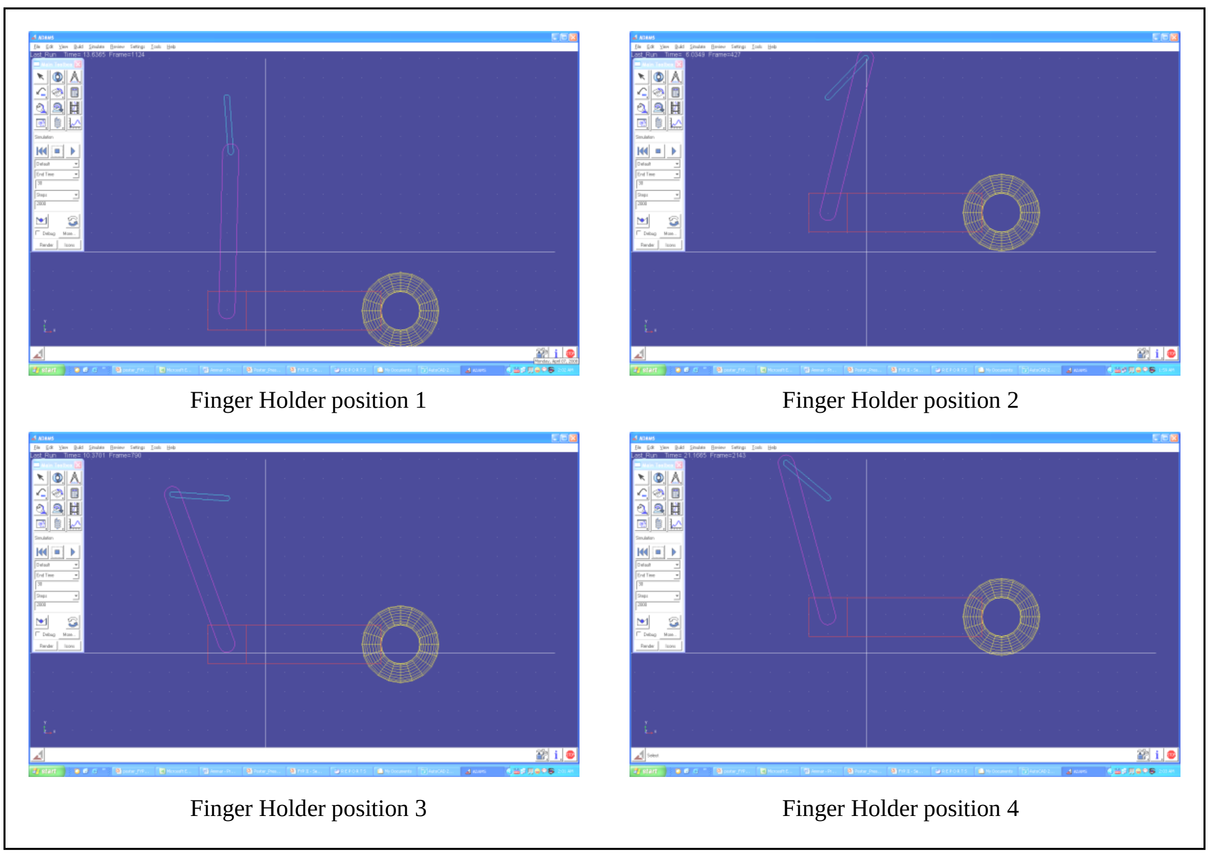


Figure 10: In-line slider mechanism simulation in ADAMS 10.0

From the simulation, it could be seen that the movement of the in-line slider crank mechanism is consistent and no jerk occurs although there is a slight change in velocity. This meets the specifications stated.

4.6.3 Mechanical parts

The mechanical design consists of 7 main parts:

Main Body	Finger Holder Link
Slider	Slider Holder Link
Slider Holder	Slider Driving Link
Finger Holder	Slider Driven Link

4.6.3.1 Main Body

The main body is where all the other parts are located. The main body is designed to be small and compact.

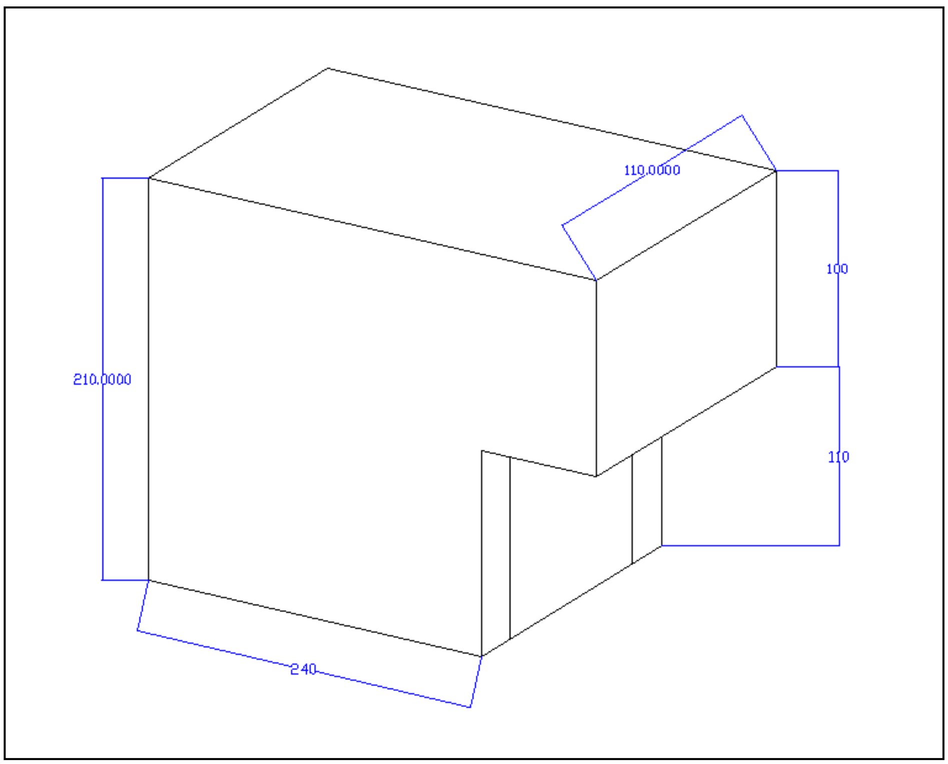


Figure 11: General drawing of the main body

4.6.3.2 Slider and slider holder

The slider and slider holder is where the link holding the finger holder is connected to. The slider is connected to the linkages driven by the motor. It will move up and down vertically inside the slider holder.

4.6.3.3 Finger Holder

The finger holder is where the finger of the patient is located. The size of the ring diameter is fabricated various sizes, to cater for different finger sizes. This holder is connected to the finger holder link.

4.6.3.4 Finger Holder Link

The link holds the finger holder and is connected to the slider.

4.6.3.5 Slider driven and driving link

Two linkages are used in the mechanism, one driven link and one driving link. The driving link is connected to the motor and drives the driven link. Once the motor rotates, the driving link will drive the driven link, which will move the slider vertically. This is what pulls and pushes the finger holder up and down.

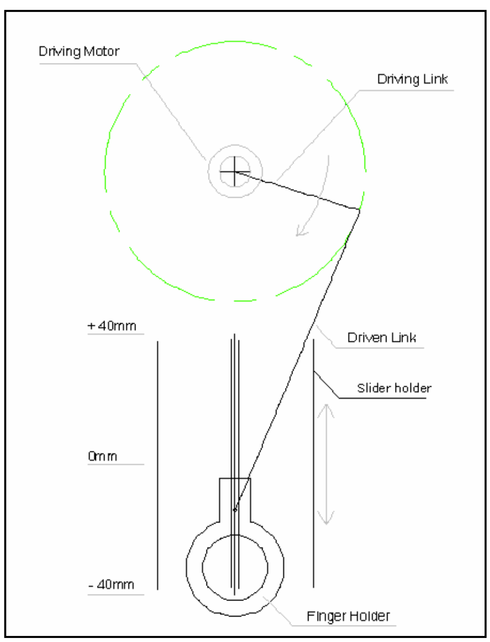


Figure 12: General drawing of the mechanism

4.7 MOTOR SELECTION

According to the specifications made during the designing phase, the finger holder must move a distance of 80mm in 2-4 seconds. An adjustable resistor is used to control the speed of the finger holder. Using the following formulas the values are calculated:

$$\text{Angular velocity } \omega = 2\pi f, \; \omega = v / r$$

Velocity, $V = \omega r$

r = driver link = 0.04m

Using the above formula, three motors were calculated to be compared with each other

Speed (rev/min)	Radius	Velocity (cm/s)
30 rpm	0.04m	12 cm/s
40 rpm	0.04m	16 cm/s
60 rpm	0.04m	24 cm/s

Table 3: Motor RPM and linear velocity comparison

From the table, the 60 rpm motor was chosen as it meets the specifications of the mechanism movement. It is chosen due to higher torque and its availability. A higher transistor is used to minimize the current supplied to the motor, thus slowing down the motor. The following are the motor specifications from the manufacturer[7] :

Parameter	**Value**
Rated Voltage	12V
DC Voltage Operating Range	DC 3 -12V
Torque (Load) at Maximum Efficiency	3.0 Kg-cm
No Load Speed	60 RPM +/- 10%
Speed at Maximum Efficiency	55 RPM +/- 10%
No Load Current	65 mA
Current at Maximum Efficiency	250 mA
Gear Ratio	270:1

Table 4: Motor specifications

In order to gain the maximum speed efficiency of the motor, a potential of 12 volts is required. However, in this project, a 9V battery will be used. To calculate the resistance required for the motor to operate at maximum power:

$$12V = 250mA \times R$$

$$R = 12V/250mA = 48\ ohm$$

Therefore, for a 9V battery the resistance is as follows:

$$9V = I \times 48ohm$$

$$I = 9V/48ohm = 0.19mA \approx 0.20mA$$

(Using a 9volt battery, 0.20mA of current and a resistance of 48ohms are required to run the motor at its maximum efficiency).

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 RESULTS

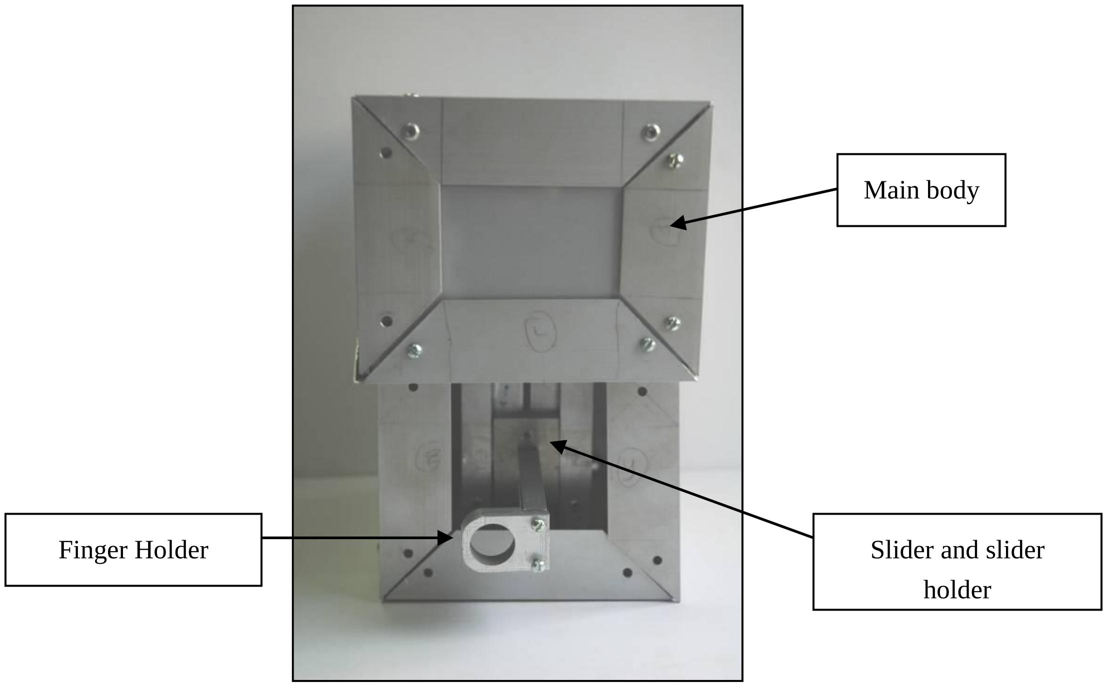
5.1.1 Completed Prototype

The completed prototype of the machine was finally achieved on Week 11 as planned. The prototype was tested in terms of its functionality as well as getting feedback from the potential end users. This was to obtain not only a working prototype but also to ensure that the finger trainer does really function as a finger trainer for stroke patients taking all factors into consideration including safety and the comfort of the users.

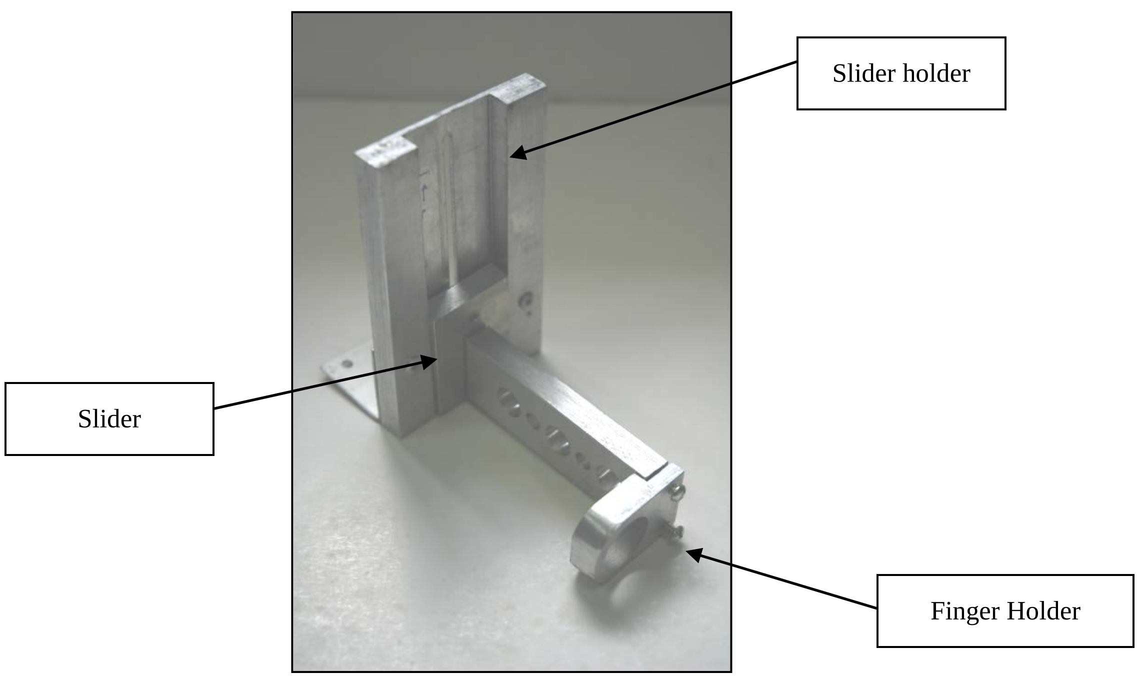
The following are pictures of the completed Finger Trainer Machine:-

Picture 1: The completed Finger Trainer machine (side view)

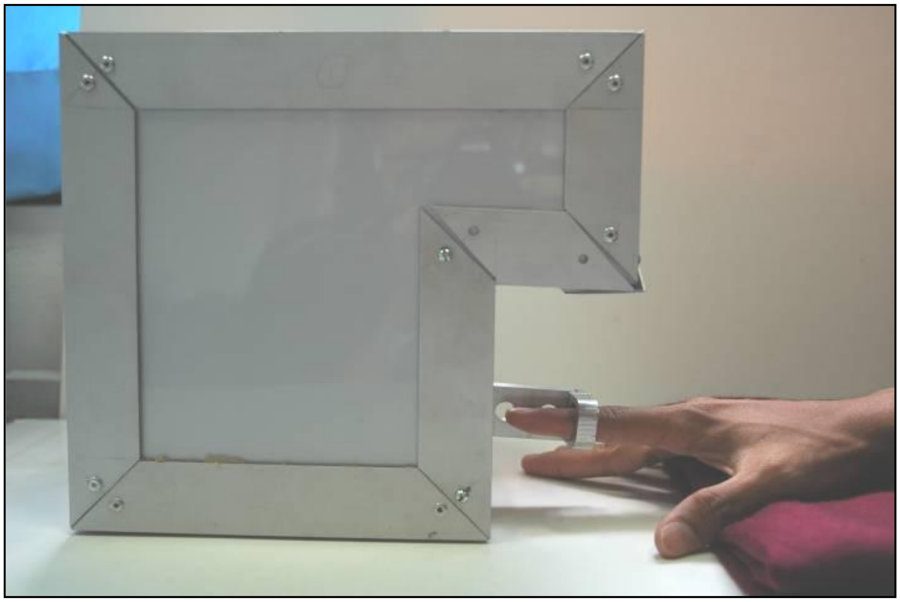
Picture 2: The completed Finger Trainer machine (front view)

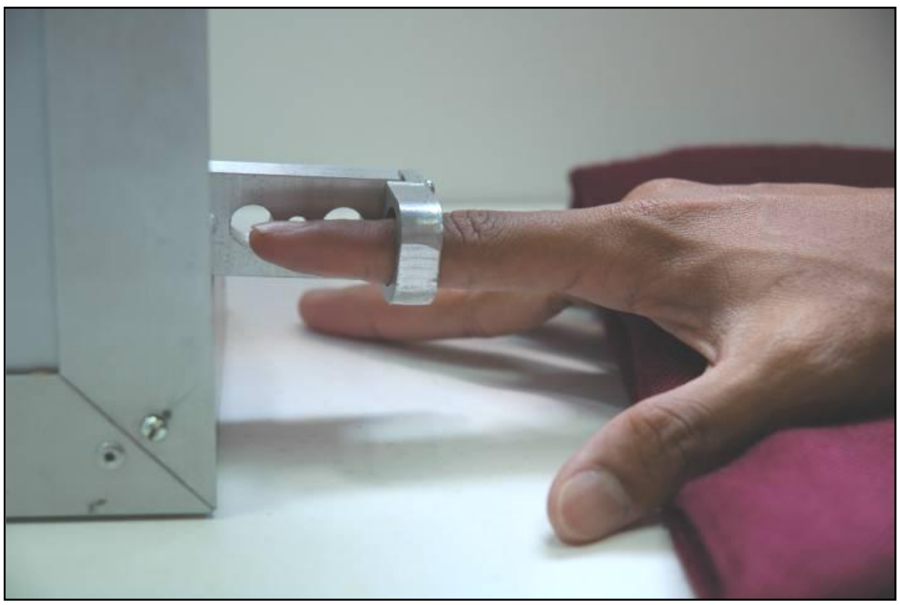


Picture 3: The moving mechanism



Picture 4: The finger trainer in use





5.1.2 Completed Prototype Testing

The completed prototype was tested to a few potential users. They were students and old people aging from 50-53 years old. The purpose of this test was to get the feedback and opinions from these people regarding the functionability of this machine, its features, and the comfort and user friendliness.

From the test, various opinions were given. This test was important as it could reveal the pros and cons of the finger trainer from the users' point of view. The following are listed among the feedback data gained:

1. Most of the test group individuals were quite impressed with the finger trainer machine as it was small, easy to operate and seemed affordable.
2. There were some safety concerns as the machine was partially made by aluminum metal which had quite sharp edges. This was later explained to then the purpose such materials were used.
3. Another issue was the comfort of the finger trainer. They were not really concerned about this but I asked for their opinions if a soft cushion-like support was placed on the finger trainer and all did agree.

CHAPTER 6
CONCLUSION AND RECOMMENDATION

6.1 RECOMMENDATIONS

1. The prototype consumed quite a sum of money for fabrication, although still within the budget. The cost could be reduced if the product is mass produced using cheaper and more appropriate materials to suit its purpose.
2. The fabrication of the prototype was done using available and easily fabricated materials including aluminum frames. This may contribute to the danger to consumers as this machine works on electronics. Insulative materials should be used in order to prevent such danger.
3. The product was tested to some potential users to get their feedback regarding the machine. There were worries of getting their fingers hurt as the finger holder was made from aluminum. Simple modifications should be done such as putting soft supports for comfort purpose.

6.2 CONCLUSION

The Finger Trainer is a simple machine that can be used to assist in training and re-teaching a stroke patient's finger. It is portable and very easy to operate as well as being comfortable to the users. Disciplined routine and consistent use of the machine would mostly help stroke patients to regain back their finger ability to move and grip, which will help a lot in doing their daily routine.

CHAPTER 7

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APPENDICES

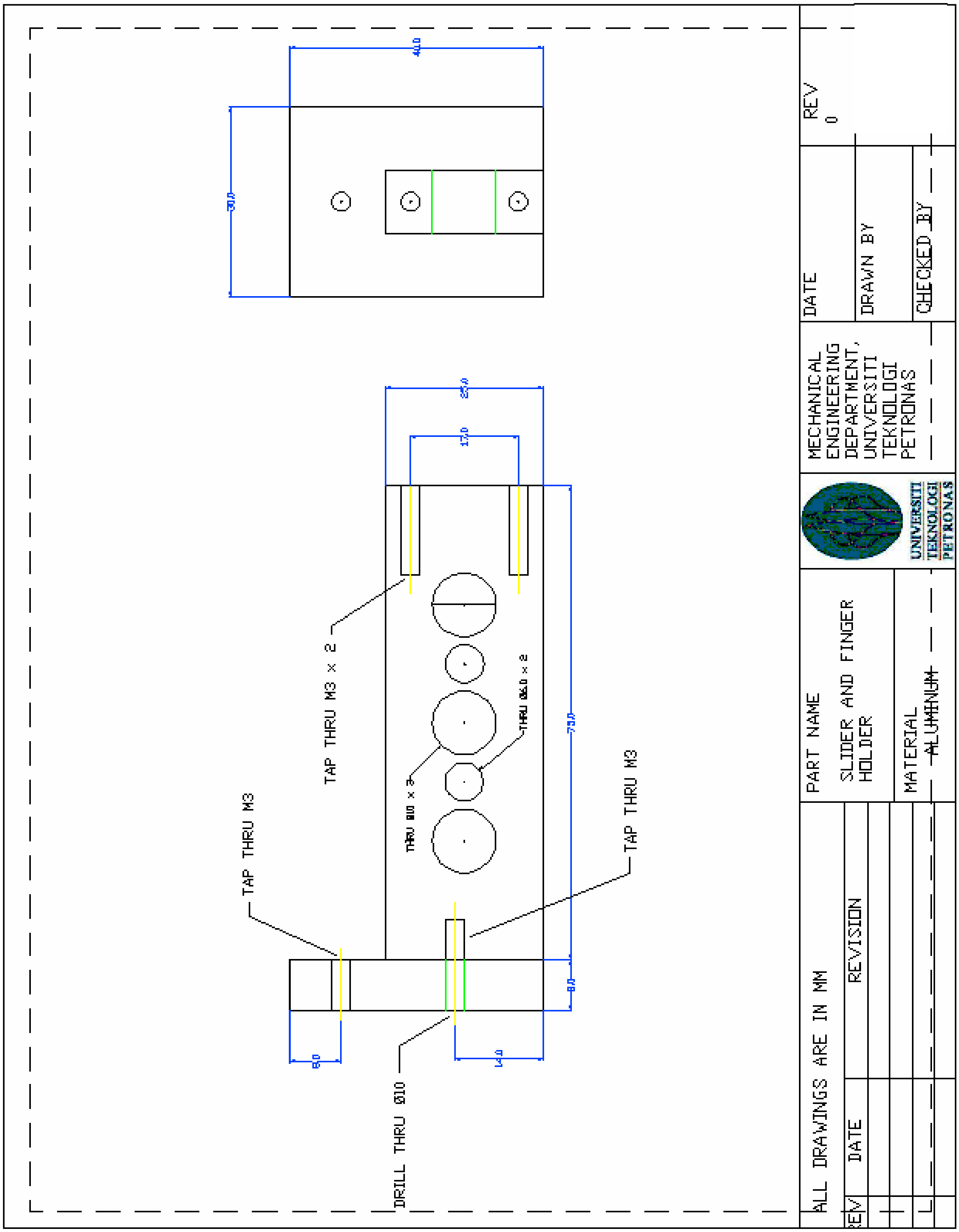

Figure 13: Engineering drawing of slider and finger holder

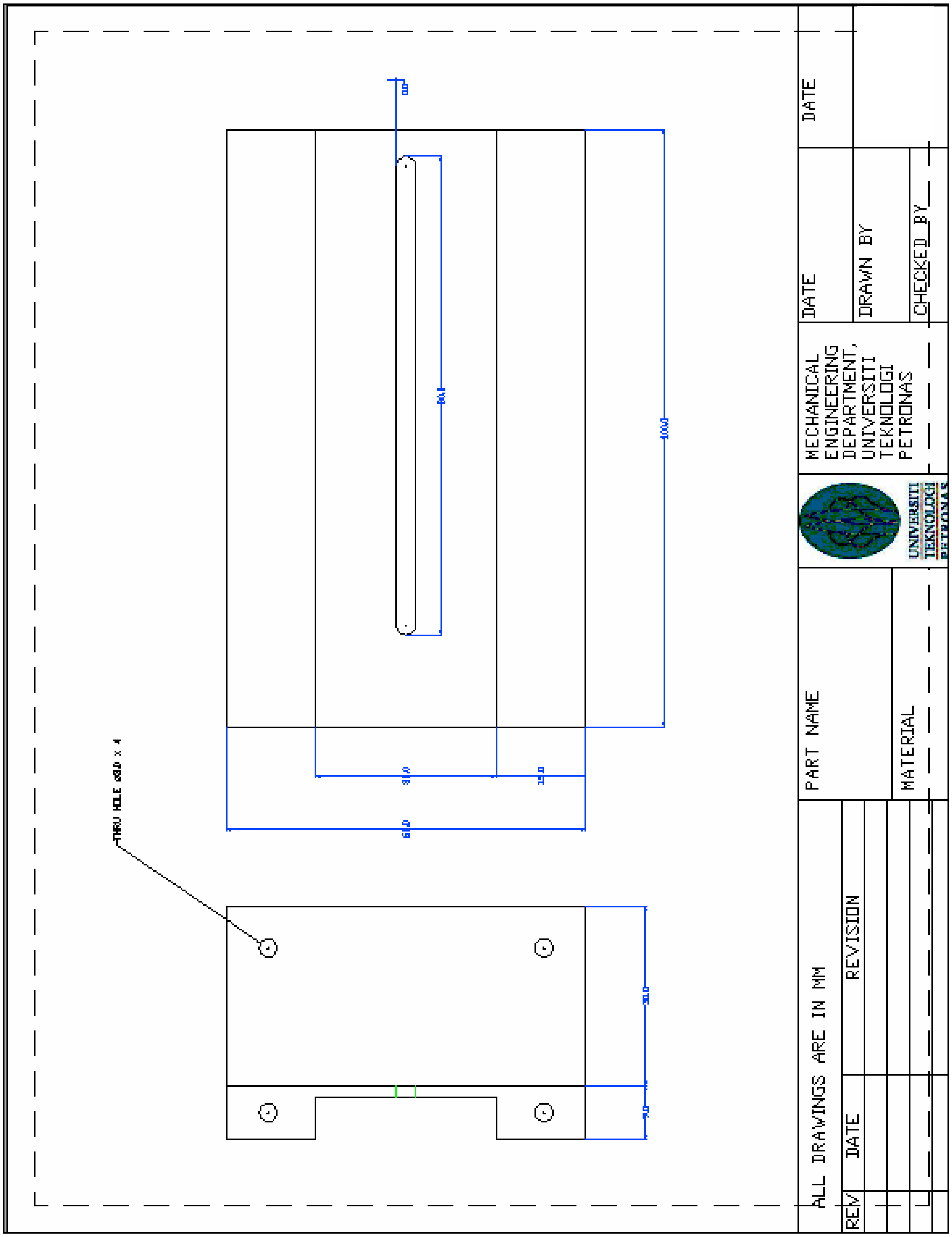

Figure 14: Engineering drawing of slider holder

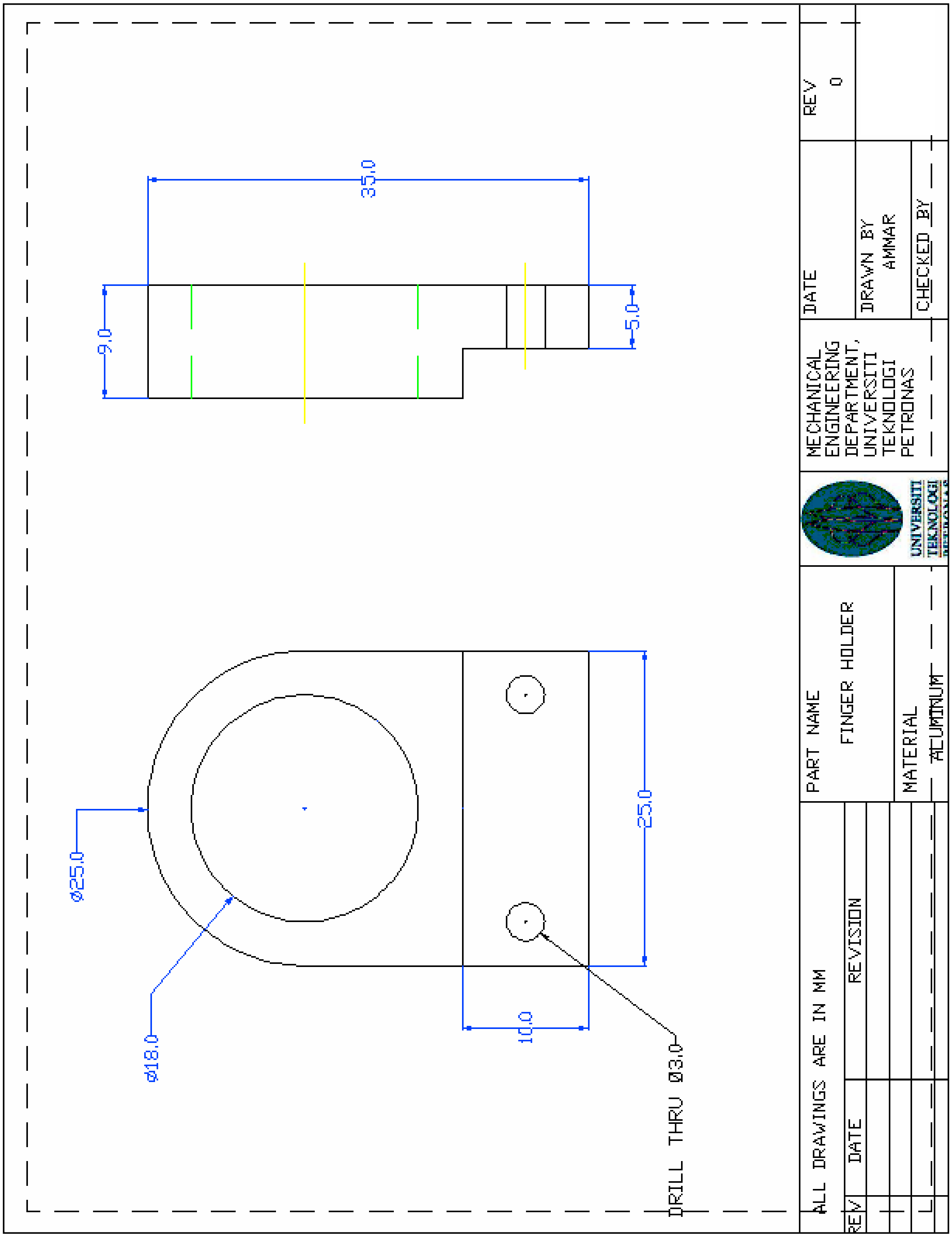

Figure 15: Engineering drawing of finger holder

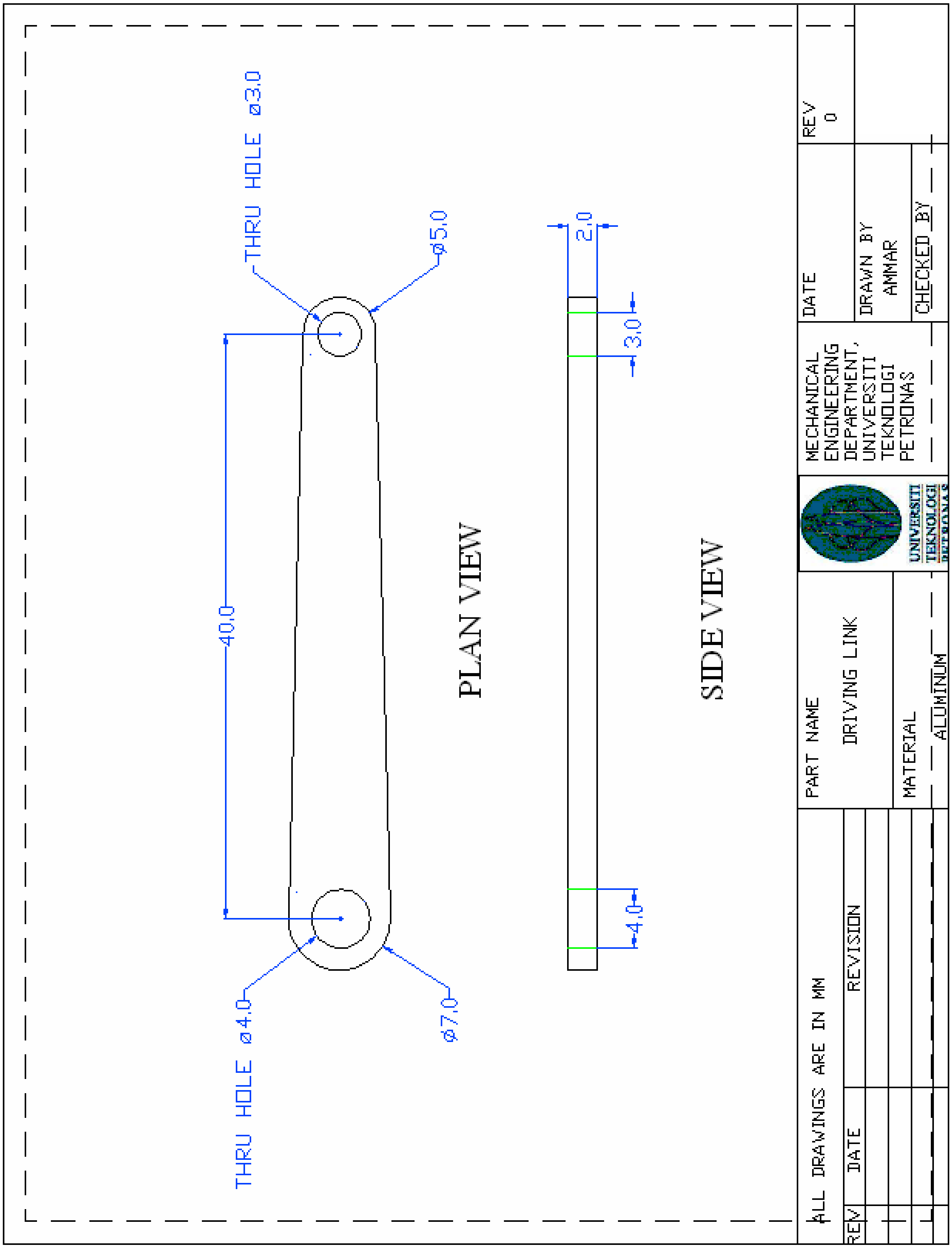

Figure 16: Engineering drawing of driving link

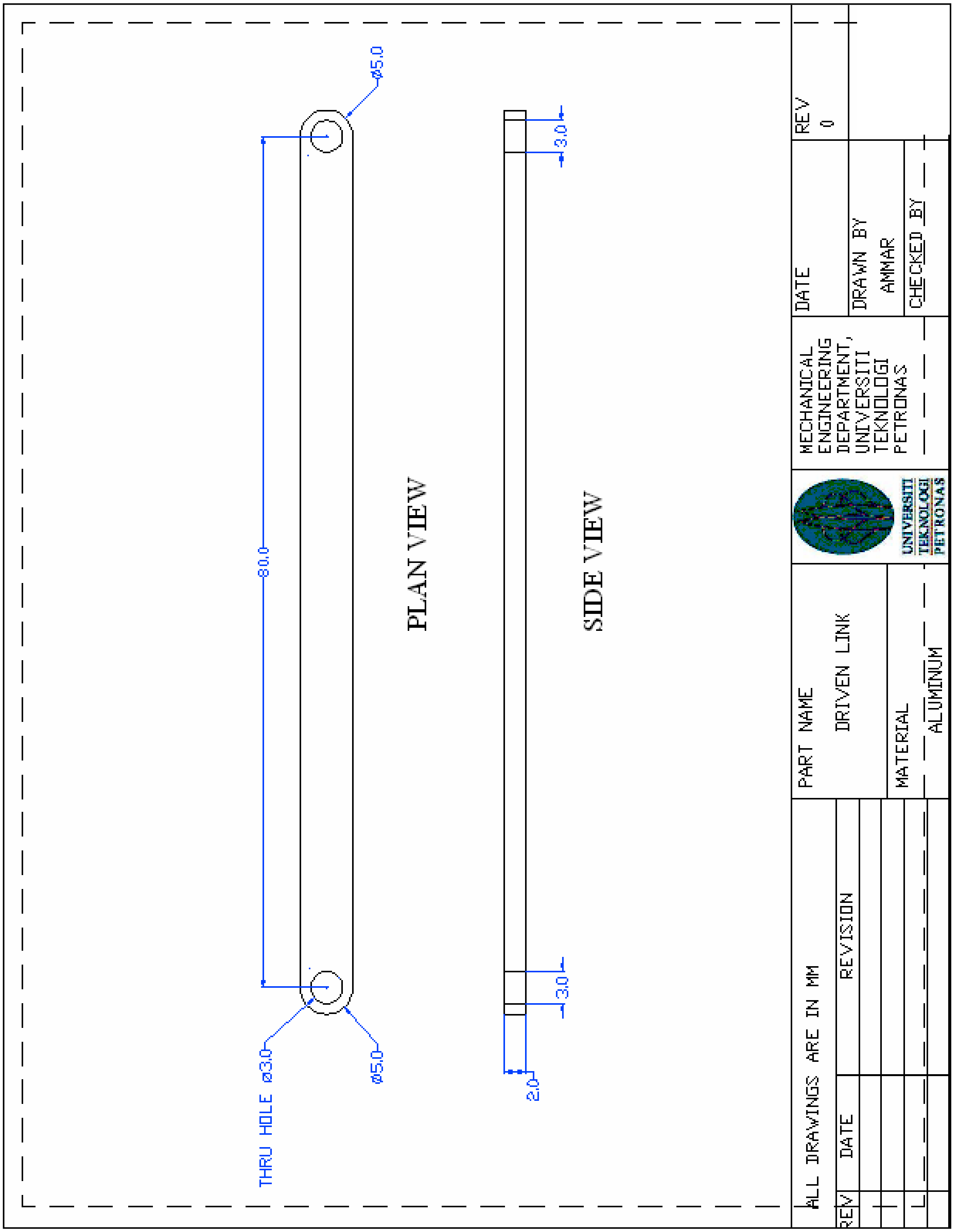

Figure 17: Engineering drawing of driven link