Design And Development of Force Measuring Device For Push and Pull for Upper Body Extremity In Rehabilitation Therapy

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Abstract Stroke patients usually experience difficulties in exercising as a result of circumstances that make it difficult to move. So, this problem can be solved by a design tool that can facilitate patients improving muscle strength and getting to know the force applied to a movement. In addition, this project is intended to build and create a tool to measure the forces that cause someone to suffer disabilities at the top of their body. The design has two important parts: mechanical parts and electronic parts to complete construction. The mechanical parts are designed by looking at the most appropriate size to implement push and pull exercises. In addition, the materials used to build the mechanical parts are necessary in accordance with the environmental conditions and the patient's condition and convenient to carry anywhere. The use of PVC material is most suitable, as PVC is resilient to heat, light, and ductility. To design the mechanical parts, SolidWork software is used, and the analysis of the mechanical parts is done using ANSYS software. In addition, the design of mechanical parts also needs to refer to the appropriate patient's condition during the push and pull exercises. The construction of the electronics will display the value of force (N) that was exerted by the patients. By using ISIS software, the development of the circuit is more accurate, orderly, and suitable for the mechanical side when the two main parts are combined to produce a device that measures the force after a push and pull exercise is done. The use of a microcontroller in the circuit facilitates the creation of measuring tools. The combination of all parts can make the LCD display the force (N) exerted after the push and pull exercise is done. In conclusion, all the movements are to identify the force exerted, apart from improving muscle strength after exercise push and pull.
Keyword: PVC material, ANSYS, SolidWork

INTRODUCTION

Our body consists of two segments: the upper body and the lower body. Each of the segments has its own function. Upper-body muscles are commonly used for hands, shoulders, and also arms to move. Lower-body exercises always focus on the legs, knees, and all about walking. In upper-body segments, there are many muscles and organs that attach to work as an upper-body system. Organs that consist of the upper body are the heart, lungs, stomach, and colon. Muscles that consist in the upper body are infraspinatus, teres major, erector spinae, latissimus dorsi, pectoralis major, serratus anterior, rectus abdominis, external oblique, biceps brachii, tendon of biceps brachii, deltoid, and brachioradialis [1]. All of these organs and muscles work together to perform the movement.

The major factor that affects patients is that they cannot conduct their upper body like normal because of the disease and also because of the accident. There are differences between the disease and the accident. The most common disease in relation to the upper body is stroke disease. If the person has this kind of disease, it is not easy to cure, and it takes more than 4 to 5 years to cure it. meaning that they need a long time to make sure they can use their upper body like normal before they get a stroke.

Stroke is a disease that happens when blood vessels in the brain are blocked or burst. This occurs as a result of bad habits or poor lifestyle choices[2]. From the statistics, many people get this kind of disease because of the food that they eat. Foods that contain high calories and fat, like fast food, can lead to stroke disease.

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METHODOLOGY

In this section, method of this device included software and hardware. Figure 1 show the flow chart of development of the device.

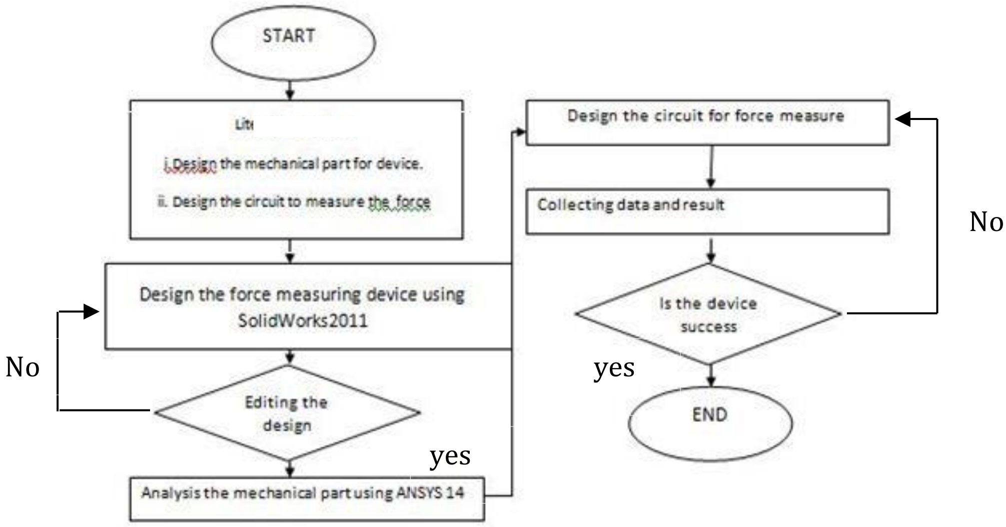

FIGURE 1 General flowchart for development of force measuring device for push and pull exercises for upper body extremity in rehabilitation therapy.

Mechanical design

This device was designed to do upper body rehabilitation for patients who have problems with their upper body. This device will display the force that the patient uses when doing some work with it. The mechanical device acts as exercise equipment to encourage the patient to do some work. In this mechanical design, there are three parts to which force will apply when the patient is doing the work: the holder, the knee holder, and the paddle (Figure 2).

FIGURE 2 Mechanical design for force measuring device

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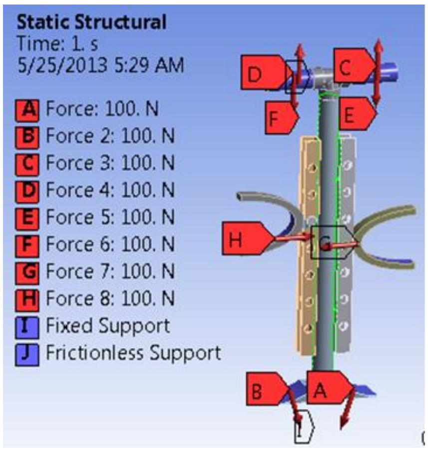

FIGURE 3 Force that apply during analysis structure

When all three part was applied by the force that was doing by the patient, push and pull activities will perform by the patient through the holder. The mechanism of the mechanical structure were, when the holder was used to pull up and push down by certain length that was set at the outer body, and also with fix mass that was setup in the inner body. Work done was done when the patient pulls up and push down continuously in one repetition. Then the device was measured the force after the push and pull exercise done.

TABLE 1 List of mechanical parts used

Label	Items	Materials	Function
1	Holder	PVC	Act as holder to lead the inner body during push and pull exercise.
2	Inner body	PVC	Act as the main function for push and pull exercise.
3	Knee holder adjustment	Aluminum	Adjust the position of the knee holder based on the high of patient.
4	Outer body	PVC	Act as the holder for knee adjustment and act as outer body for inner body.
5	Knee holder	Aluminum	To hold the knee to ensure that the knee not remove when patient doing push and pull exercise.
6	Paddle	Aluminum	Act as the foots support.

Develop the circuit using ISIS

a. By using ISIS, circuit was developed to use as a model before it use a real electronic component. Circuit was developed to measure force by using three component; switch, PIC 18f4550 and LCD (**Figure 4**)

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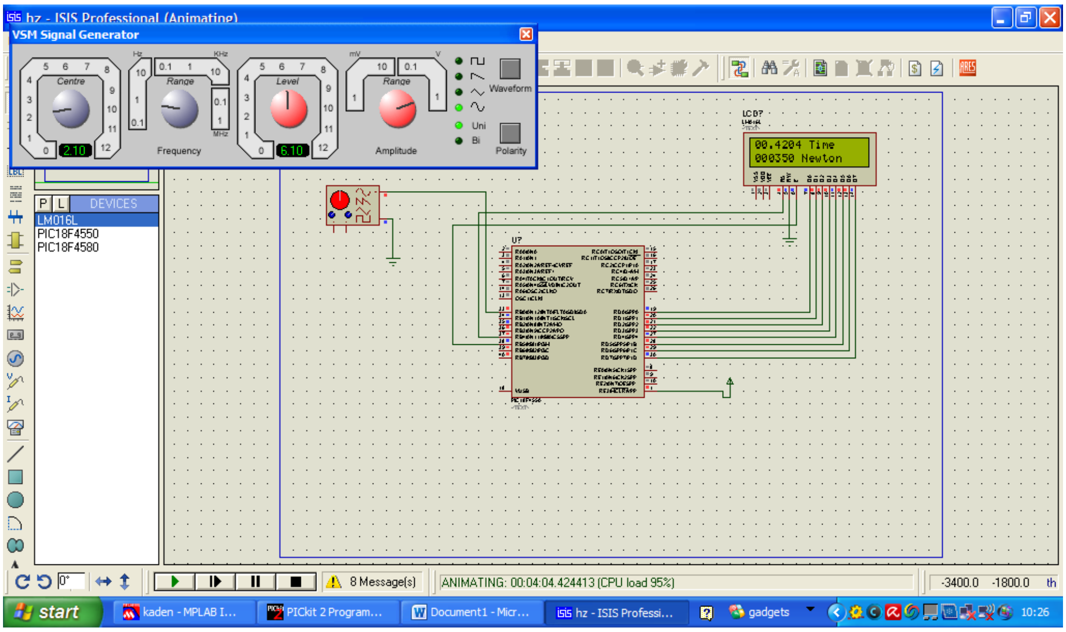

Figure 4 ISIS

b. The PIC 18F4550 was setup as timer to send time to the formula that already write in the programming language.

c. The program was setup will import to the ISIS to ensure that it will run successfully. The program was run success and finally it display the result.

2. Programming the circuit by using 40 pins PIC Start-UP kit 18F4550
   a. Design Program Language
   b. Build and compile (**Figure 5**)

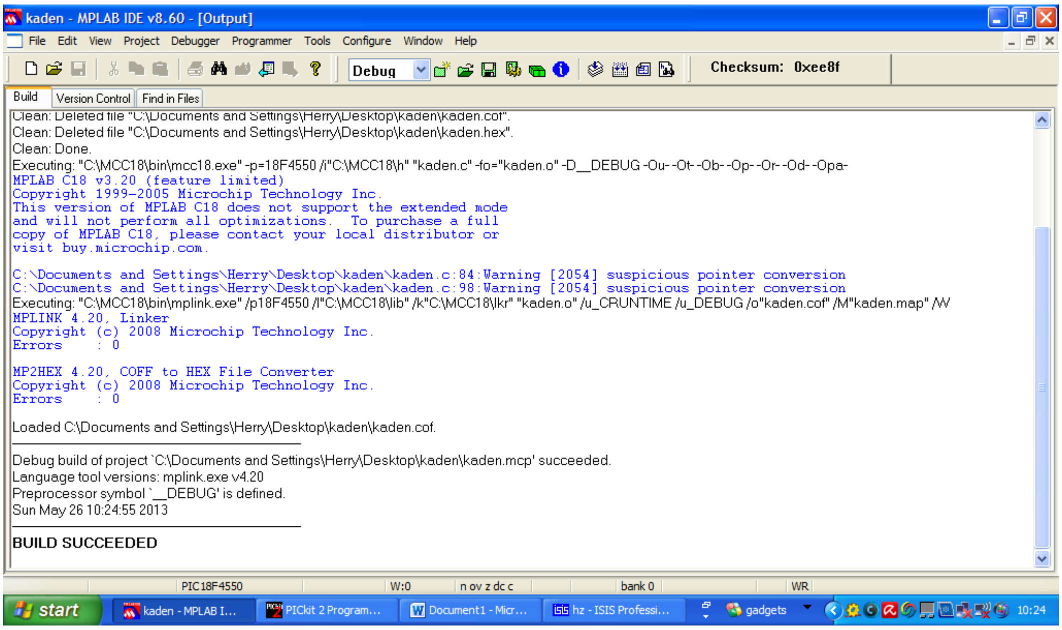

FIGURE 5 Build Succeeded

d. Import the program language to the PIC-Kit Programmer (**Figure 6**)

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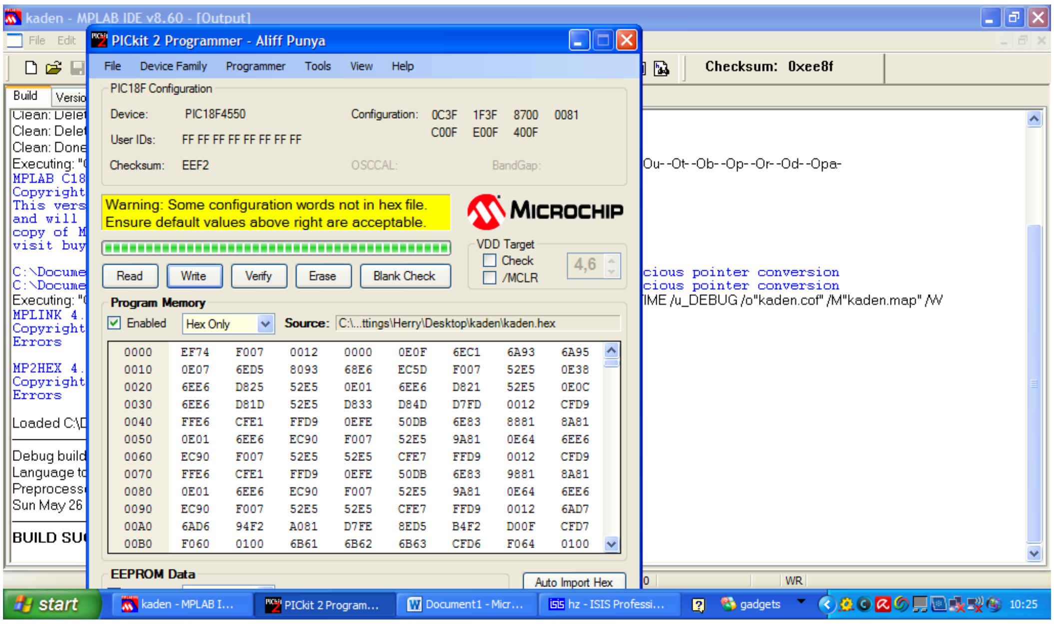

FIGURE 6 Write Language

e. Program was write (**Figure 7**) and success (**Figure 8**)

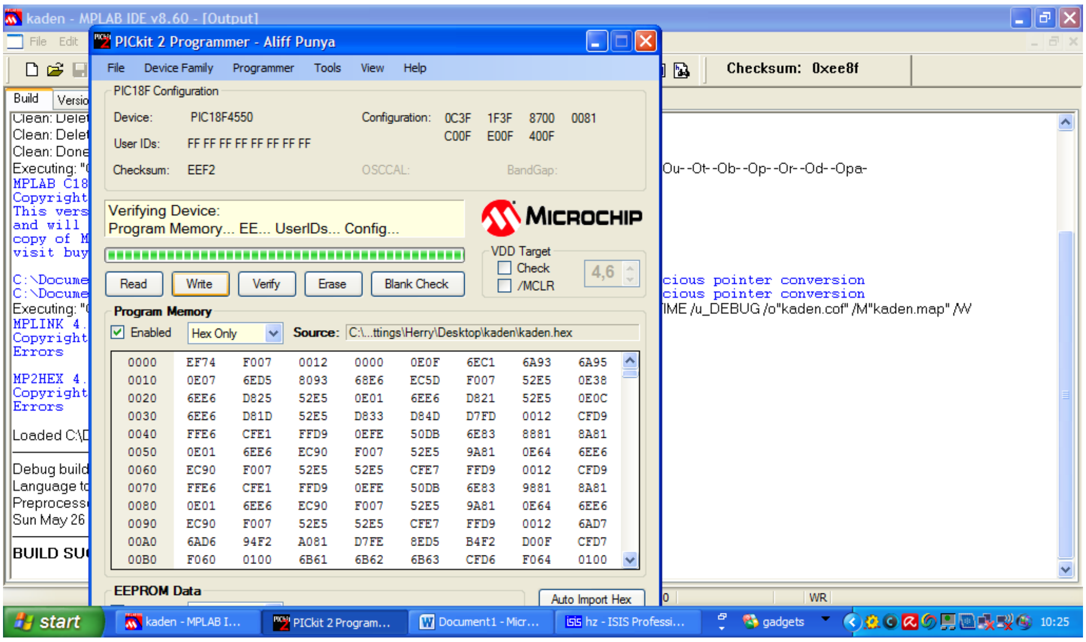

FIGURE 7 Verifying Device

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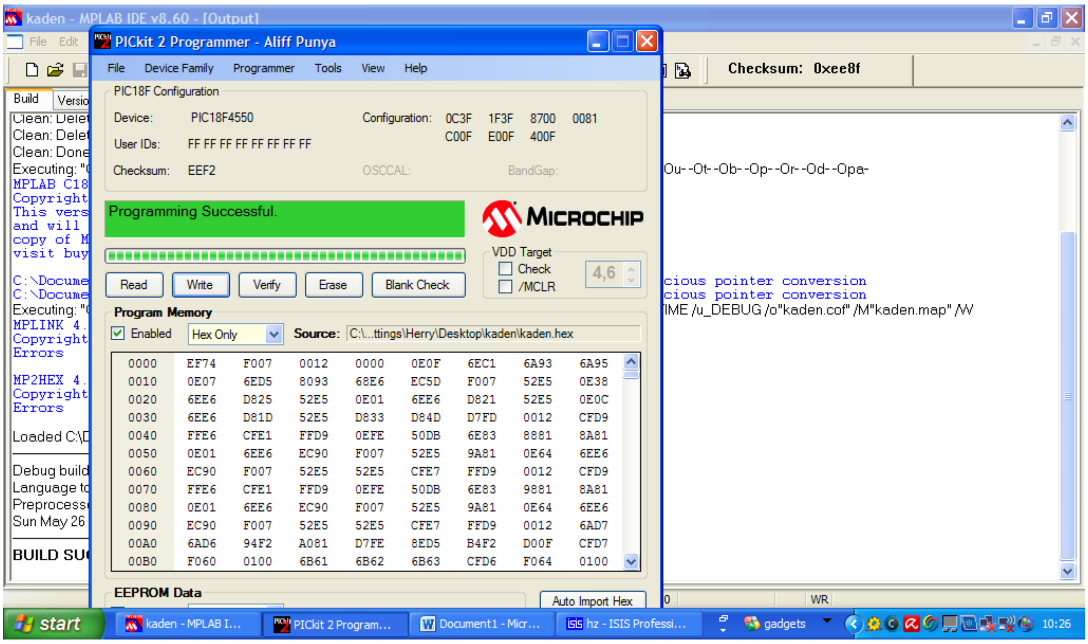

FIGURE 8 Programming Successful

f. After it is success it will import to the ISIS to run by using the circuit that already setup. After it is success than the program will burn into the 40 pins PIC Start-UP 18F4550.
g. The development of the device was successes.

RESULT AND DISCUSSION

Mechanical

From the analysis, each element of the analysis came with a different result. The analysis depended on the element that was to be analysed by using ANSYS. There are five elements that must be looked at and analysed to ensure that the design is suitable or not. The maximum force of 100 N was applied to know the strength of the design.

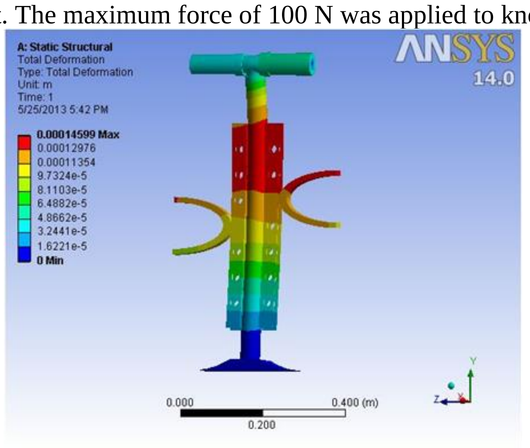

FIGURE 9 Total Deformation

It shows that the most critical part was the red segment. The blue segment shows the design has low strength because the force applied was maximum. At certain times, the red segment part will bend (Figure 10).

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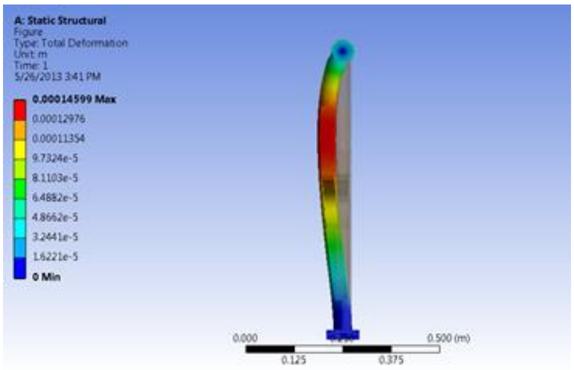

FIGURE 10 Front View

After a certain amount of time, the actual and bending sides will bend. It is because of the maximum force that is applied and also because of the material that is used. PVC was used because it was not flammable and not easy to crack. Commonly, patients will apply minimum or standard force, so the possibility of bending is small. **Figure 11** shows the design in the proportional vector.

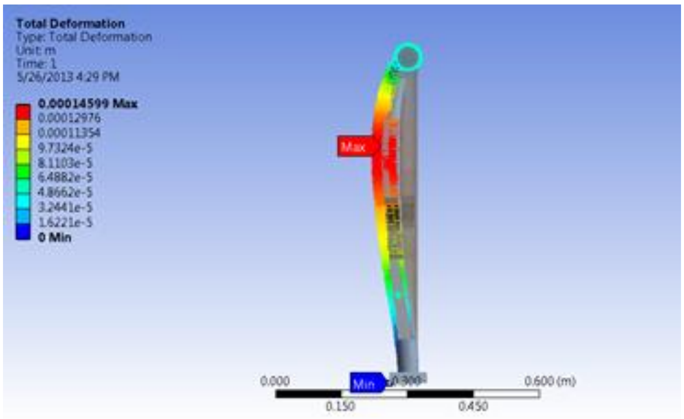

FIGURE 11 Proportional Vector

From this side of the view, we can see the maximum total deformation was at the red segment and the low total deformation was at the bottom because the high part of the outer body was the first to receive the force compared to the bottom part. On the other hand, the grey colour is the actual design, and it slowly becomes bent over time. This happens because each material has a lifetime to handle force.

Step to Using the Device for Calculate the Force.

Force measuring device was developed to calculate the force that using by the patient to conduct push and pull exercise for upper body extremity rehabilitation therapy have certain ways to give the outcome and display the force (N).

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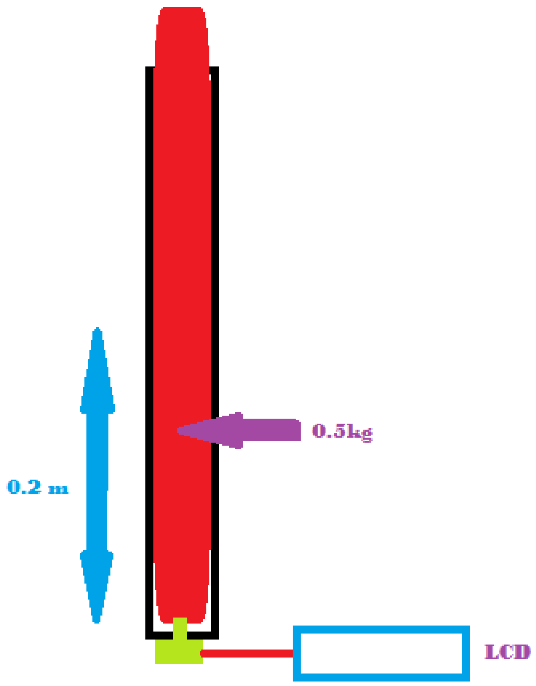

FIGURE 12 FIRST Step

The first step is to handle the force measuring device. Based on Figure **12**, it shows that the outer inner body attaches the switch. When the inner body attaches the switch, it automatically turns on, and at that time the time will run. The patient must pull the inner body until it reaches 0.2 metres as the constant distance. This distance was chosen because it's the minimum distance that can be tested for the stroke patient because the potential of the stroke patient to pull the inner body with a constant 0.5kg weight [3] also depends on the human potential. If the patient lifts heavy weights, it can cause high blood pressure, and for safety reasons, the most suitable weight to assume is 0.5kg. It was also the same for the high because the high and the weight related to each other when the push and pull activity occurred. The constant weight and constant height were used by the patient simultaneously when push and pull activities were conducted by the patient.

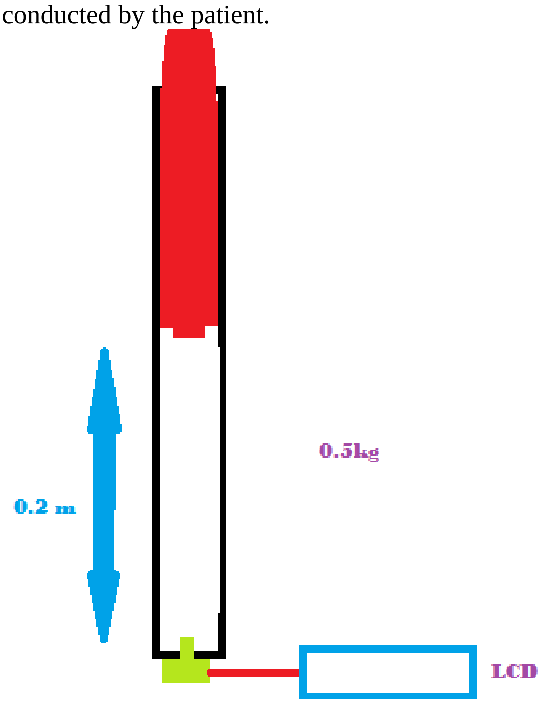

FIGURE 13 Second Step

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Second step to handle Force measuring device, based on the **Figure 13,** the inner body was pull until reach 0.2 meter before it will push until reach the bottom of the outer body that contain switch to off the time. When the time stop, force was calculated and it will display through the LCD.

When its display through the display it will publish the time (s) and the Force (N). So, the objective was achieved. The simulation of the push and pull exercise was confirm that the force that use by the patient was depend on the time that the patient doing the push and pull exercise. Based on the equation three [4], the equation was used because the patient will use velocity that depend on the vertical activity and it also include the gravity. In that situation, the suitable formula was used to calculate the force of the stroke's patient use during push and pull activity for upper body extremity rehabilitation therapy [5]. The force was display through the LCD (**Figure 14 and Figure 15**) to show that the objective of the project was achived and the value of force also shown.

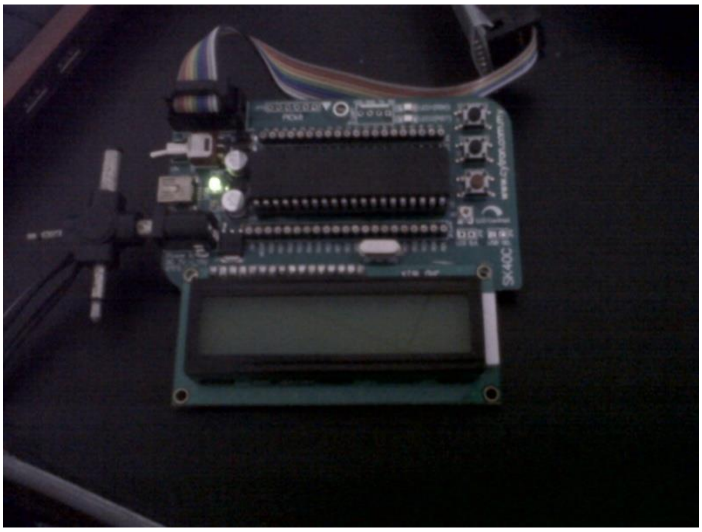

FIGURE 14 Electronic Part Force Measuring Device

FIGURE 15 0.33 second the value of the Force was 4.00N

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CONCLUSION

The development of the project had achieved the objective of the project as stated. The design and development of a force measuring device for push and pull exercises for upper body extremities in rehabilitation therapy was successful in two parts: the mechanical part and the electronic part.

The mechanical part was developed by using SolidWorks in a suitable dimension, and the design was done after the investigation of the best position for a stroke patient to use the device. After that, the design was analysed using ANSYS to ensure that it was suitable and safe to use regarding the strength of the material [6].

The electronic part was designed using a PIC 18F4550 40-pin. The circuit was designed using ISIS, and the programme language was setup using MPLan and compiled. After its success, it was imported to ISIS to ensure that the project ran correctly and was successful. Then, finally, it will burn into the PIC 18F4550 by using the PIC 2 Programmer. The test was already done, and the force was published through the LCD display [7].

Future development will involve the pressure sensor because it is more accurate. The pressure sensor will show the force of the patient based on the pressure that was transferred by the patient. Other than that, the design must also have a specific length for each part. Meaning that, when the patient does the push and pull exercise, in each high, there is a sensor that will transfer the high that the patient can achieve to the microcontroller, and it will transfer directly into the formula. Therefore, the manipulable variables become two. There are times and lengths, so the values of force are more accurate.

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