

DESIGN, SIMULATION AND FABRICATION OF PAIN THERAPIST ROBOT

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechanical Engineering

By

ARAVINDH G (Reg. No. 39150007)

BARATH C (Reg. No. 39150018)



**DEPARTMENT OF MECHANICAL ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with grade "A" by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600119.**

APRIL - 2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **ARAVINDH G (39150007)** and **BARATH C (39150018)** who carried out the project entitled **"DESIGN ,SIMULATION AND FABRICATION OF PAIN THERAPIST ROBOT"** under my supervision from December 2022 to April 2023.

Project Guide

Dr. J. JEYA JEEVAHAN M.E., Ph.D.,

Head of the Department

Dr. G. ARUNKUMAR, M.E., Ph.D.,

Submitted for Viva-voce Examination Held on April 2023 10-05-2023

Internal Examiner

External Examiner

DECLARATION

We, **ARAVINDH G** and **BARATH C** hereby declare that the project Report entitled “**DESIGN, SIMULATION AND FABRICATION OF PAIN THERAPIST ROBOT**” done by us under the guidance of **Dr. JEYA JEEVAHAN, M.E ., Ph.D.**, at Sathyabama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering in Mechanical Engineering.

DATE: 10-05-2023

PLACE: Chennai



1) ARAVINDH G



2) BARATH C

SIGNATURE OF THE CANDIDATES

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We would like to express our sincere and deep sense of gratitude to our Project Guide **Dr. JEYA JEEVAHAN, M.E., Ph.D.**, for his valuable guidance, suggestions, and constant encouragement that paved the way for the successful completion of our project work.

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ABSTRACT

Pain accounts for about 80% visits of all-aged people to healthcare. Pain or massage therapy is recognized as a safe and powerful way to treat the pain with fewer risks. Massaging not only lessens different kinds of pains in the elderly people, but also can improve the personal life by reducing depression and anxiety. However, hesitation to seek help from others, less accessibility to visit spa, and less affordability can limit the elderly people from using the massage therapy. Current massaging products require assistance from other people to use them, which is an important research gap. In this research, a novel pain therapist robot is designed with object recognition and massager unit. The model is created in Webots® robot simulator package, and simulated with python controller programming. The simulation results shows that the pain therapist robot can be used for applying various massaging cycles on the back of the elderly people and lessening the back pains without the assistance of another person.

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LIST OF ABBREVIATIONS

PLA	Polylactic Acid
3D	Three Dimensional
SW	Solid Works
FV	Front View
TV	Top View
SV	Side View
mm	Millimeter

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO PAIN THERAPIST ROBOT

In today's world everyone are focused in their work and duties but we are not taking care of their own body further following a unhealthy lifestyle leads to have some kind of normal body pains . This affects and causes pains in major parts of our body like shoulder pain, knee pain, leg pain, back pain and neck pains further increase the mental stresses. Our physical and mental stresses level rises,we also increase in illness, leading us to seek mental advice and take much medicine for normal pains .As we known the elderly people are struggling with the pains in their body to get away from the pains, they are taking medicines or they need the help of others to massage them, this leads them to be dependent person.

Sometimes elderly people are not happy with the massages done by other makes them to feel unsatisfied and uncomfortable. The fast working professionally who running to sustain their jobs are working more than 9hours in a day. This makes them feel very tired and anxious with the remaining time. The pains in their body are unlimited because they are working more than half day 12hours further they are spending their remaining time without happiness, pains in their body after reaching home struggles them more.

1.2 PROBLEM STATEMENT

Based on a survey conducted from the elderly people and working professionals they suffered by lack of body pain, so to get away from the pains they need the help of others for massaging as they feel depend on others, or they will consult a physiotherapy for normal body pains and taking medicines. By purchasing former products those are manually controlled and some expensive to purchase by they refuse to purchase these products.

1.3 MOTIVE OF THE PRODUCT

So the main purpose of this product is to give effective comfort in massaging with their own usage of time, as it works with their automatic controls so they can increase and decrease the required pressure of the device and to bring the product

with the best affordable price of purchase further all may be able to use it. Thus, a novel pain therapist robot is proposed to overcome the problems mentioned above, it provides a proper pain relief and gives safe and secure massage with adjacent force. It gives a massage either at sitting position or sleeping position. This pain therapist robot is moved from one place to another place using the four wheels fixed at each corner with rotatory motor is added on each wheel.

1.4 FORMER PRODUCTS

There are some former products that are available in the market that have different specifications with a variety of working processes and functions.

- Swing roller
- Shoulder relief
- Vibrator massager
- Roller massager
- Vibrator chair
- Electric massager
- Kneading massager

1.5 MOTOR

The servo motors are used to precise the rotational motion required. They are frequently used in robotic arms and angle control applications. This servo motor produces the torque and velocity based on the supplied current and voltage . The servo motor is fixed at the robotic arm to provide different rotational motions in different positions .so the device and move in three freedom of degrees it also control the position of which is moved in all angles.

CHAPTER 2

LITERATURE SURVEY

Lessy Willson et al., 2005 Vibrator massager product mainly employ 'vibration' to ease aches and pains in the muscles and to encourage relaxation. This products are focused not only a relaxation needed for people an also it is popular as gifts. This are the products which had been succeed in the market if they address actual user needs. (Lessy Willson et al., 2005) The handheld device known as a massager vibrates the skin's surface, this vibration is frequently used to promote relaxation and reduce physical tension. Most devices on the market based on the vibrators products are battery operated base or electronic.

The design are focused in this vibrators as compared to the automation system robots because this products are used by many customers also aimed to design for the sports that use intense vibration to ease aches and pains. Airports, ferries, shopping centres, and other public locations frequently have vibro massage chairs installed as a free or paid service to patrons. In automobiles, some producers offer vibro massage chairs in second-row seats . Some authorities and producers of percussion portable instruments assert that it may aid in muscle rehabilitation .

Mauricio Torres Quezada et al., 2020 The function is followed by using robotics is the hemiplegic shoulder pain treatment by this reduction of discomfort, spasticity and improvement of tone muscle strength and increased satisfaction and finally a great relief firm severe pains.(Mauricio Torres Quezada et al., 2020) The creation of exoskeleton plays a key role in, neurological rehabilitation technologies this contributes about the upper limb proto types are compared, put to test and formally verified.

Jimenez et al., 2020 Five out of ten working individuals experience back pain annually, and nine out of ten adults will experience it at some point in their lives. Some experts believe that as many as 95% of people will experience back pain at some point in their career.(Jimenez et al., 2020) The future of precise personalized robotic physiotherapy the robotic technology provides comfort people with back pain. A technology advancement automates the detection and

management of chronic back pain, it is focused for people deliver advantaged to countless pain relief, labor productivity and therapists with a tool to save time.

(Yassine Bouteraa et al., 2021) Smart solution for pain detection in remote rehabilitation describes a low cost, open-source robotic method, for distance rehabilitation. This device basically, works by a therapy robot that are equipped with new technology like sensors that track movement kinematics and kinetics. The purpose is mainly obtained benefit from the physiotherapists agility and robotic accuracy.

(Shaher A. I. Shalfawi et al., 2019) The purpose is focused in the acute effects of myofascial tissue movement on endurance performance and recovery using a novel self-propelled multi-pole mechanical roller massager. In the Myofascial quadriceps rolling, the use of roller-massager led to higher blood lactate awareness at exhaustion and a bigger blood lactate clearance after 10 min. Foam rollers have a short term positive impact in the range of motion of joints, but long term performance or range of motion benefits are unknown.

CHAPTER 3

AIM AND SCOPE

3.1 AIM OF THE PROJECT

Our primary aim of this project is to create a automatic pain therapist robot for elderly people and working professionals.

3.2 OBJECTIVE

- To solve the people pains and anxiety feelings and tiredness for normal body pains.
- To save their money by spending their savings on medicines and their transport charges to consult doctors always for normal pains.
- The survey taken from the people about the former products found some minor problems that do not satisfy them to use it always.
- As the former products have disadvantages with its use, some products are handhold device that may be used only by ourselves, expensive products available in market cannot be used by all, discomfort in using cheap massaging devices.

3.3 SCOPE OF THE PROJECT

- From Assumption Mapping we found the problem statement, that till now what are the problems people facing. How they are suffering by pains and why they are not comfortable with former products .
- Then survey taken from both elderly and working professionals with our problem assumption question we known well about their problems.
- With the efficient need of the elderly people and working professional we are gone through the better design to give the best pain relief mechanism.

CHAPTER 4

MATERIAL AND METHODOLOGY

4.1 MATERIALS

4.1.1 Frame

A frame acts as a major component in end effector of a pain therapist robot which carries load of other components and act as support to components. The frame is designed in solid works with accurate dimensions. The physical appearance of frame looks like U shaped size in upper side of the frame and a rectangular shaped size in lower side of the frame. The Frame Carries the 2 rods, rack, pinion and the servo motor. The Rod is mounted at the top of the frame which is supported by the rack. In the bottom of the frame the servo motor is fixed, and it's connected to the pinion. The servo motor does the function of rotation further using the rack and pinion the movement of the axis in the rod is done. The frame does the major function because the full load and motor vibration are carried by the frame while performing the operations.

The dimensions of the frame:

- The total length of the frame: 190mm
- The breadth of the frame (from left to right) = 142mm
- The thickness of the frame varies from top to bottom
- The cylindrical shaped rod is fixed at bottom of frame to connect with the robotic arm.
- The length of the rod is 40mm.
- The lower rectangular shaped in frame support the servo motor
- The length of the lower rectangular shape = 52mm
- The breadth of the lower rectangular shape = 62mm
- The thickness of the lower rectangular shape = 6mm
- There is a rectangular shaped hole in the middle of the U shaped frame.

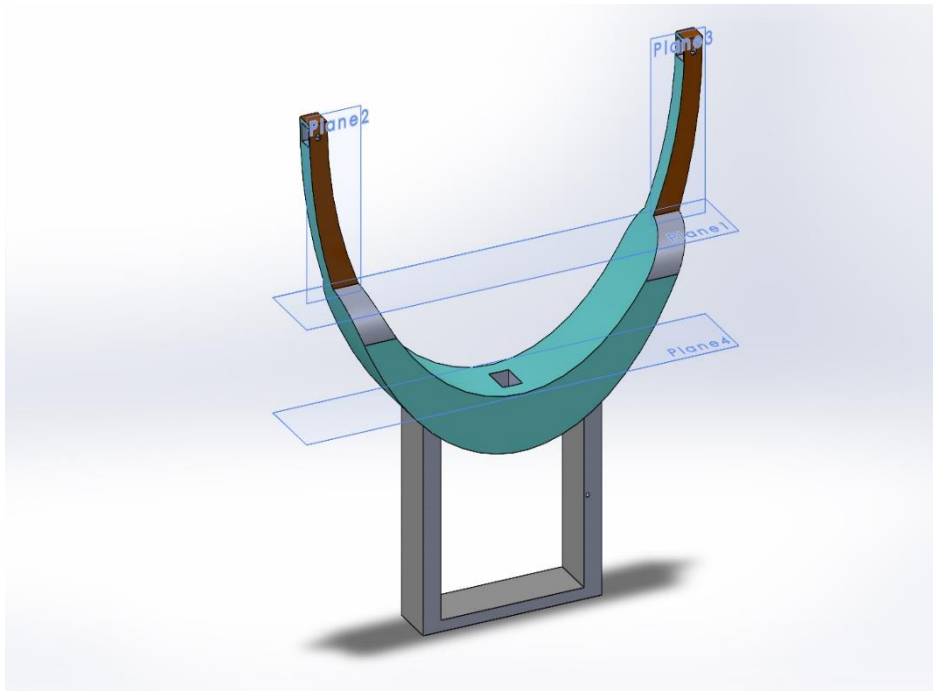


Figure 4.1: Frame

4.1.2 Rod

The other components of a pain therapist robot is connecting rod, it is connected to the top of the frame. There is a two-connecting rod, one connected to the left side of the frame and the other is connected to the right side of the frame. The connecting rods moves up and down when servo motor rotates. The physical appearance of connecting rod, the one end of the connecting rod is looks like ball shaped with hole present in it, connected with frame with ball and socket. The other end of the connecting rod looks like ring shaped, in which the connecting rods are connected to bolt and nut. The connecting rod carries the rubber balls which is in contact with the user body. The rod does the function to carry the rubber balls and to move forward and backward direction according to the movement of the rack and pinion.

The dimensions of the connecting rod :

- The total length of the rod =73mm
- Number of rods used = 2 Nos
- The outer diameter of the ring shaped end =6mm
- The inner diameter of the ring shaped end =4mm
- The diameter of the ball shaped end =6mm
- The diameter of the hole ball shaped end = 2.5 mm

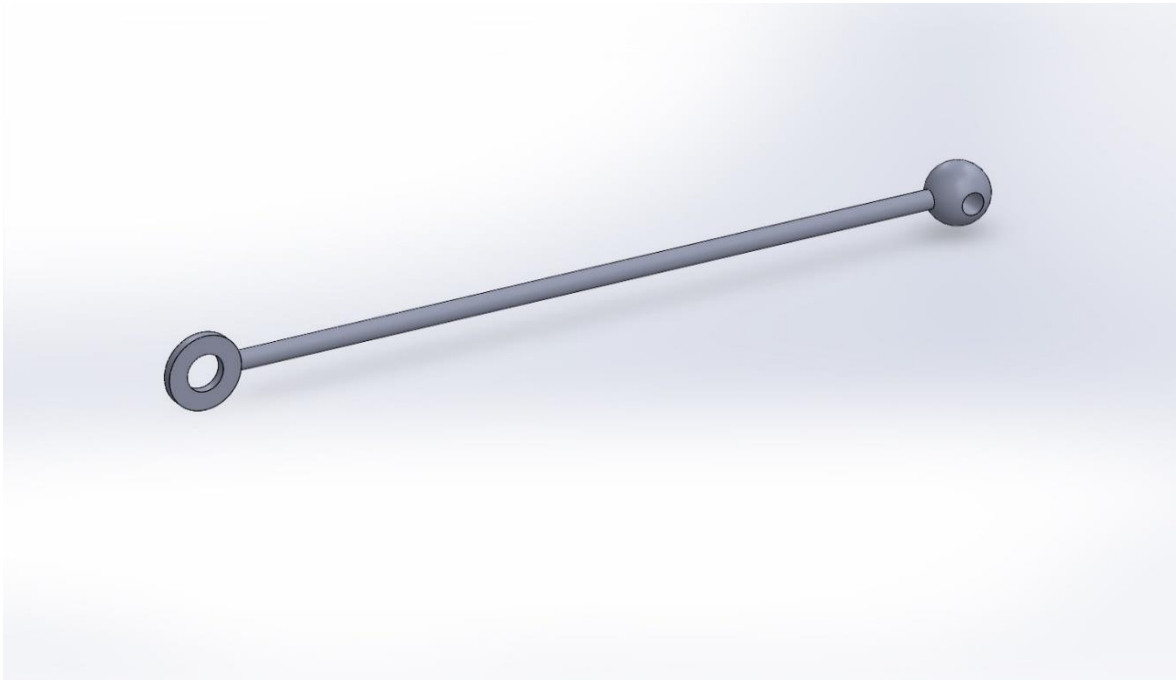


Figure 4.2: Rod

4.1.3 Rack and Pinion

Rack and pinion play major mechanism in this pain therapist robot. The pinion is connected to the servo motor and the rack is connected to the two rods. When the servo motor receives the signal from the arduino it begins to rotate with the pinion as the rotational motion is converted into the linear motion due to the strong connection between rack and pinion. This results the circular motion in pinion and the rack gives the linear movement. This linear movement of rack helps in up and down movement of connecting rod.

The dimensions of pinion gear (Fig:4.1.4)

- The diameter of pinion = 30mm
- Total number of teeth in pinion = 21 teeth
- Pitch circle = 4mm
- The diameter of inner hole = 5mm
- The width of the pinion gear = 5.5mm

The dimension of rack (Fig:4.1.3)

- The total length of the rack = 108mm
- Total number of teeth in rack = 22mm
- The width of the rack = 5.5mm

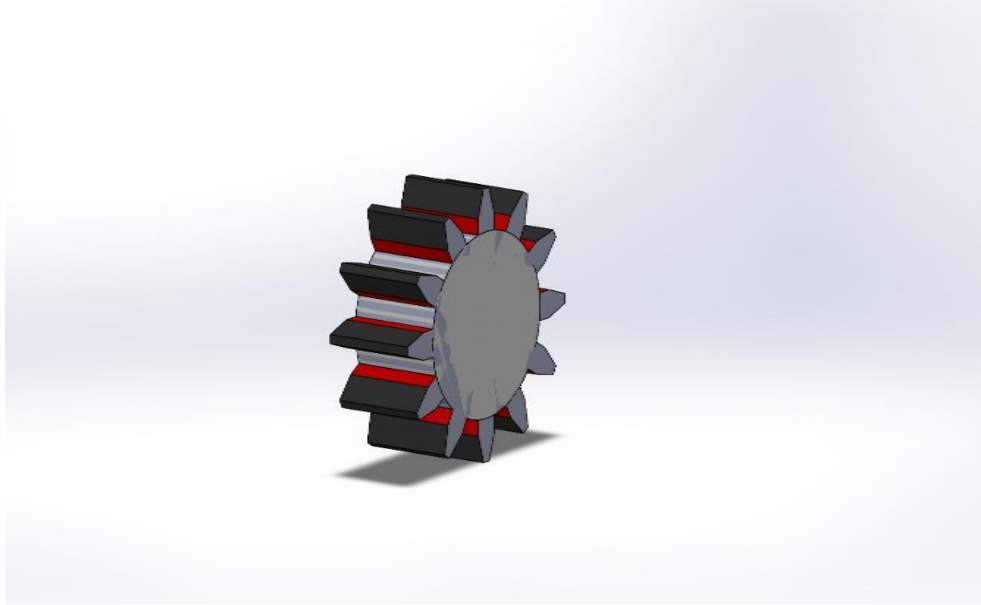


Figure 4.3: Pinion



Figure 4.4: Rack

4.1.4 Servo Motor

In this pain therapist robot we are using servo motor to rotate the pinion with specified torque and specified angle of rotation. Servo motor not only helps in rotation it also helps to push the object forward and backward. Here we are using servo sg90 model to run the pinion. The servo motor controlled electrically through ARDUINO UNO programed in a ARDUINO software with specified angle and torque. The servo motor consists of three connecting wire red, brown and orange. The red is the positive terminal, the brown is the negative terminal, and it is grounded.



Figure 4.5: Servo Motor

4.1.5 Arduino Uno

The Arduino Uno is used to control the servo motor rotation angle according to the required time intervals. There are three connecting pins from the servo motor which is connected to Arduino Uno. The red wire pin (positive) is connected to 5v pin in Arduino, the brown colour wire (negative) is connected to ground, the yellow wire pin (signal) is connected to the pin9 in Arduino. Using the c programming the Arduino is controlled to do its function. The main function of the Arduino is to control the servo motor which is connected to pinion.

```
#include<Servo.h>
Servo s1;
void setup() {
    // put your setup code here, to run once:
    s1.attach(9);
}

void loop() {
    // put your main code here, to run repeatedly:
    s1.write(0);
    delay(1000);
    s1.write(180);
    delay(1000);
}
```



Figure 4.6: Arduino UNO

4.1.6 Rubber Ball

The Rubber balls is fixed in the frame rod and it does the major role of compressing with the required force .This rubber ball plays a vital role for the pain relief for the users. The function of the rubber balls is to have the contact with the user body to press with the required force and also rotate itself in 360 degrees.

Dimensions of the Rubber Ball:

- The Diameter of the rubber ball is 28 mm.
- The Inner hole diameter is 4mm.

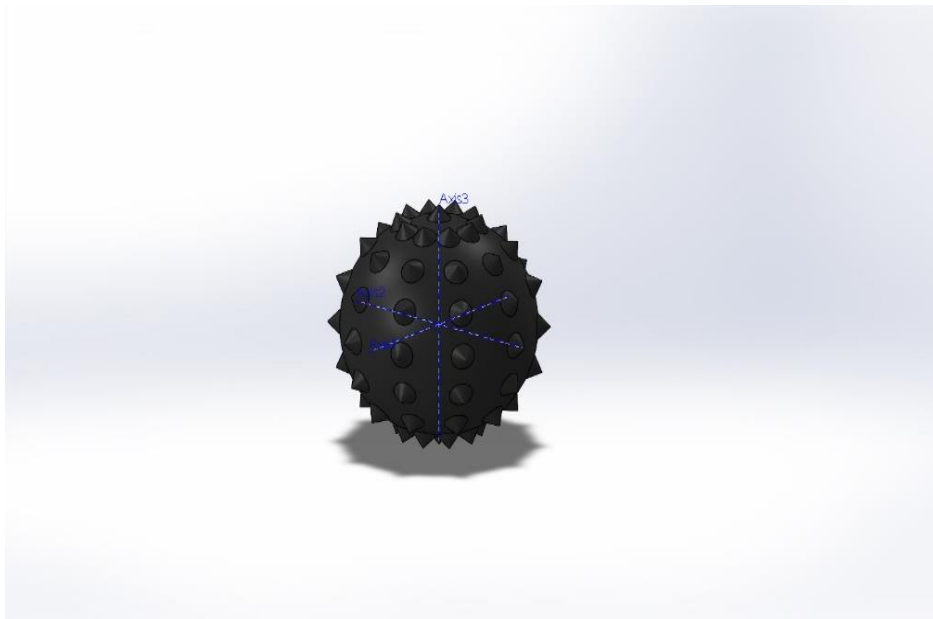


Figure 4.7: Rubber Ball

4.2 METHODOLOGY

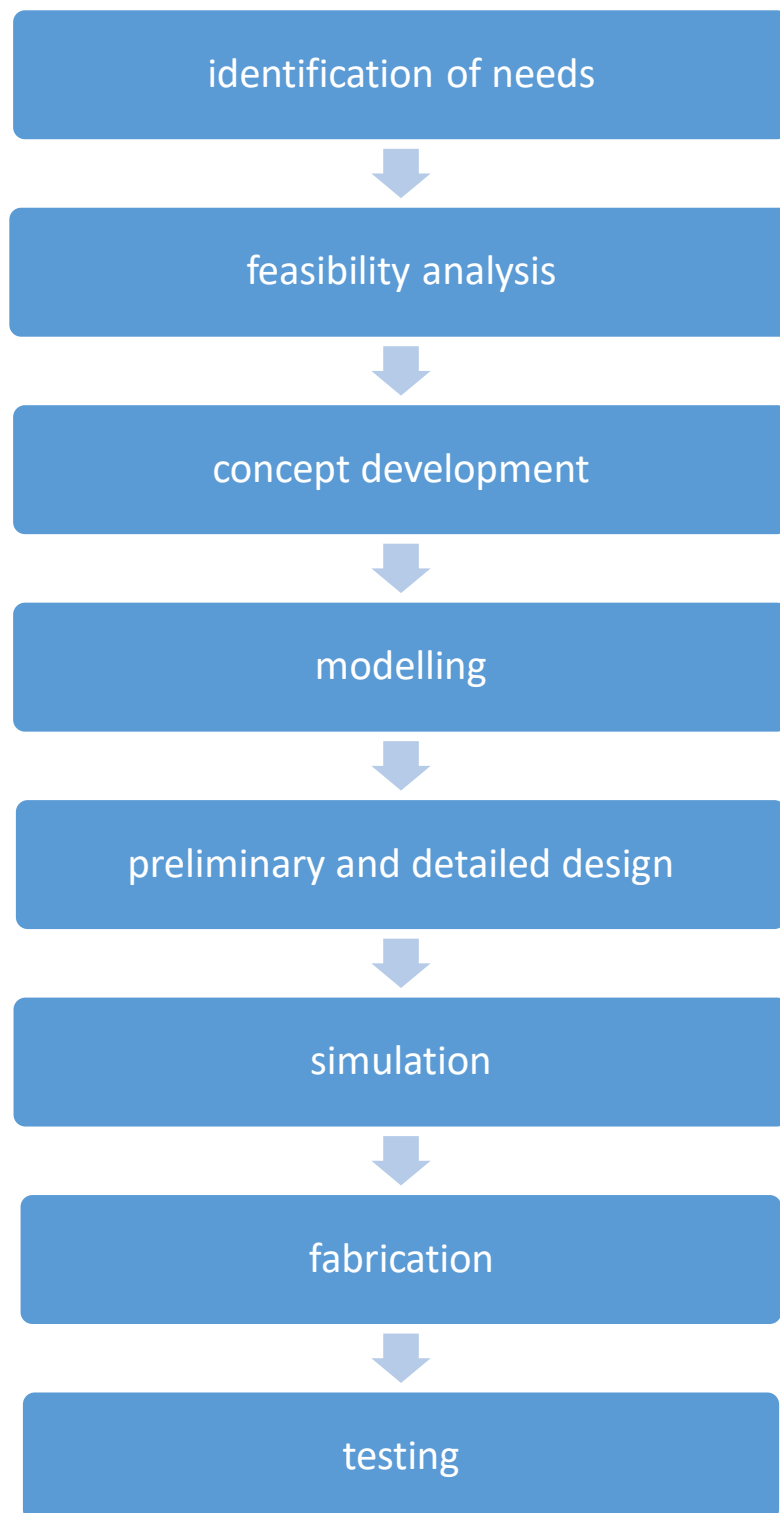
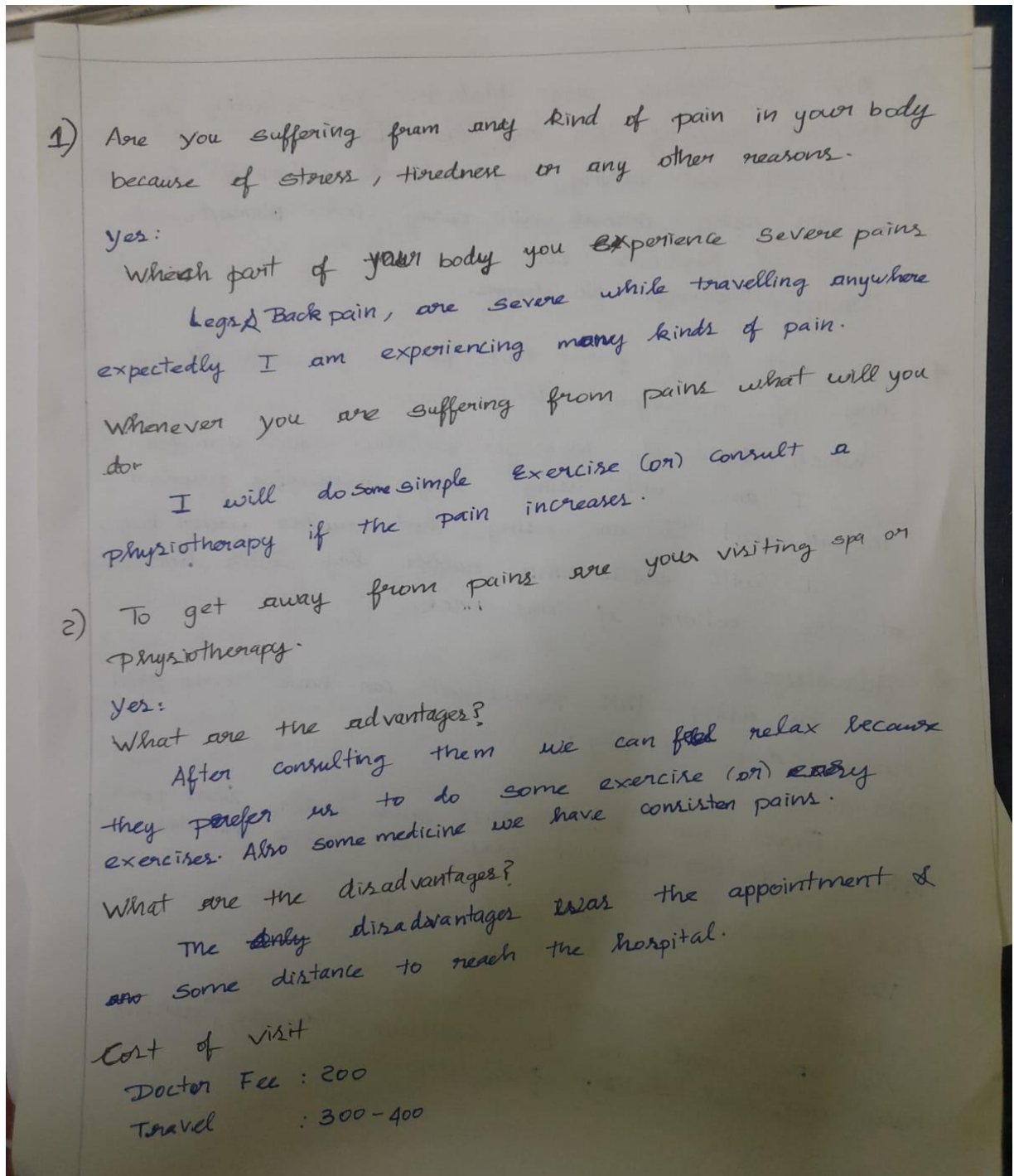


Figure 4.8 Flow Chart

4.2.1 Identification of Need

The survey taken from the several peoples like elderly aged and working professional , as they following different life styles in focusing their works and duties. They are not taking care of their own body, this causes severe pain in their bodies further increase body pain and mental stresses. By finding a way to cure this kind of pains massager is needed but without the help of others it's difficult to solve, former products in the market are manually controlled devices.



1) Are you suffering from any kind of pain in your body because of stress, tiredness or any other reasons.

Yes:

Which part of your body you experience severe pains
Legs & Back pain, are severe while travelling anywhere
expectedly I am experiencing many kinds of pain.
Whenever you are suffering from pains what will you do
I will do some simple Exercise (or) consult a physiotherapy if the pain increases.

2) To get away from pains are you visiting spa or physiotherapy.

Yes:

What are the advantages?
After consulting them we can feel relax because they prefer us to do some exercise (or) easy exercises. Also some medicine we have consistent pains.

What are the disadvantages?
The ~~only~~ disadvantages is the appointment & some distance to reach the hospital.

Cost of visit

Doctor Fee	: 200
Travel	: 300-400

Figure 4.9: Survey Page 1

3) Are you taking any Medicines or visiting the hospital regularly for this pain. [yes]

No, I not taking any internal medicines but I am using normal volini spray, iodox pinmort.

Cost of Medicine : 200

Transport charge: No charges.

4) To get relief from this pains, you are using any of massaging devices:

Which type of Massager product will you use:

I am not using any massaging product instead but I am using hot rubber water bag.

I will settle this rubber bag with hot water at the bottom of my back.

Advantages:

By using this persistent can have some pain relief day by day.

Disadvantages:

First we should Boil some water, then pour into the rubber bag it may take some minutes.

5) For Massaging do you ask help from other:

Yes : Sometimes.

1) what will be your mood while asking help:
As we need to be dependent, because ^{while} asking help we ^{also} need their ^{free} time.

Figure 4.10: Survey Page 2

What will be their mood:

They will do a good massaging but if they have some important work they ~~not~~ will ~~regret~~ refuse to do (or) do for a little bit time.

⑥ Do you feel comfort by their Massage?

Yes: Sometimes.

Which kind of Massage do you prefer for your pain.

* By holding (or) pressing ~~out~~ legs.

* By Pressing Back & shoulders.

⑦ We have decided to construct a device "pain therapist Robot" with our innovative idea & skills. We have planned to ~~construct~~ this device with as a ~~frame~~ ^{using} ~~make~~ ~~product~~ with a affordable budget.

i) What should be the need of our device for your massaging & your expectations.

The device must press (or) hold ~~not~~ the back & shoulder with the adjustable pressure. And it should work with our limited time usage.

⑧ Why you need the Automatic Adjustable massager?

As I have sometimes a little pain & some times have severe pains in my body how can your robot know.

So it should work with the adjustable pressure with our manually control.

Figure 4.11: Survey Page 3

4.2.2 Feasibility Analysis

ASSUMPTION MAPPING

As we gone through assumption mapping with four category

- Known – important
- Unknown –important
- Known – unimportant
- Unknown –unimportant

To Create the model according to the need of the user, the assumption mapping method is used to define the known problems, unknown problems and former prototype problems and what are the benefits that are present in the former products. By this method we can able to understand the problem and new build a design.



Figure 4.12: Assumption Mapping

4.2.3 Simulation

The software used to model a product's design and functionality is called Webots. First, a solid rectangular robotic construction called "robot" is developed. Two more position sensors are then connected to it and are controlled by the programming.

Ps1=robot.getDevice("ls.left") ,

The wheels may be moved without running over any people or objects. The wheel is an independently built hinge joint with four wheels that is part of the robot construction. Each wheel is equipped with an independent rotating motor, which is managed by Python code.

motor1=robot.getDevice('wheel')

motor1.setposition(float('inf')).

The speed of four wheel controlled by motor with the code motor1.setvelocity(2.0)

Then, a three-jointed arm is added and installed in a fixed vertical column. This arm is designated arm 1, and a rotating motor is fixed in it. Arms 2 and 3 are then added, and when arm 3 is combined with the rotational motor, it is capable of moving up to a 90-degree angle.

The comfort massager is fixed to the arm 3 with a distance sensor, which subtracts and regulates the massager in accordance with the patient's practical needs.

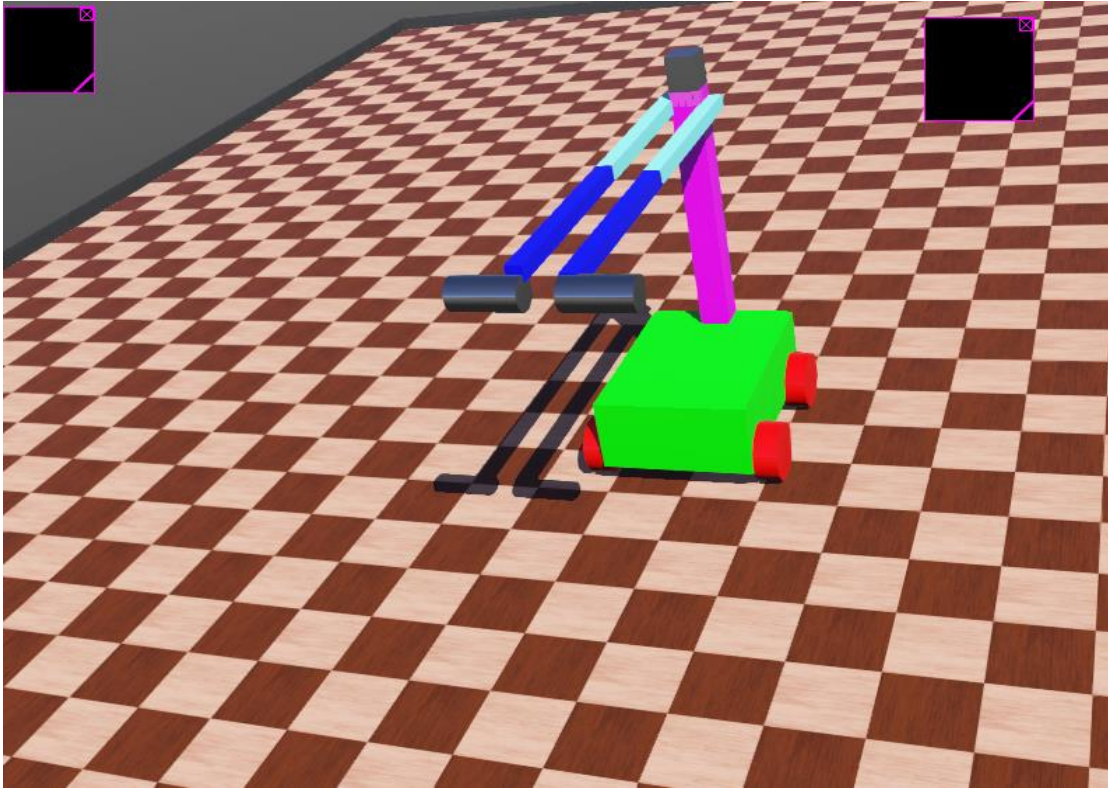


Figure 4.13: Webot Simulation 1

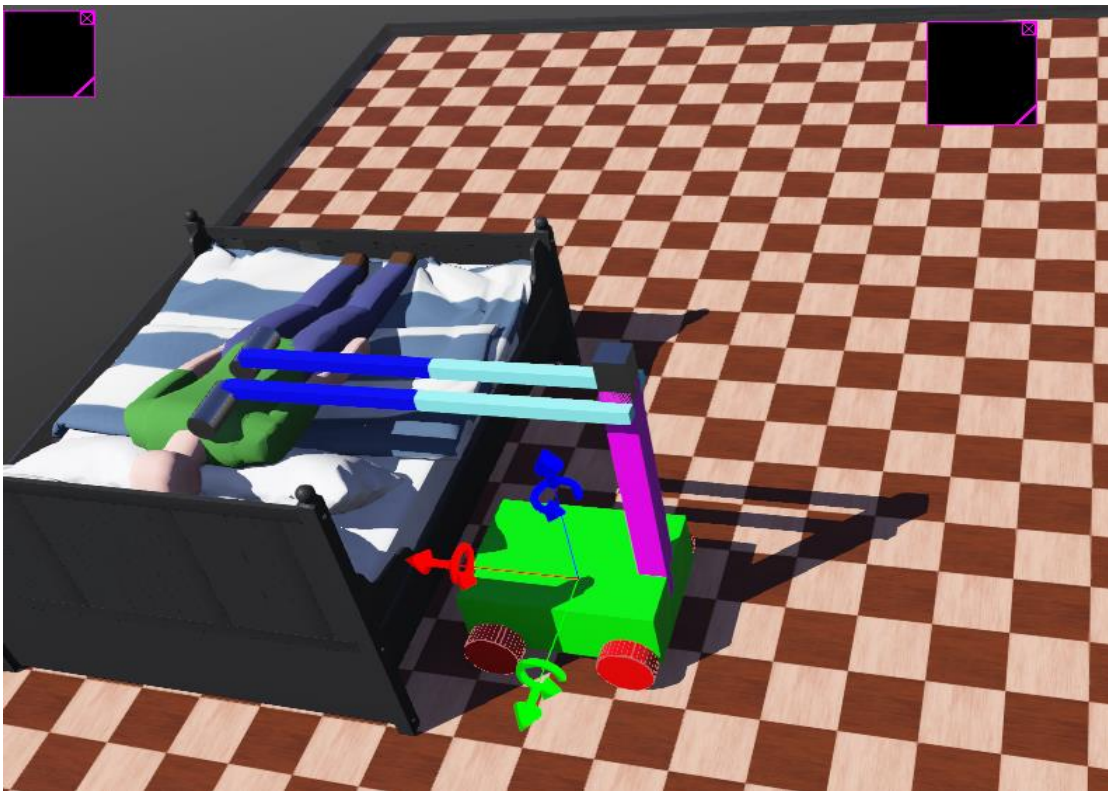


Figure 4.14: Webot Simulation 2

4.2.4 Alternative Designs

The below images represent the former designs of the pain therapist robot. More than eight designs were created using the cad software. Then those designs are created as simple prototypes, further some problems are defined in the product. The rod is unable to bend flexible and it reaches its fracture point very fast. So, the next design is created with more servo motors but due to U shaped design of the frame it's a difficult task to control all the rack and motors simultaneously. This may cause some problems in the user body if there is any change in the movement of motors. So finally, by dividing the rod it is easier to move forward and backward for the rod and with the up and down positions the prototype obtains a better effect in the user body.

Design 1

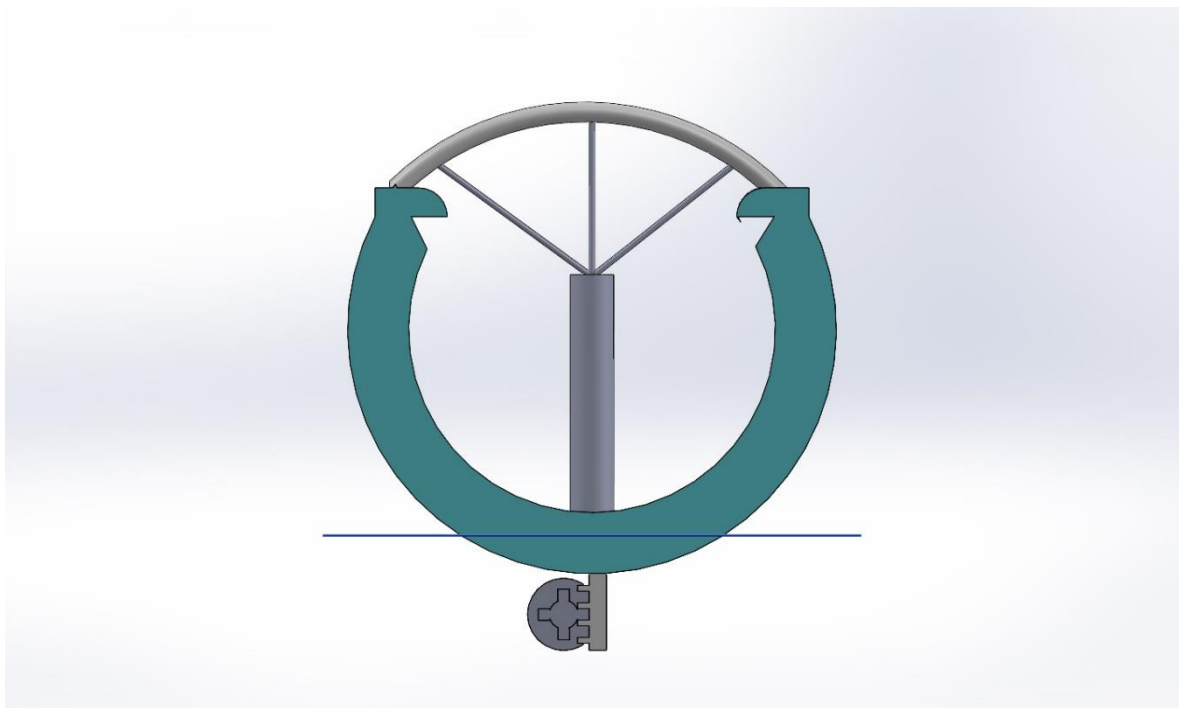


Figure 4.15: Front View

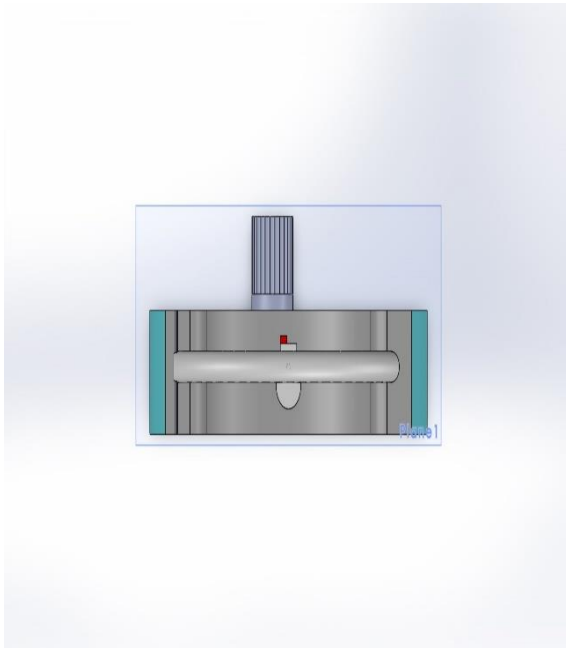


Figure 4.16: Top View

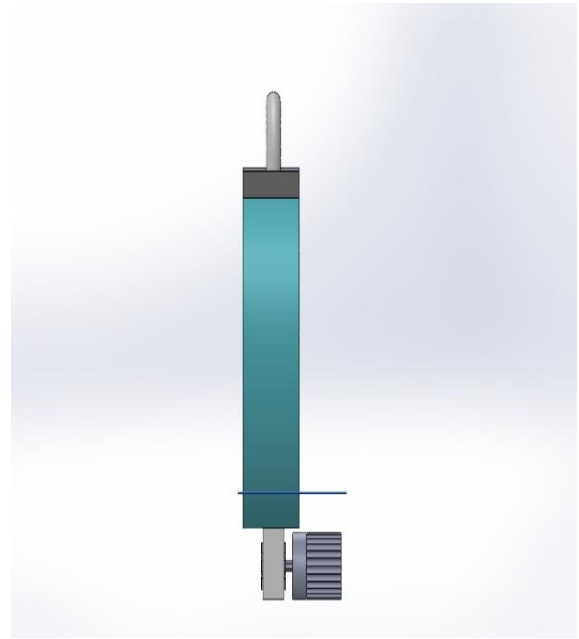


Figure 4.17: Side View

Design 2

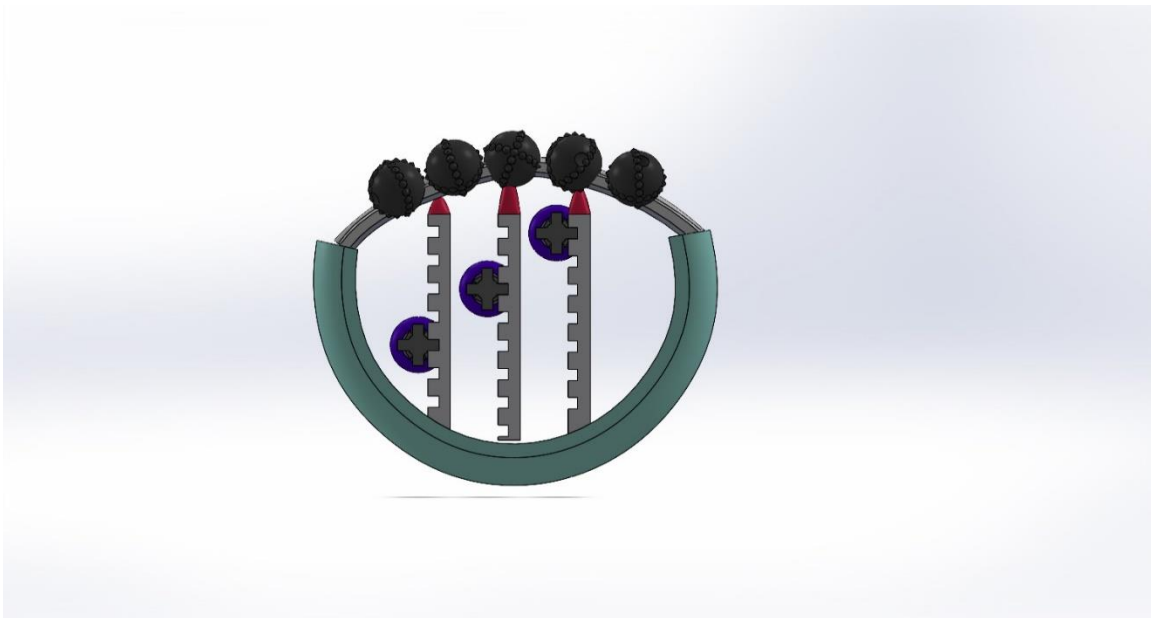


Figure 4.18: Front View

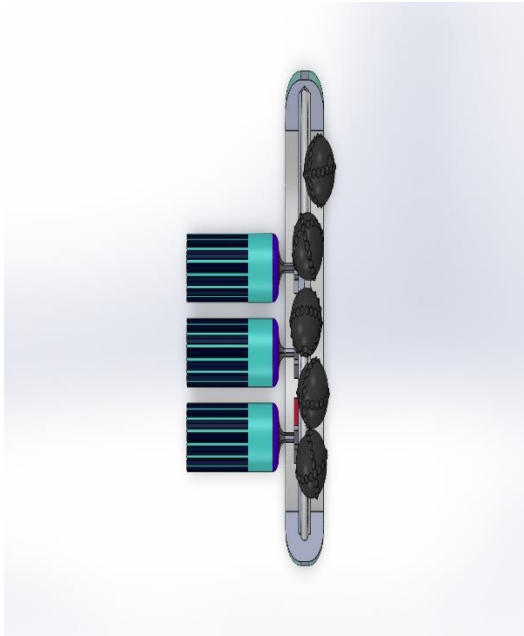


Figure 4.19: Top View

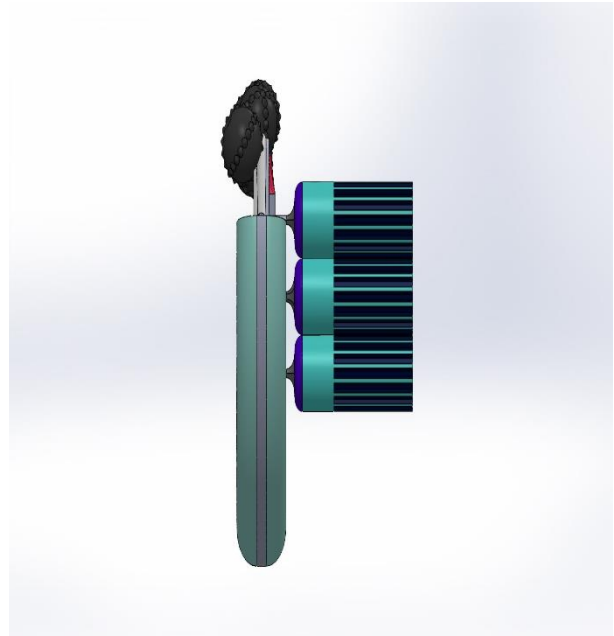


Figure 4.20: Side View

Design 3

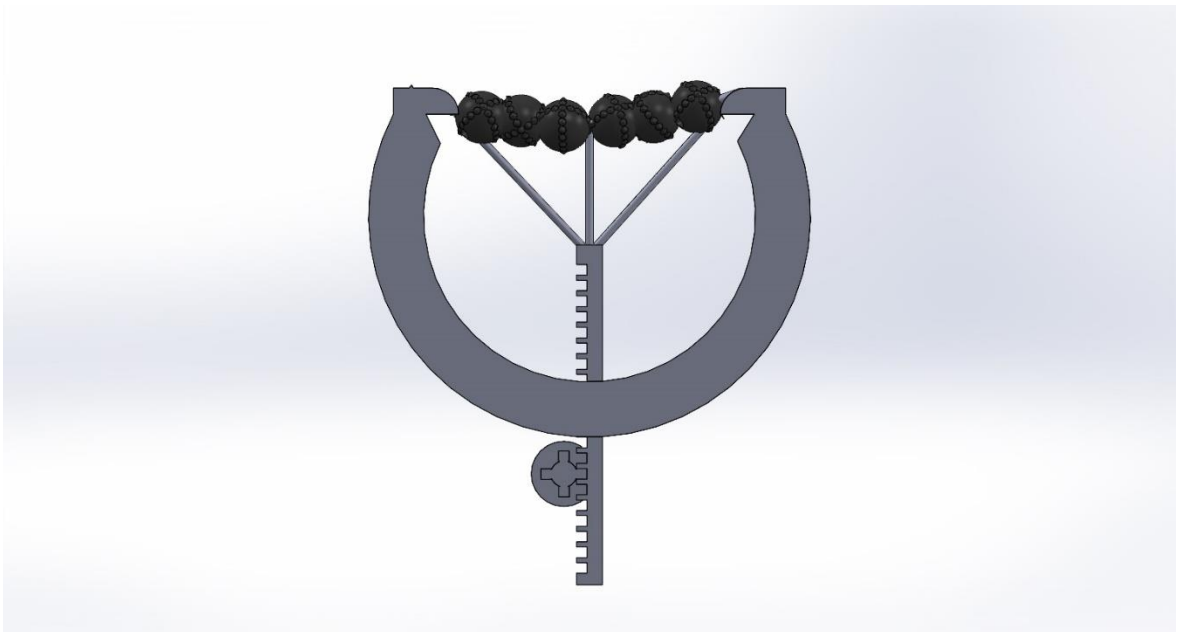


Figure 4.21: Front View

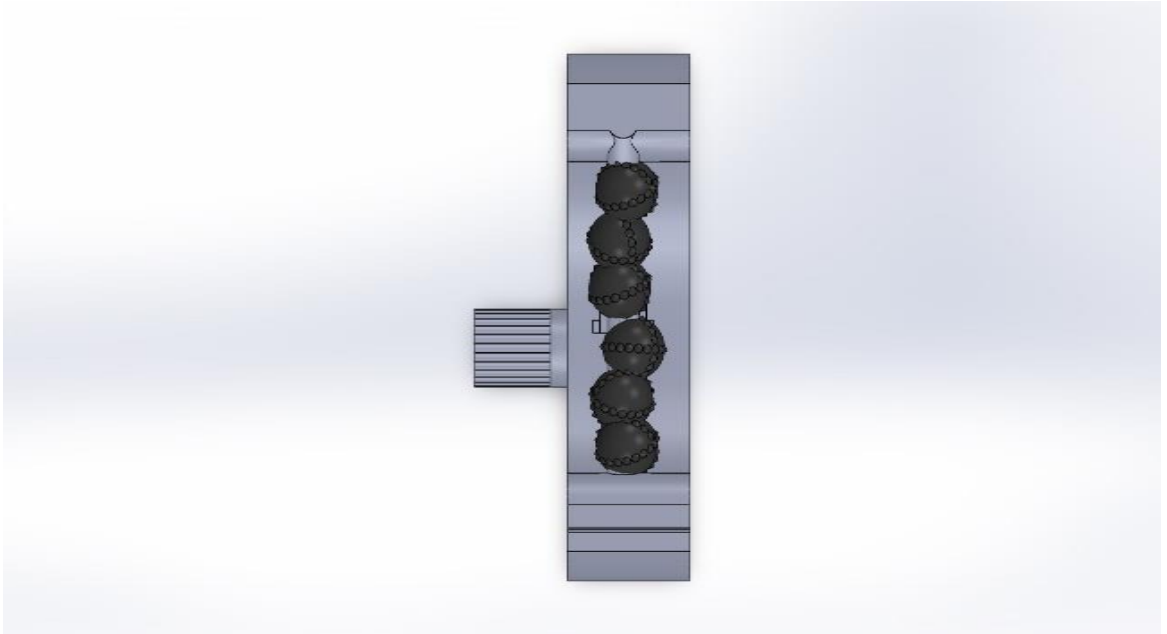


Figure 4.22: Top View

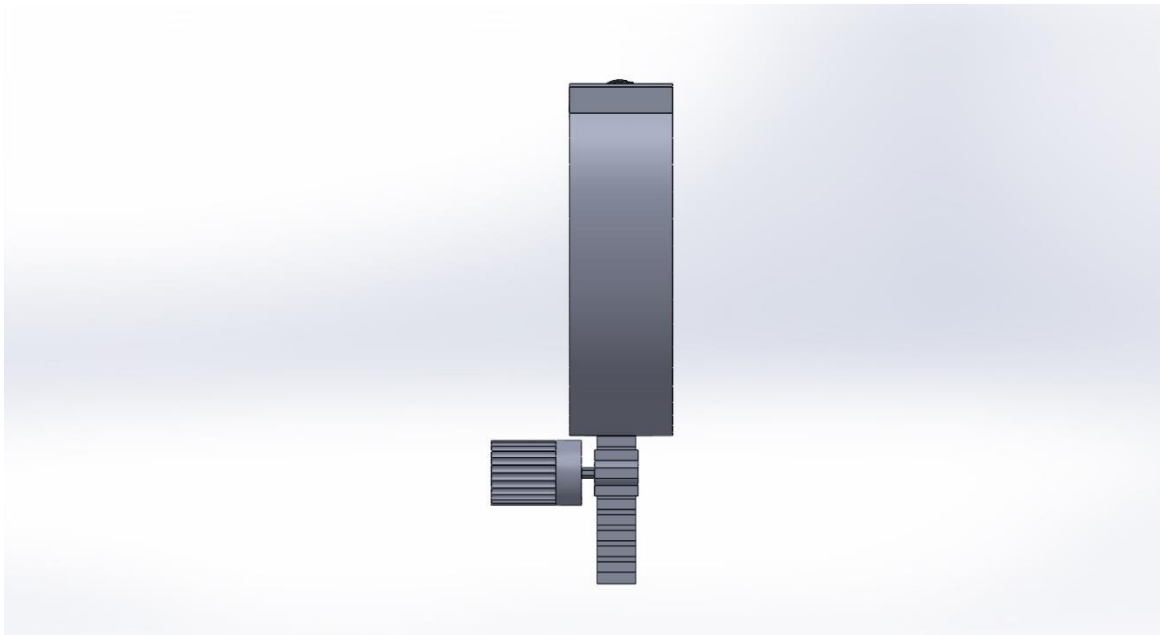


Figure 4.23: Side View

4.2.5 Finalized Design

The Final design of the Pain Therapist robot is done by the innovation of the part design components. The former design is are improved a lot to solve the various problems. The final design is created with the required dimensions and the simulation is performed in the solidworks software.

For final design of pain therapy robot, three to four designs were sketched out on paper with approximate dimensions. One design that felt comfortable and compact in size was chosen, and some more functions were added to it. The concept has now been accurately modelled in solid Works with four wheels, two distance sensors, a rotatory motor, a vertical column that is four feet tall, and a jointed arm with a horizontal axis.

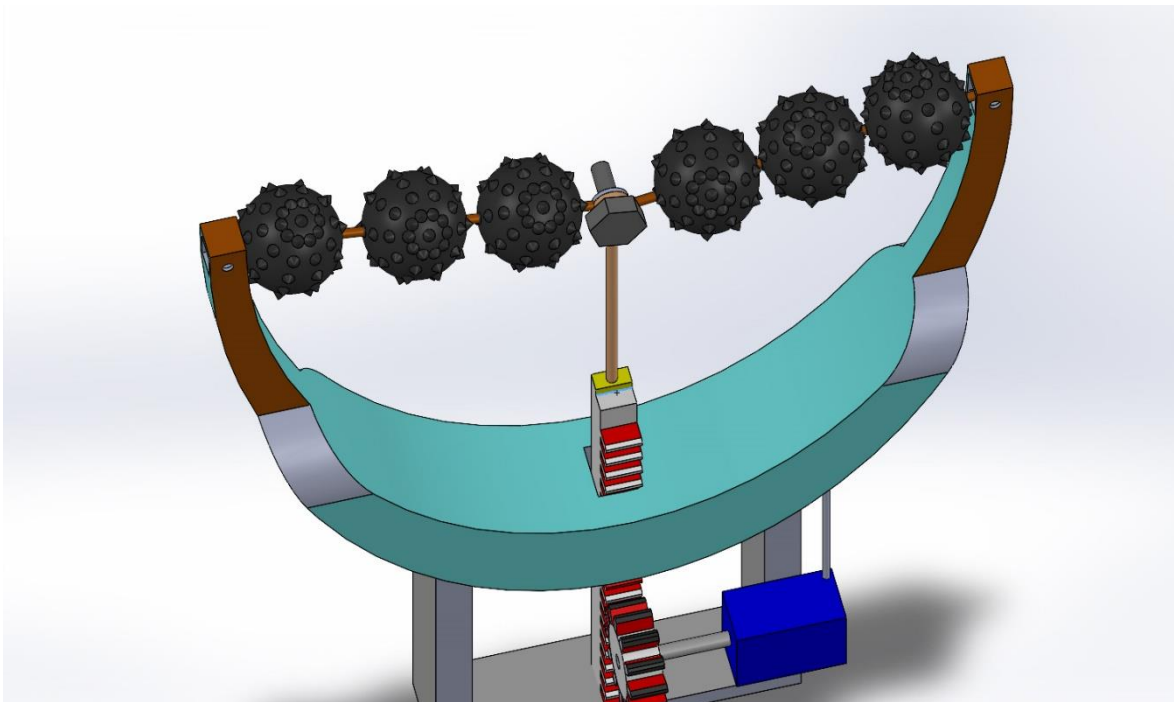


Figure 4.24: Design

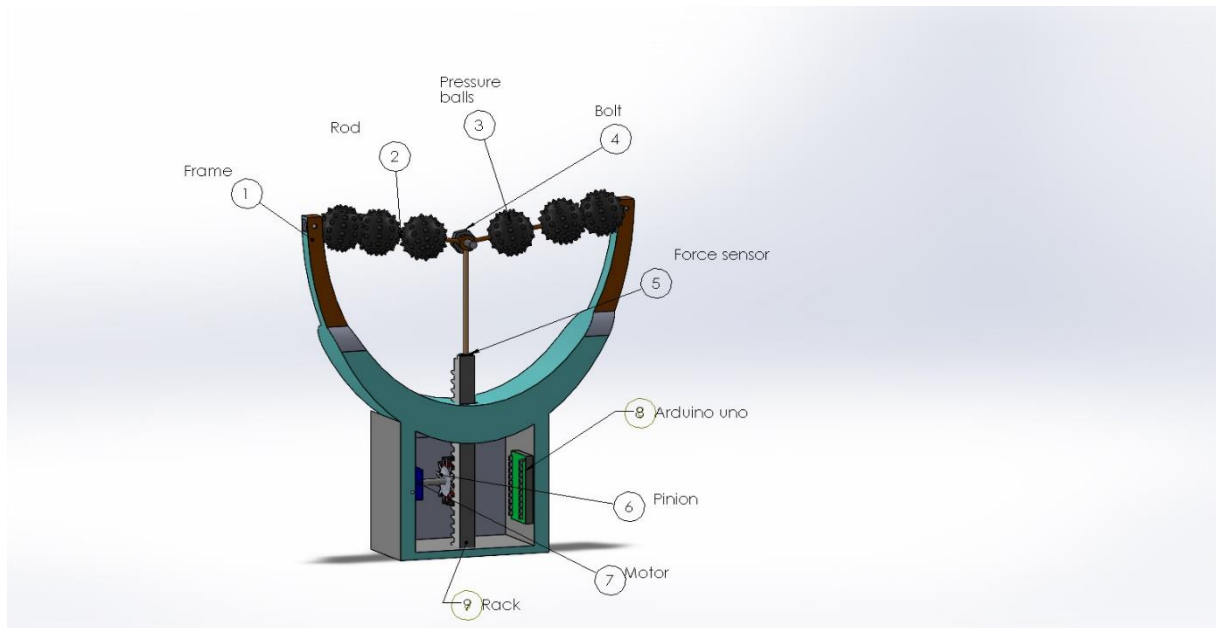


Figure 4.25: Design Components

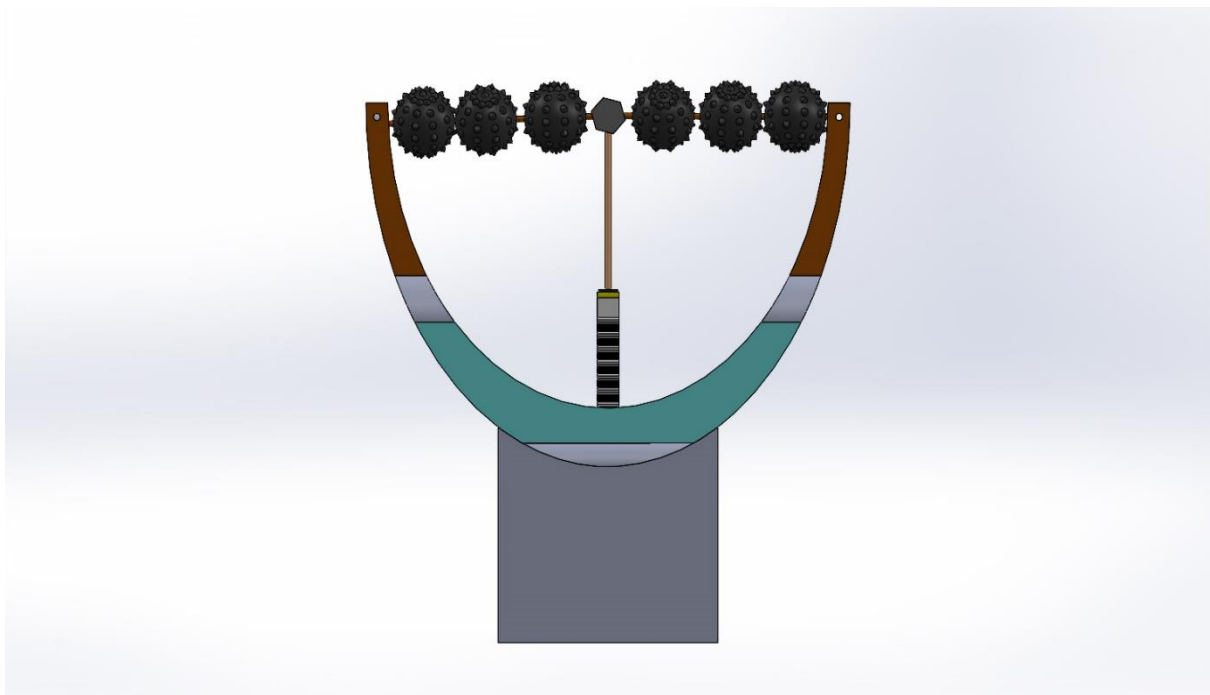


Figure 4.26: Design Front

4.2.6 Experimental Setup

3D PRINTED PARTS:

The final design is 3d printed using the PLA material and assembled to do the function.

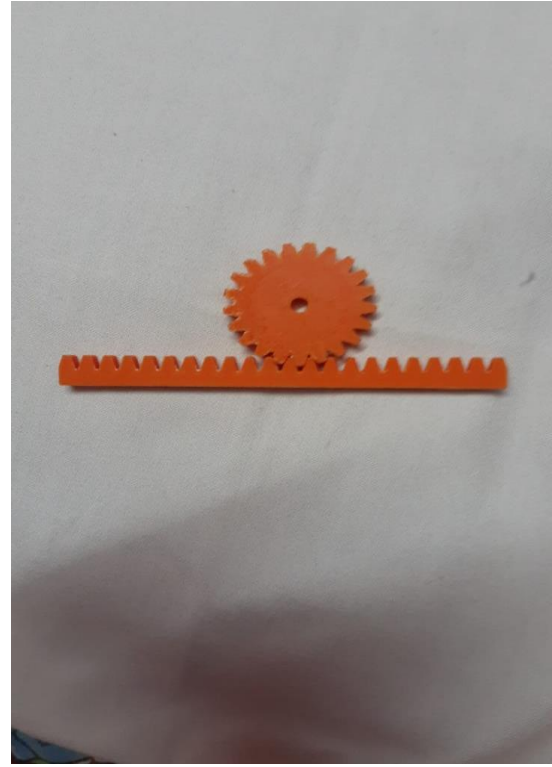


Figure 4.27: 3D Printed PLA Parts

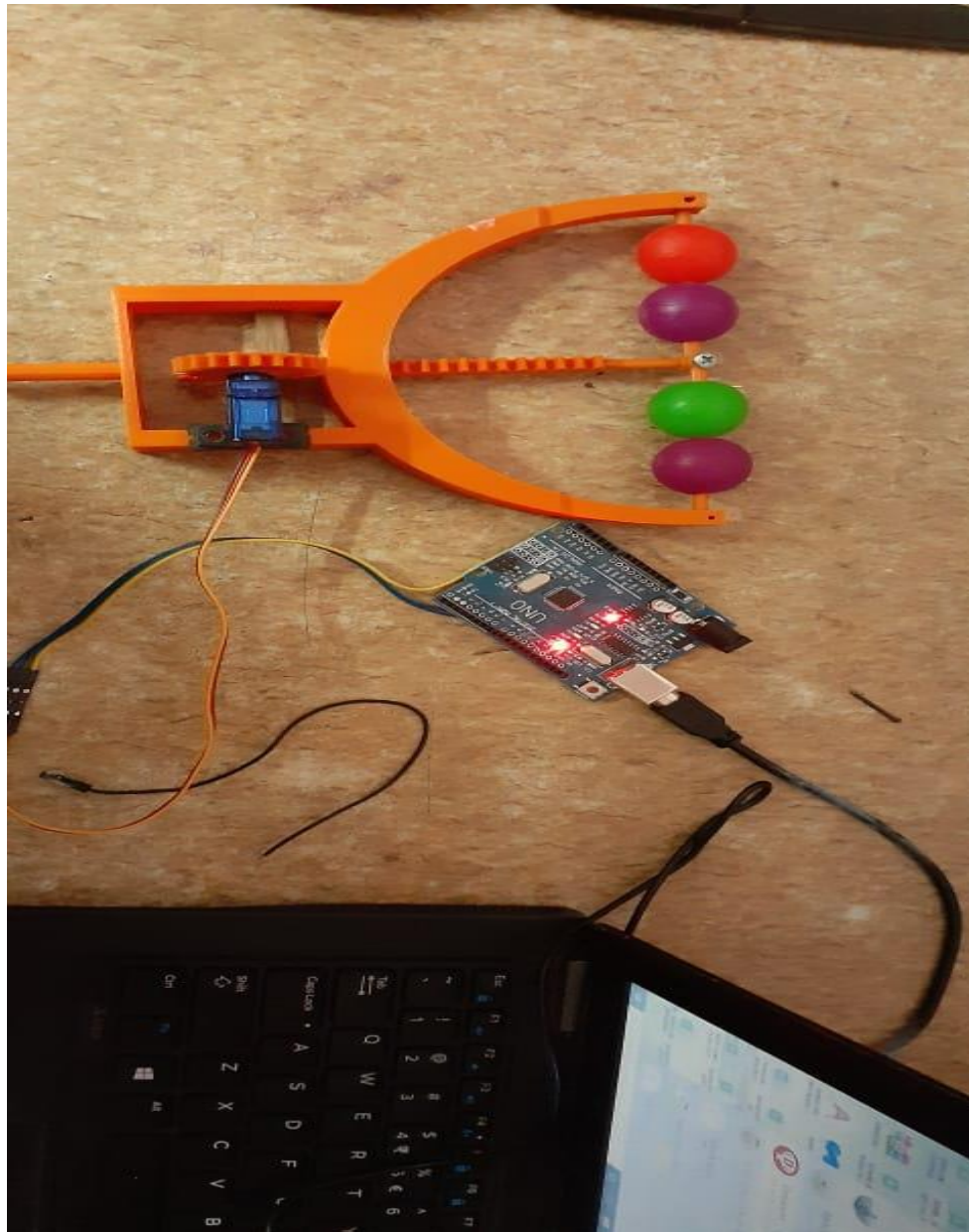


Figure 4.28: Functioning of Prototype Integrated with Arduino

The design is created, and the simulation is performed in the software with the rack and pinion mechanism. But to check the proper working of the design it is created as 3d printed PLA material. The below image shows the different components like frame, rod, rack and pinion which are assembled to do the functioning operations.

CHAPTER 5

CONCLUSION

The Final model is created with the process of finding the problem statement, building the assumption mapping, and finding the real problems in the presented prototype and prototype making. By creating a lot of questions from the method of assumption mapping, the survey is taken to the elderly peoples, working professional. By that we conclude the idea what kind of problems they are facing and how they are getting away from their pains. So, by studying the former products which result in no automatic working and building this product as automation with low-cost. The primary aim of the model is to give good comfort while using, weightless and less cost. The objective of the project is mainly focused on the end effector of the robotic arm, so a lot of design is created until it solves a lack of problems. Finally, 3d printed Pla material is made to process the working of the design. The 3d printed pla material is fixed at the end effector of the robotic arm then it is used and by using the given program it can function with the user requirement. The prototype can be used as good massaging device when it is used. The motive of the device is to give a good massing effect to the elderly people while using the product. The design and model are built with a good comfort for the users. Automation plays a vital role when robotic arm and the 3d model are joined together.

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