This book aims to design and construct a new Delta Robot that makes improvements over several previous designs. This thesis involves the design, Modeling, Construction, and Dynamic Analysis of robots. In the thesis, we can design and develop models using design software, mechanical simulation software and construct through new technology like 3D printing. We can also use traditional manufacturing operations like marching, drilling, etc.

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Design, Modeling, Dynamic Analysis, and Construction of 3 DOF Robot

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Abstract

This book aims to design and construct a new Delta Robot that makes improvements over several previous designs. This thesis involves the design, Modeling, Construction, and Dynamic Analysis of robots. In the thesis, we can design and develop model using design software, mechanical simulation software and construct through new technology like 3D printing. We can also use traditional manufacturing operations like marching, drilling, etc.

Table of Contents

Chapter 1: Introduction

1.1 Introduction of Robotics–

Today's robots can be used in various industrial settings, where humans are not always available. They can also perform tasks that require special skills or knowledge, such as bomb detection and environmental monitoring.

1.2 Introduction to Automation –

- ❖ Ford introduced mass production lines in 1905. Specialized machines were also used to make high-volume parts.
- ❖ High custom machines were designed for manufacturing for maximum volume production of mechanical and electrical parts.
- ❖ When a production cycle ends and new elements are brought, manufacturing machines need to be shut down and the hardware retooled.
- ❖ Since periodic modification of the manufacturing hardware is needed, this type of automation is called Hard Automation.
- ❖ When used with programmable mechanical structures, new additives can be made without programming the machine. This type of automation is called Soft Automation

1.3 Use of the word Robot –

- ❖ The word robota was first used in 1921 by Karel Capek.
- ❖ The depiction of robots in fictional technology fiction movies is to date from reality to make them appear primitive.

1.4 Industrial Robots –

Material handling, plasma Arc cutting, Spot, Seam, or Resistant welding are all performed effectively via the six axes Panasonic VR-120HII. This excessive overall Performance robotic is managed to utilize the easy to use Panasonic robot controller

Fig 1- MIG Welding Robot

The VR-5 AII from Panasonic is a slim-design robot that fits in tight work areas. It features a self-inflating surface that allows it to perform various tasks efficiently.

1.5 Automation and Robotics-

- A robot is a programmable multi-purpose device that can move various parts and materials through a series of controlled movements.
- A robot is a device that uses sensors to control its end-effectors by moving objects in a physical space.
- The robot is an Autonomous device that uses sensors and actuators to control its quit-effectors by transferring objects in a physical space.

- ❖ Contrary to popular notions, today's industrial robots are anthropomorphic and do not have Androids.

1.6 Industrial Robot – History

- ❖ The Unimate was the first industrial robot. George Devol developed it in 1954.
- ❖ In 1961, Eagleburger established Unimation, a company in Danbury, Connecticut, to develop the robotic industry he created.

The first industrial robot produced by Unimation was installed in General Motors, the USA, in 1961**.**

1.7 The Robotics trends and the prospects –

- ❖ Industry 4.0 refers to the continuous evolution of manufacturing technology, which includes the Internet of things and cognitive computing

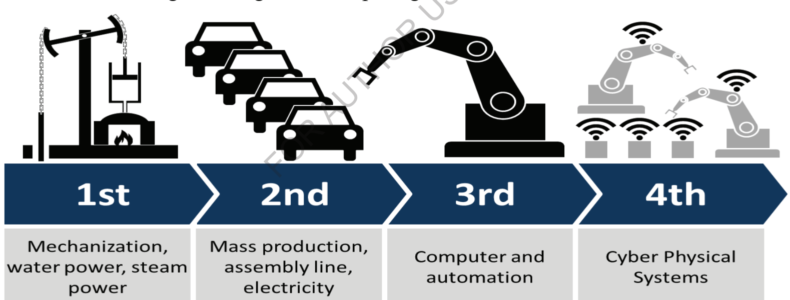

Fig 2- Industrial Revolution

- ❖ First Generation Robots
  - ❖ Repeating
  - ❖ Non-servo, Pick and Place
- ❖ Second Generation Robots
  - ❖ Use of Sensing devices
  - ❖ Response to sensory feedback

- ❖ Third Generation Robots
    - ❖ Artificial intelligence
    - ❖ Self-learning
    - ❖ Conclusion drawing from past experiences
- ❖ Fourth Generation Robots
    - ❖ May Be an android or a Biological Robot

1.8 The Robotics trends and the prospects -

- ❖ Public Security / Military
- ❖ Healthcare
- ❖ Coworkers
- ❖ Robots at Home
- ❖ Robots in Education
- ❖ Entertainment

Chapter 2
Design of Robot

2.1 History of Design of Delta Robot:

The Delta Robot was developed by way of Reymond Clavel in 1985. As shown in Figure 5, the original Delta Robot has three rotary input axes. Three palms stick to a few decreased hands that consist of parallel bars, every forming a parallelogram. This parallelogram restrained the movement of the end effector to a few translational steps of freedom. The Delta robot changed into, in general, invented as a privileged and regional system to move around candies from the conveyor belt to their packaging.

Fig 3- Clavel's Delta Robot

Recently with the appearance of 3-d printing, the Delta Robot has been revisited. Its layout excels at this undertaking due to its three translational levels of freedom and its pace. Hobbyists and engineers have developed many extraordinary designs for the Delta Robot for three-D printing. Most importantly, the usage of linear inputs pushed via way of timing belts alternatively of rotational inputs. Figure 6 demonstrates how they give up the effector of the linear enter Delta Robot moves with 3 translational degrees of freedom due to three linear inputs driving carriages with round or often occurring joints connecting parallel rods to the end effector. The linear enter Delta Robot has to turn out to be a commonplace choice at the same time as buying a three-D printer

Fig 4- Linear Input Delta Robot

The Delta Robot belongs to a collection referred to as parallel robots that use multiple links connected to the give-up effector if you want to move. In most instances, most cars used to parallel robots are set up to the stationary body of the robot and do not
move. Parallel robots excel at select and region operations where the pace is crucial. The first Delta Robot became used to move coco from a conveyor belt to their packaging site, and nowadays, parallel robots are used for comparable responsibilities like Pick and place jobs.

Robots that are not parallel are known as serial robots. Serial robots have the best link connected to the cease effector, and the automobiles are often attached to the robot's dynamic parts. The traditional robot arm is an instance of a serial robot, as proven in Figure 7.
Other serial robots include the conventional 3-D printer, which consists of a transferring gantry with two ranges of freedom and a construct plate with one degree of freedom, as proven in Figure 8.

Fig 5-Robotic Arm

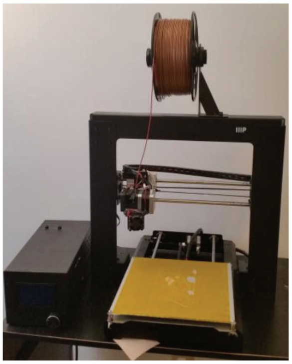

Fig 6 - Cartesian co-ordinates 3D Printer

The motive of this thesis is the design and construction of a Delta Robot, which makes improvements over present designs. In this thesis, we have used a new control technique with the Adriano board to control the motion of the delta robot. Adriano is very cheap as compared to other controllers.

2D sheets of the Delta Robot Part Created in Solid works Design software. In this design Part, the robot can be classified into two parts like Structure body and moveable body. In the structure body, we have seven layers of Plates like Top plate, Middle Plate, base plate, and pillar of the robot. In the movable body part, we have arm links, effectors.

2.2 Delta Robot Design

Inspired by the above designs, we have designed a prototype of the delta robot one. It follows the law of parallelogram.

It has three degrees of freedom as it moves in the X, Y, and Z directions. It is designed as a Kit. The layer system of the robot and a clickable mechanical solution makes the assembly fast and easy. We have inserted different layers above the workspace of the robot to insert several electronic components into it. Designs of different layers are listed below: -

2.2.1. Base layer: - it is the base layer of the robot above the workspace. All the layers are mounted on it. Different cuts have been made in the layer. Side cuts connect links with the motor to attain flexible movement, holes for fixing pillars, and several layers with screws.

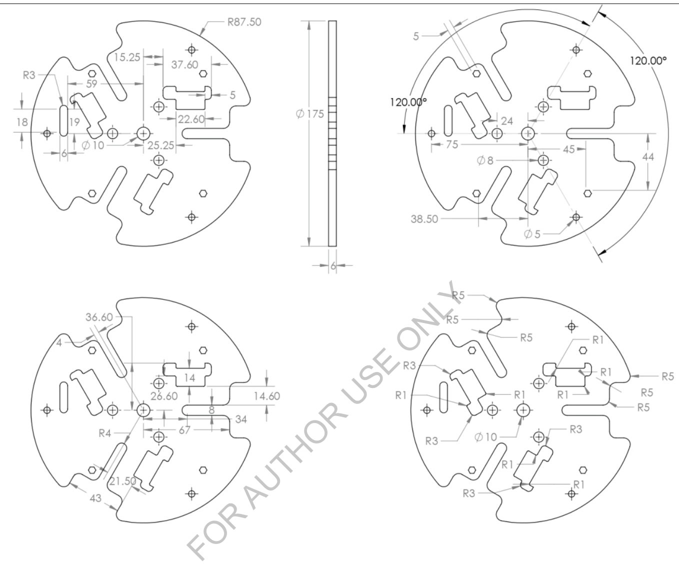

Fig 7 – 2D sheet Diagram of the base layer

2.2.2. Servo layers 1 & 2: It is placed above the base layer, servo motors are mounted on the three cutouts in it.

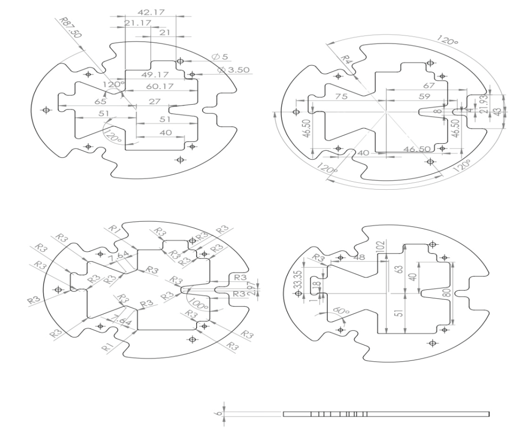

Fig 8 - 2D sheet Diagram of Servo Layer

2.2.3. Middle layer 1: it is placed above the servo layer. It provides the gaps to link the connections of servo motors to PCB.

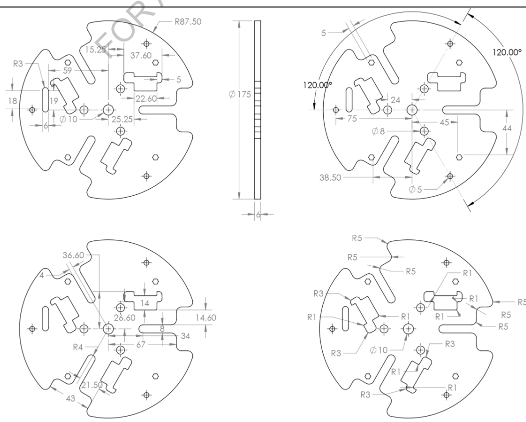

Fig 9 - 2D sheet Diagram of Middle layer 1

2.2 4. Middle layer 2: it is placed above middle layer 1, and extrude cuts are provided for wires and PCB.

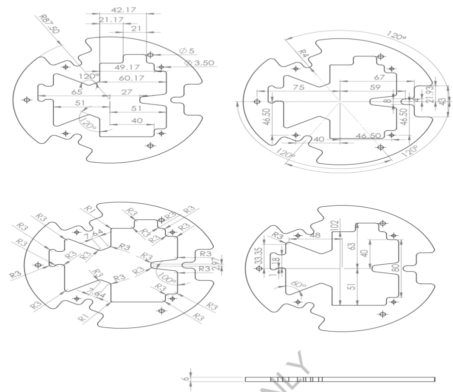

Fig 10 – 2D sheet Diagram of Middle layer 2

2.2.5. PCB layers 1, 2, 3: these layers are placed above the middle layer 2. In these layers, PCB is placed.

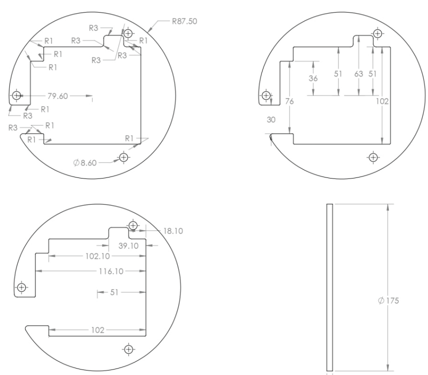

Fig 11 – 2D sheet Diagram of PCB layer 1

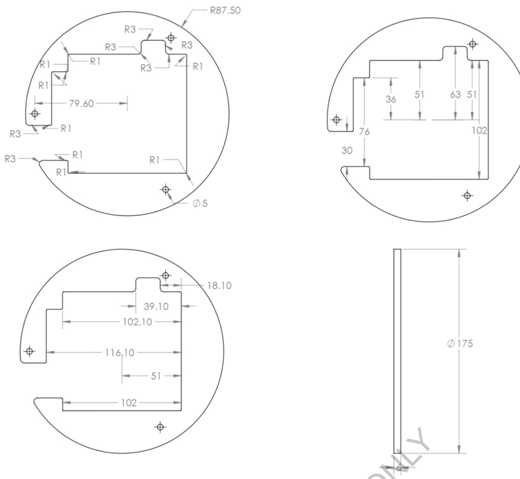

Fig 12 - 2D sheet Diagram of PCB layer 2

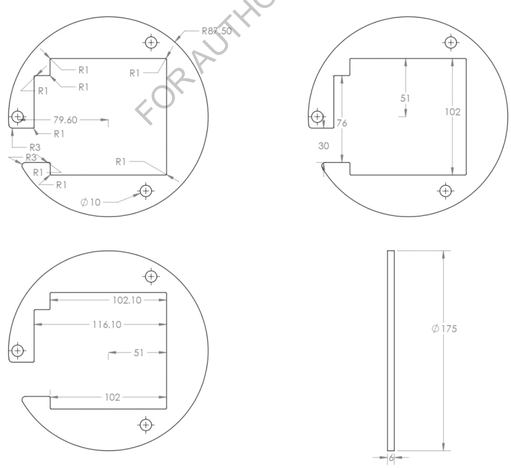

Fig 13 - 2D sheet Diagram of PCB layer 3

2.2.6. Top layer: it is placed above the PCB layer 3. It is the top layer of the base of the robot. Groove and holes have been given for LED display and control switches.

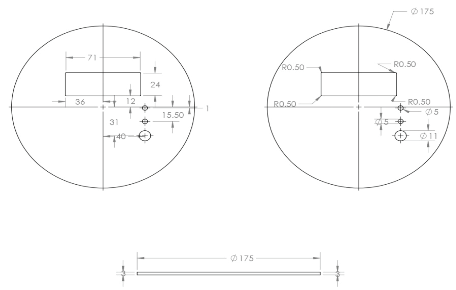

Fig 14 - 2D sheet Diagram of Top Layer

2.2.7. Place layer: it is placed below the workspace of the robot. It is attached to the base layer via pillars. It is the main platform where the picking and placing of the object take place.

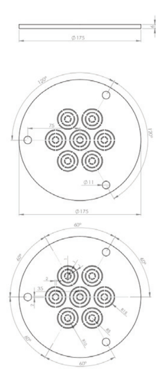

Fig 15 – 2D sheet Diagram of Place layer

2.3 Kinematics Part

The mechanic parts of the robot are split into two categories like 3D-printing parts and metal parts. The 3D printing parts consist of effector, effector links, and servo links. These three parts together form a link mechanism. These three parts move relative to each other in 3 directions, i.e., X, Y, and Z-axis. The metal parts consist of screws that connect all the layers. Designs of different 3D printing parts are listed below: -

2.3.1 Effector: it is the base of the link mechanism. It is connected with the electromagnet, which picks and places the object. Effector links are connected to the effector.

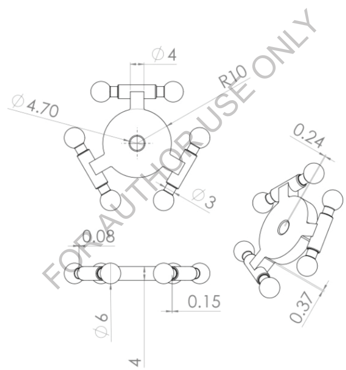

Fig 16 – 2D sheet Diagram of Effector

2.3.2 Effector links: these are the arms of the link mechanism. It connects the servo links to the effector. It helps in transmitting the motion.

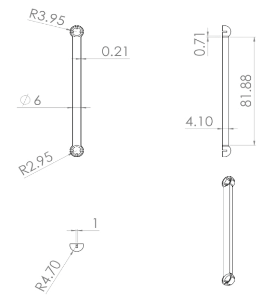

Fig17 – 2D sheet Diagram of Effector links

2.3.3 Servo links: these are connected to the servo motors. It connects the motors to the effector links and transmits rotary motion to linear motion.

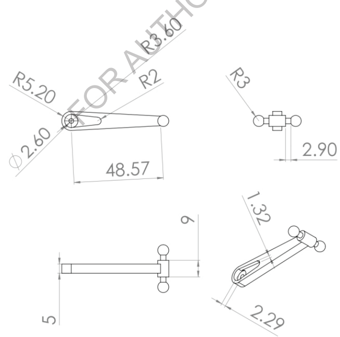

Fig 18 – 2D sheet Diagram of Servo Links

2.4 Pillars:

it is the link between the base layer and the place layer. It's the support of the robot.

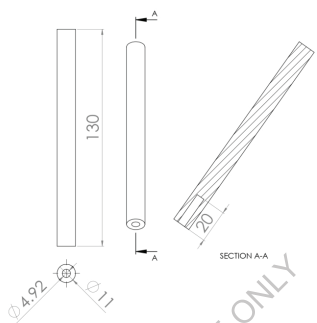

Fig 19 – 2D sheet Diagram of Pillars

After completing the Design of the Delta Robot, we can identify some results of design based on mechanical constraints. In this part of the Simulation, we can Simulation software like ANSYS 21.0. we can identify structure results like total deformation of the structure, Maximum and Minimum Principle Stresses of Structure, Maximum Shear Stress, Strain Energy of Structure Etc.

2.5 Material Details of Delta Robot:

In Simulation, we can use an acrylic Plastic Sheet for Upper body material.

PROPERTY	METRIC	UNITS
Density	1.397e3 - 1.432e3	kg/m^3
Yield Strength	2.861e7 - 7.248e7	Pascal
Tensile Strength	6e7 - 8.96e7	Pascal
Elongation	0.11 – 0.75	Percentage of strain

Hardness	1.431e8 - 2.438e8	Pascal
Fracture Toughness	1.711e6 - 4.12e6	pascal/m^0.5
Young's Modulus	2.51e9 – 5.01e9	Pascal
Max Service Temperature	76.92 - 96.98	°Celsius
Melting Temperature	160 - 184	°Celsius
Insulator or Conductor	Insulator	J/kg °C
Specific Heat Capability	1.346e3 - 1.433e3	strain/°C
Thermal Expansion Coefficient	7.577e5 - 2.021e4	/°C

Table 1: **Acrylic Material Properties**

And Links are made by **Acrylonitrile Butadiene Styrene** (ABS) through the 3D printing process.

PROPERTY	**METRIC**	**UNITS**
Density	1.011e3 - 1.21e3	kg/m^3
Yield Strength	1.85e7 - 5.1e7	Pascal
Tensile Strength	2.76e7 - 5.52e7	Pascal
Elongation	0.015 – 1	% strain
Hardness	5.491e8 – 1.51e8	Pascal
Fracture Toughness	1.191e6 – 4.291e6	Pascal/m^0.5
Young's Modulus	1.129e9 – 2.91e9	Pascal
Max Service Temperature	61.90 - 76.94	°C
Insulator or Conductor	Insulator	J/kg °C
Specific Heat Capability	1.366e3 - 1.921e3	strain/°C
Thermal Expansion Coefficient	8.467e5 - 2.344e4	

Table 2: **Acrylonitrile Butadiene Styrene (ABS) Properties**

2.6 Meshing of Delta Robot:

The ANSYS is based on FEM (Finite element analysis). We just find exact or accurate simulation analysis of the Delta robot. In this method, we create a course element of the delta robot.

Meshing is an essential part of computer-aided engineering (CAE). The mesh impacts the exact, convergent, and velocity of the answer. Furthermore, the time it takes to create a mesh version is mostly a significant part of the time it takes to get outcomes from a CAE solution.

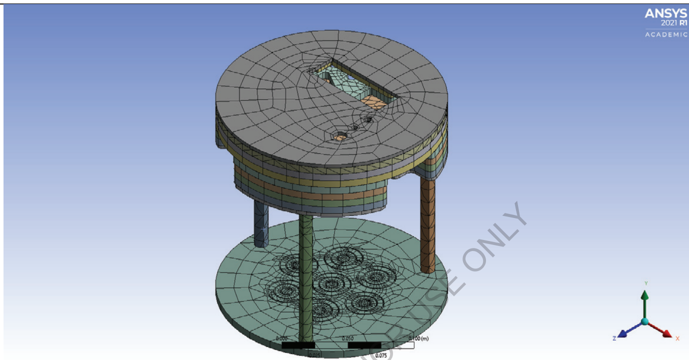

Fig 20: Meshing of delta Robot in Ansys 2021

2.7 Static Structure:

In this part, we just put Constraints on Delta Robot like applying Load, Moment, and support conditions.

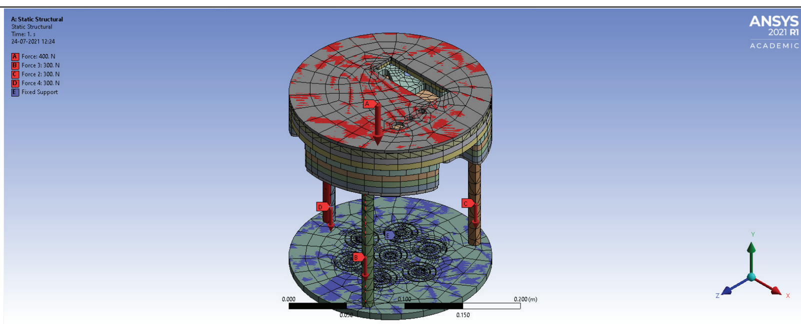

Fig 21: Static Loading Condition

2.8 Solutions of Delta Robot:

In Ansys, we apply mechanical conditions like total deformation, Equivalent Elastic Strain, Maximum Principal Elastic strain, Equivalent von-misses Strain, Maximum Principal Stress, Minimum Principal Stress.

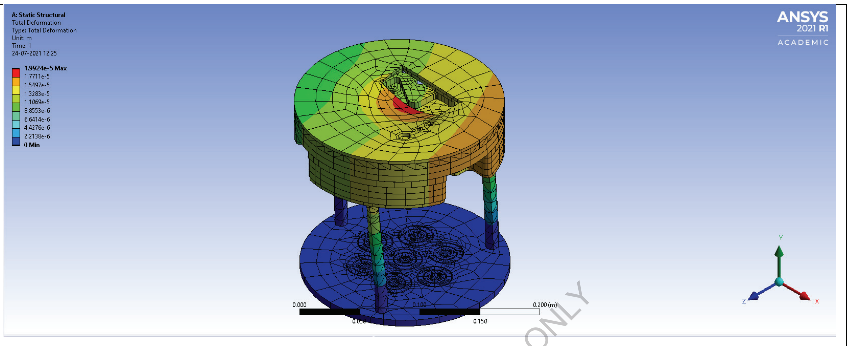

Fig 22: Total Deformation of Delta Robot.

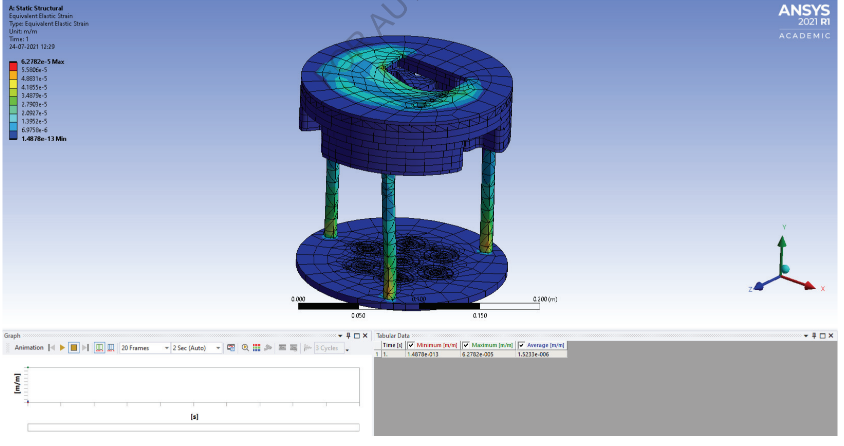

Fig 23: Equivalent Elastic Strain of Delta Robot

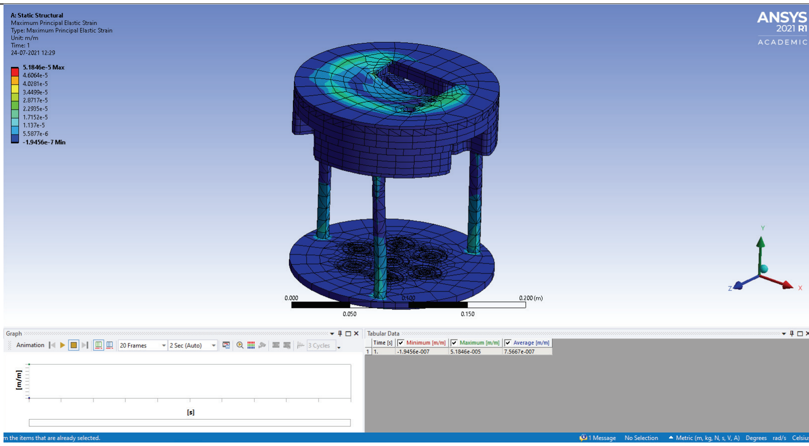

Fig 24: Minimum Principal Elastic Strain of Delta Robot

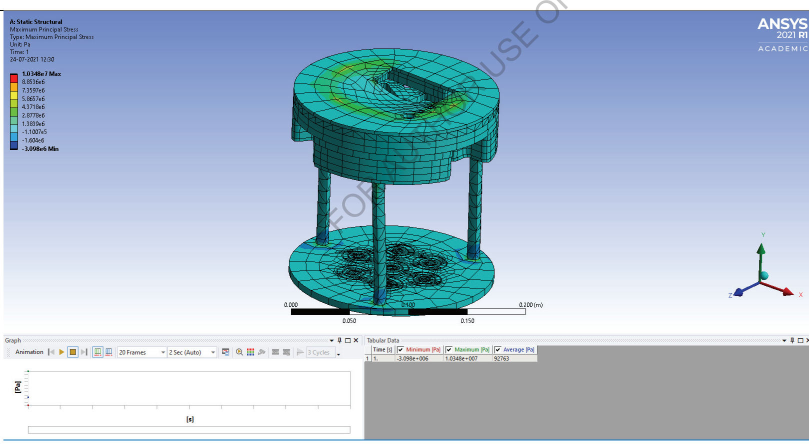

Fig 25: Maximum Principal Stress of Delta Robot

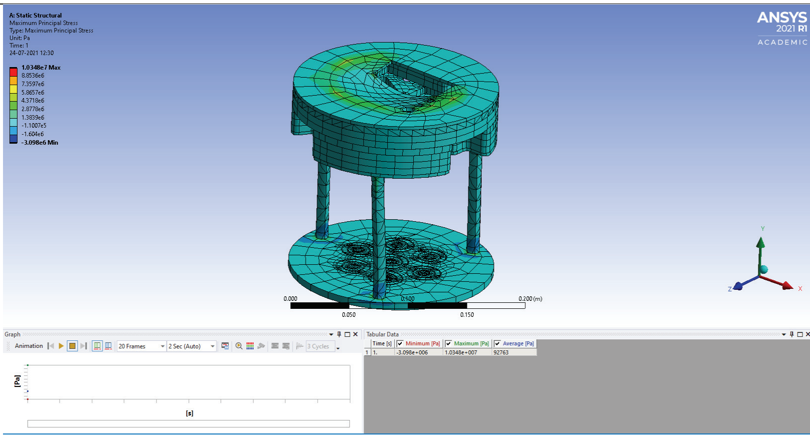

Fig 26- Maximum Principal Stress

Chapter - 3

Manufacturing of delta robot

The robot will be designed and manufactured with less expense in mind, as this project aims to achieve good quality working performance at a low cost.

3.1 The manufacturing of the delta one robot is carried out in three ways:

1. The various layers of the delta one robot, such as the top layer, base layer, etc., are manufactured with the help of an acrylic sheet.
2. The other small parts, such as the effector, effector link, servo link, etc., are manufactured with the help of 3D printing.
3. The supporting pillars between workspace and base layers are manufactured by wood with the help of a lathe machine

3.2 Manufacturing of various layers by acrylic sheet

Acrylic is a transparent plastic that has superior strength, stiffness, and optical transparency. It is easy to fabricate and is compatible with various solvents.

Acrylic sheet exhibits the qualities of glass but at half the weight. However, it has the impact resistance of glass.

Fig 27: various layers by acrylic sheet

All layers are manufactured using an acrylic sheet of thickness 5mm; the acrylic sheet is cut into a round shape of diameter 175mm with the help of a glass cutter. There are three holes in the layer, which are cut with the help of a drill machine. The manufactured layers are listed below: -

Fig 28: base layer

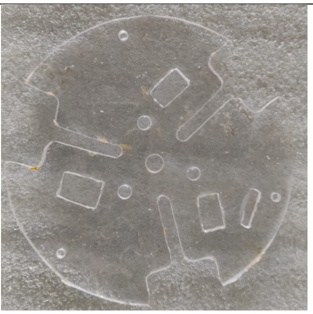

Fig 29: servo layer 1

Fig 30: servo layer 2

Fig 31: the middle layer

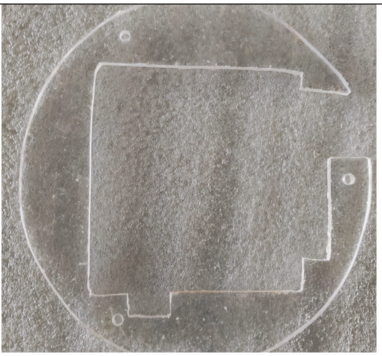

Fig 32: PCB layer 1

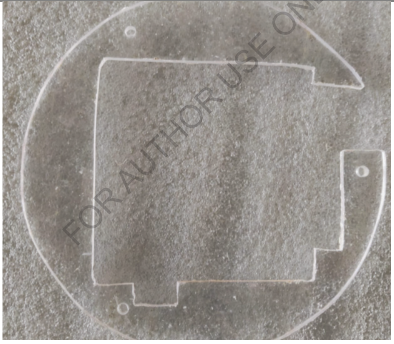

Fig 34: PCB layer 2

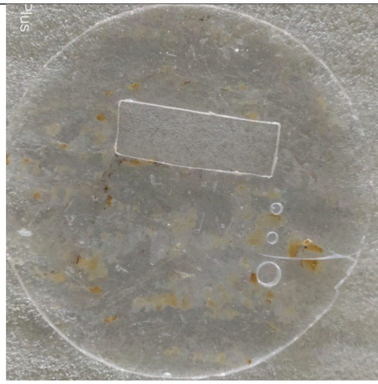

Fig 35: Top layer

Fig 36: PCB layer 3

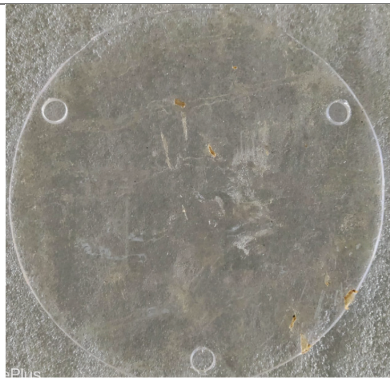

Fig 37: Place layer

3.3 Manufacturing of effectors, effectors link, or servo link by 3D printing

3D printing is when physical objects are made from a three-dimensional digital model by laying down many thin layers of material in succession.

The material we used for 3D printing ABS filament, which is strong and durable printing material with good impact resistance

Fig 38: 3D printed part of effectors link

Fig 39: 3D printed effectors

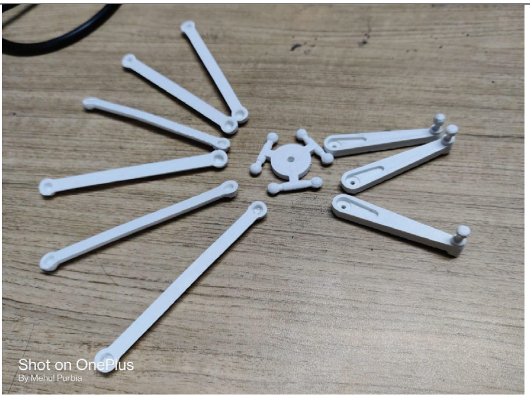

Fig 40: 3D printed part

3.4 Manufacturing of supporting pillars

The supporting pillars of the Delta robot are manufactured by hardwood which is easily available and easy to do machining.

There are 3 supporting pillars required in this delta, one robot.

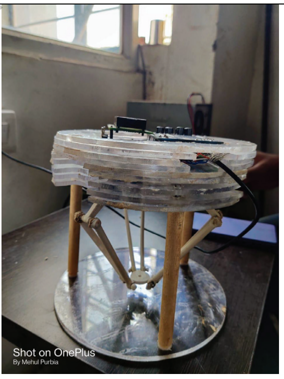

Fig 41 – wooden pillars

Chapter - 4

Kinematics of Delta robot

This Chapter is about the kinematics mechanism of Delta-Robot. Here you get all the information to calculate the servo angles to control a delta robot like this.

This is not complicated mathematics. The main advantage of this robot is that all things we have to know are basic geometric functions.

Delta-Robot belongs to the family of parallel robots. A delta robot has three actuated joints (here servo motors) and three degrees of freedom that means the effector/Tool Center Point (TCP) can move in three directions. This delta robot could move on x,y, the z-axis of the coordinate system. In other words forwards(x-) / backwards(x+), left (-y) / right(y+) and up (z-) / down (z+).

Moving the robot is changing the position of the Tool Center Point (TCP). The TCP is defined in the middle of the effector (for this robot). If a tool like a gripper or something is mounted on the effector, the TCP must be modified on a real robot.

The following picture explains the movement of the TCP. The position of the TCP always depends on the base coordinate system of the robot (Robot Root). In the case of Delta-Robot One, this system is defined in the middle of the robot body on the level of the servo motor axis.

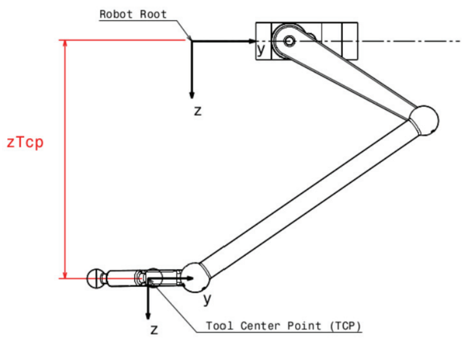

Fig 42: Movement of z-TCP (Tool Center Position)

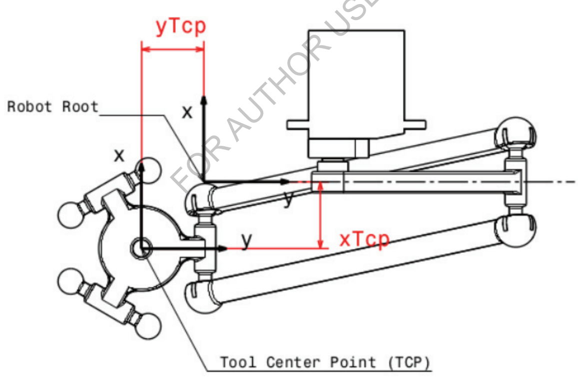

Fig 43: Movement of x-TCP and y-TCP (Tool Center Position)

To move the TCP of the robot we need to define the target position of the robot. We have to define the values for every axis:

posX -> forwards(TCPx-) / backwards(TCPx+)

posY -> left(-TCPy) / right(TCPy+)
posZ -> up(TCPz-) / down(TCPz+)

Later these are the target position in your robot move function you can use in your code. We also need the servo motor position to calculate the right servo motor control angle. Let's define a function called "deltakinematic" with the needed parameters:

deltakinematic(float posX, float posY, float posZ, char servo).

The next picture shows the coordinate systems Robot Root and Tool Center Point, the servo motor, the mounted servo link, two effector links, and the effector. For this explanation, only one robot arm is visible. There are some triangles marked in the image. This triangle we want to calculate. Our goal is to determine the three angles alpha, beta, and the servo control angle gamma.

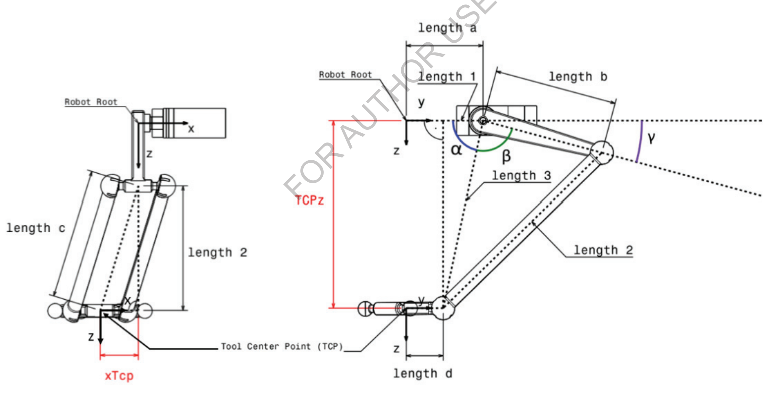

Fig 44: Angles of Delta Robot (alpha, beta, and gamma)

First, we do the easiest part and enter the fixed lengths of the robot kinematics. These are the lengths given from the mechanical parts shown in the mechanical drawings:

Robot Root -> Servo motor axis: 31 mm

Servo motor axis -> joints of servo link: 50 mm

Joints of servolink -> joints of end effector: 90 mm

Joints of endeffector -> TCP: 15 mm

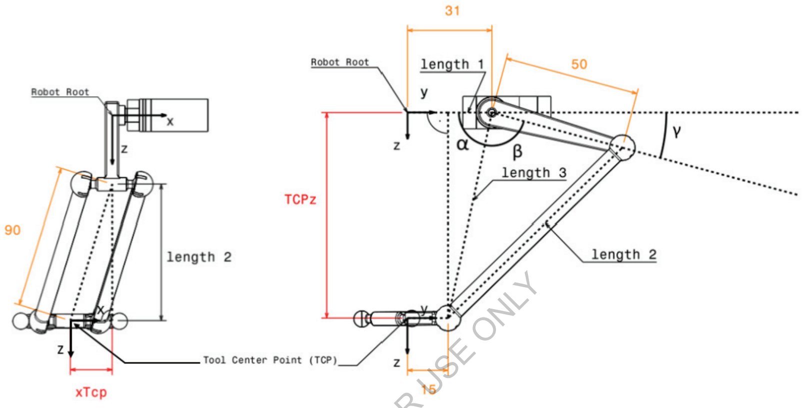

Fig 45: Fixed Length of Delta robot

The next part is the calculation of the first angle alpha. We have a triangle with a right angle and two given sides. So we can easily use a trigonometric function. In this case, the arctangent can be used to get the needed angle. The first calculations of lenght1 depend on the given lengths a,d, and the goal position of the Tool Center Point TCPy (y). Here is a modified image that shows a moved TCP in the y-direction to better see the given parameters to calculate length 1.

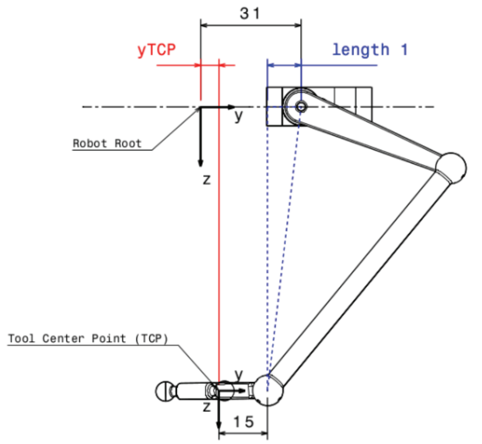

Fig 46: calculation of the alpha angle

The second calculation to get angle alpha is the arctangent function using the goal position of the Tool Center Point TCPz (z) and the calculated length1.

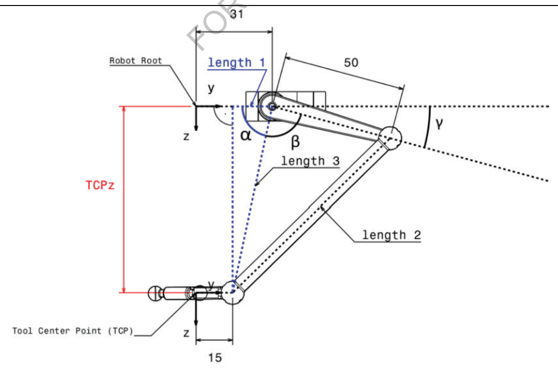

Fig 47: calculation of z-TCP

We are transferring these mathematics to program code (Arduino c/c++) using the atan2 function of the build-in mathematics library. Change the angle from radiant to the degree with 360/2*PI.

Float length1 = (length.a - length.d - y);

Float alpha = (360.0F / (2.0F * PI)) * (atan2(z, length1));

The next angle we want to calculate is beta. In this case, we have no right angle, so we have to use the cosine theorem. But before we can use this theorem to calculate an angle, it is required to know the length of all three sides.

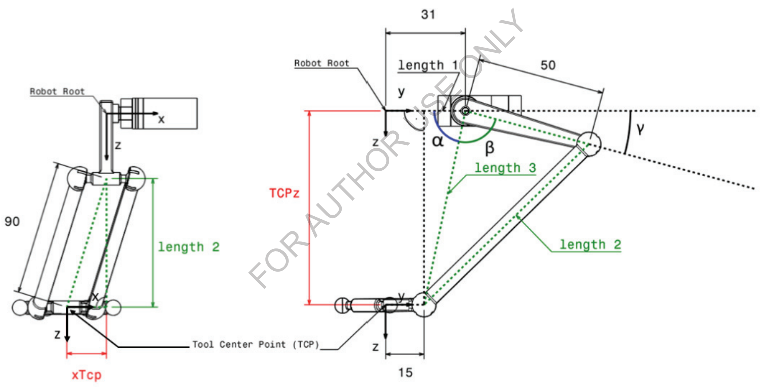

Fig 48: position representation of the beta angle

First, we can easily calculate the lengths 2 and 3 because they have a right angle, and 2 sides of the triangles are given. So we use the Pythagorean theorem to get the needed lengths.
float length2 = sqrt(pow(length1, 2.0F) + pow(z, 2.0F));

float lenght3 = sqrt(pow(length.c, 2.0F) - pow(x, 2.0F));
After that we use the cosine theorem to get the angle beta.

float beta = (360.0F / (2.0F * PI)) * (acos((pow(lenght3, 2) - pow(length2, 2.0F) - pow(length.b, 2.0F)) / (-2.0F * length2 * length.b)));

At least we have to get the last angle gamma. For this, we only need to subtract the calculated angles alpha and beta from 180 degrees. Now we can control the first servo motor A of a Delta-Robot One.

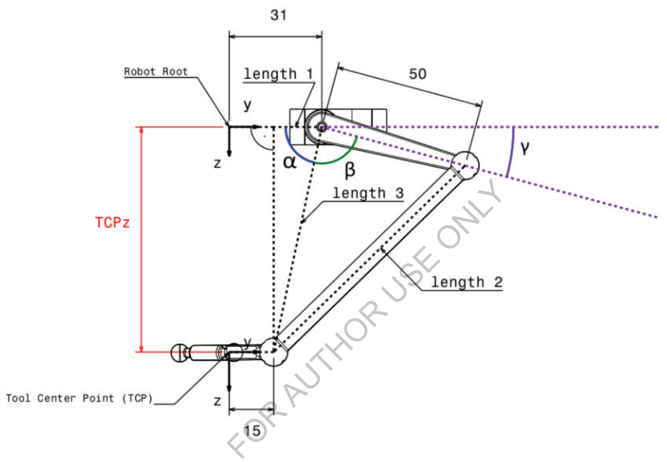

Fig 49: calculation of gamma angle

float gamma = 180.0F - alpha - beta;

To calculate the control angles for servo motor B and C, we must only transform the given TCP values (posX, posY, posZ) to the other servo motors coordinate systems. This can be done with so-called rotation matrices. These matrices only describe the rotation of x and y values with a given angle. If you rotate an axis, it has a sine and cosine component, and so the matrices are constructed. For better understanding, have a look at Wikipedia?

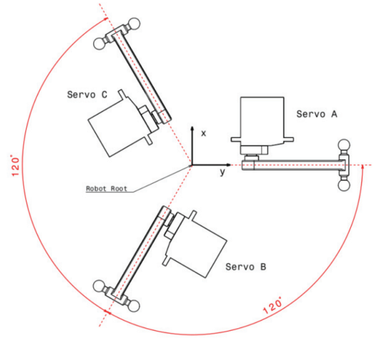

Fig 50: positions of servo motors

For our code example, we calculate the rotation before using the basic functions because these are identically after the rotation of the coordinate systems. With a parameter of the delta kinematic function (servo), we can choose the right rotation matrices for servo motor A, B, and C.

```
if (servo == 'A')
{
   x = posX;
   y = posY;
   z = posZ;
}

if (servo == 'B')
{
   x = (cos(pi120)*(posX)) + (sin(pi120)*(posY));
   y = - (sin(pi120)*(posX)) + (cos(pi120)*(posY));
   z = posZ;
}

if (servo == 'C')
```

```
{
   x = (cos(pi240)*(posX)) + (sin(pi240)*(posY));
   y = -(sin(pi240)*(posX)) + (cos(pi240)*(posY));
   z = posZ;
}
```

Chapter: 5

Controlling of delta robot

We desire to make servo motors agile enough so that they can rotate freely in all 3-dimensional space (degree of freedom 6) to pick and place the object in a particular constraint radius. We use several parts such as servo motors which are efficient to provide angular motion to the servo links; Microcontroller (Arduino-UNO) helps to control the motion of the motor by receiving input data from the remote via Bluetooth.

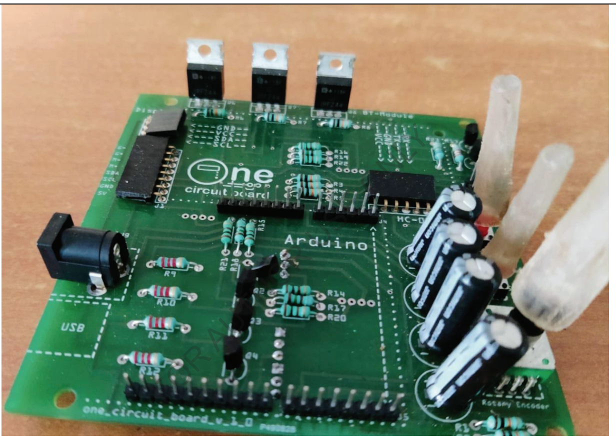

Fig 51: PCB with Electronics components

To design the circuit, we prerequisite several vital components for diverse functions such as

5.1 Arduino-UNO:

In 2005 to Arduino was introduced. Provide an inexpensive and easy way for study purposes. Students and professionals to create a device that infects with their environment whiny Sensors and actuators. It is an open-source & 8-bit microcontroller. This Board had 3212-byte flash memory, 2k byte RAM & a 1 Kbyte of EPROM. Also, this Board contains ATMEGA328 Processor. We can program processors using the C/C++ language in Arduino IDE software. It is a basic but essential component to work as a manager and memory to ensure that all other components work in coordination by maintaining harmony in the system.

Arduino can be in numerous ways; uses depend on requirements, cost, productivity, etc. The brain of the robot is Arduino worked as a microcontroller. Arduino can control every circuit part as per requirement. In our circuit, it works; similarly, it controls the motion of the servomotor linked with it by data cable(M\F) to move as per the data input by the controller through a Bluetooth connectivity device. The microcontroller takes input from HM-10 and converts the input signal into digital output to run motors in a particular sway manner to acquire the required position to pick the metallic object using electromagnetic. To control the robot, we have to need the signal through remote converted into electric signal input by Arduino and command the circuit to run current through the coil to pick the object and command to remove current or to shut the coil to drop the object at a particular point. Arduino is connected to the 16*2 display, which shows the position of the servo link; the controller gives the signal as a digital input to the display by resolving and analyzing the servo motor's position.

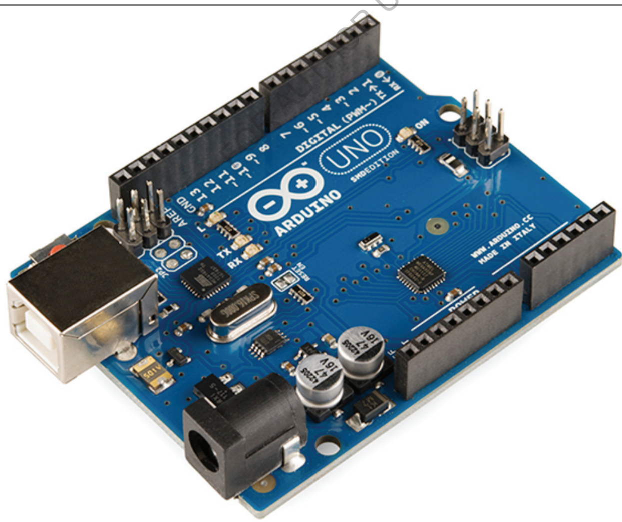

Fig 52: Arduino UNO

5.2 Display:

Display represents the outcome of functions performed by all several parts. We used 16*2 LCD to show the resultant output of the position of the motor and magnet. Liquid Crystal Display shows characters by the combination of crystals in its matrix. 16*2 displays mean blocks in 16 columns and 2 rows. Each block of the display is further divided by a matrix of crystals. The display takes digital signal input from Arduino to display characters or numbers to represent the position.

Fig 53: Display

5.3 HM-10 Bluetooth Modules:

This module can transmit 2.4GHz. ISM band and is a Bluetooth 4.0 module that includes Bluetooth low energy (BLE). It takes low power to operate & it is used as a viable option for IoT Communication between devices. The BLE uses the VART protocol to communicate with the microcontroller. It had four-pin +VCC. GND, RDX, TXD. It can be Operated between 3.6-6V. In VART Communication, the Receive line (R2) on one device is connected to the transmit (Tx) to the other and vice-versa. VCC & GND Should also be connected. In this Project, HM-10 Modules control the robot delta one robot using mobile.

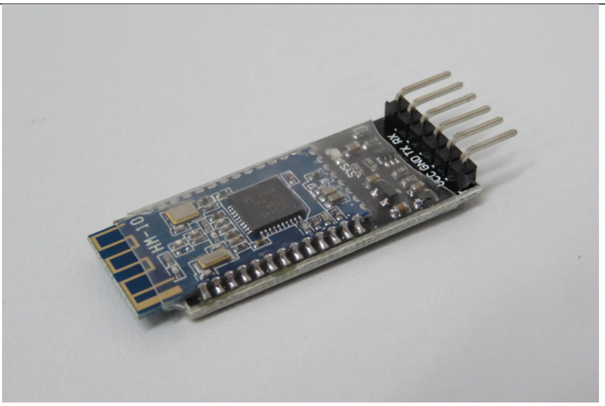

Fig 54: HM-10 Bluetooth modules

5.4 Rotary Encoder:

It is an electro-mechanical device that converts a shaft or axle's angular motion position to an analog or digital output Signal. These are used in a wide range of applications that require monitoring or control or both at the same time of mechanical Systems, including industrial controls, robotics, photographic lenses, ill computer device such as opt mechanical mice and trackballs, etc. It is also called Shaft encodes. In our project, we use it to control & operate the 16×2 LCD.

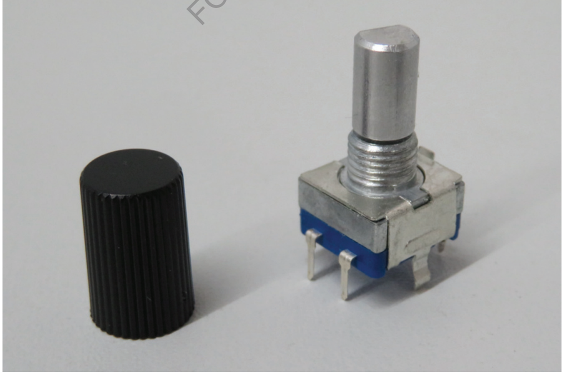

Fig 55: Rotary Encoder

5.5 Push Buttons:

A Push Button switch is a type of Switch that consists of a simple electrical mechanism or air switch mechanism to turn something on or off. In our project, we use 2 four-pin push buttons, one to reset the system and another to bring it up to default position.

Fig 56: Push Button

5.6 Servo Motors:

A servo motor provides accurate angular precision. It is a versatile and special kind of motor whose operation is automatic to a certain limit to a given command to operate the Performance correctly. We use Servo motors because of their special arrangement, which rotate at a certain angle for a given electrical input. Servo motors work on a Principle of Servomechanism. A servomechanism is nothing but an automatic closed-loop Control System.

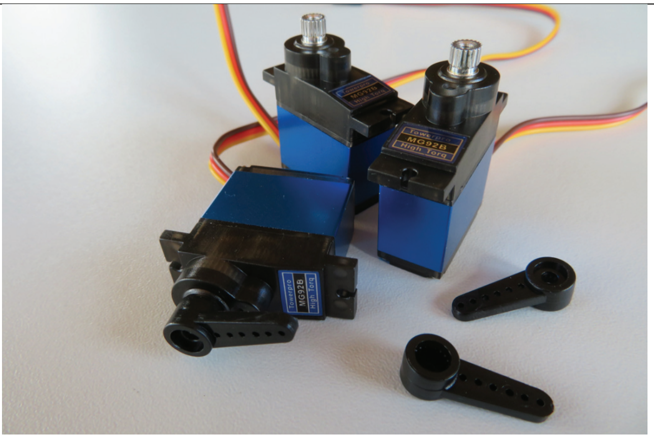

Fig 57: Servo motor

5.6 Arduino UNO Pin connection details:

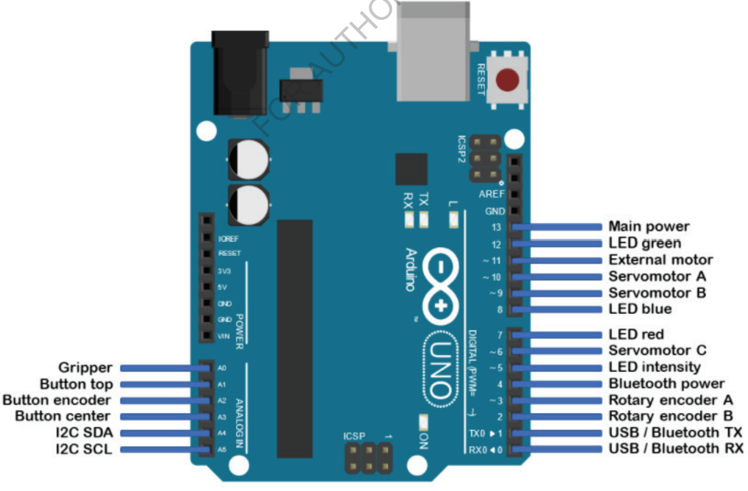

Fig 58: Arduino Uno Connection Diagram

A0	Gripper
A1	Button top
A2	Button Encoder
A3	Button Center
A4	12C SDA
A5	12C SCL
TX0	USB / Bluetooth RX
RX0	USB / Bluetooth TX
2	Rotary Encoder B
3	Rotary Encoder A
4	Bluetooth power
5	Led Intensity
6	Servo Motor C
7	Led red
8	Led Blue
9	Servo Motor B
10	Servo Motor A
11	External Motor
12	LED Green
13	Main Power

Table 3 - Arduino Uno Connection

5.7 Circuit board Schematics:

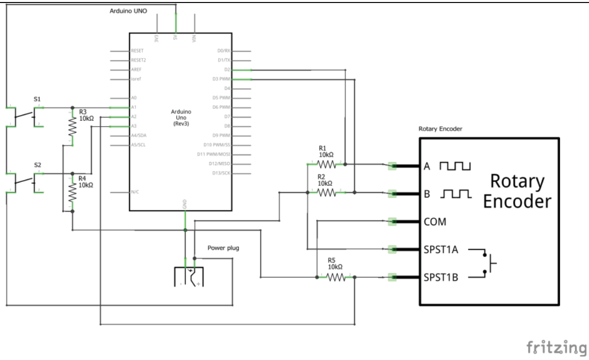

Fig 59: Connection diagram of Rotary Encoder

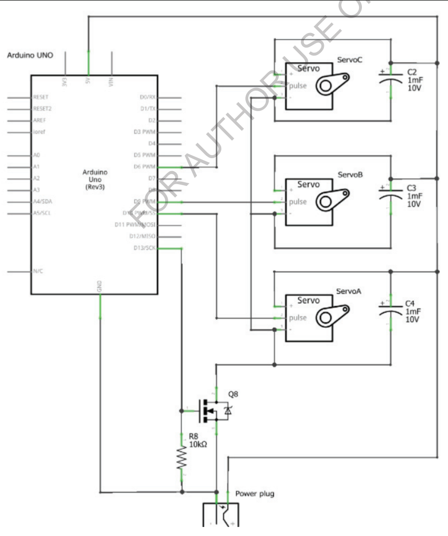

Fig 60: Servo Motor Connection

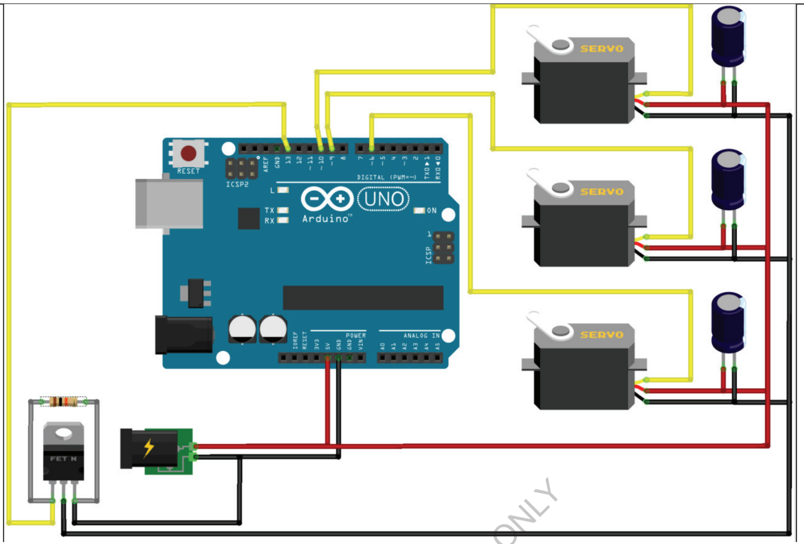

Fig 61: Servo Motor Connection Schematic Diagram

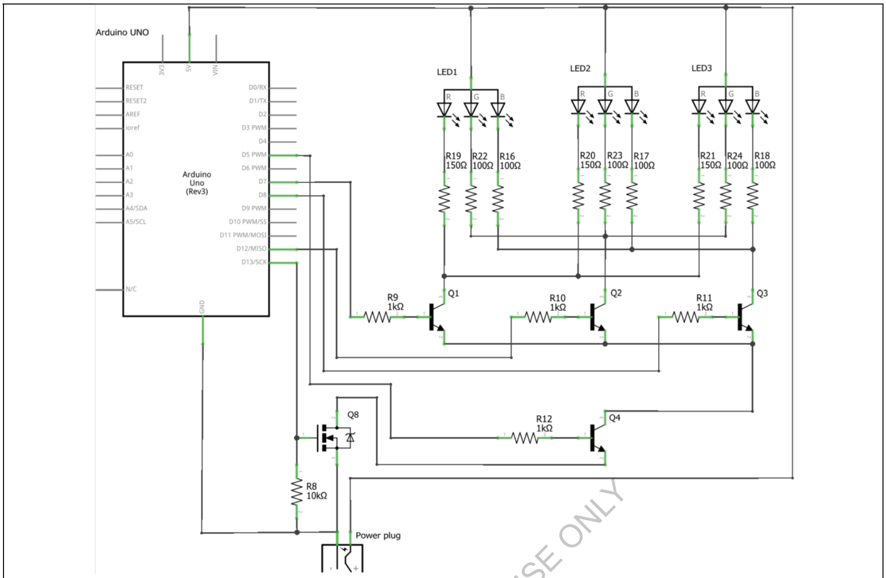

Fig 62: LED Light connection

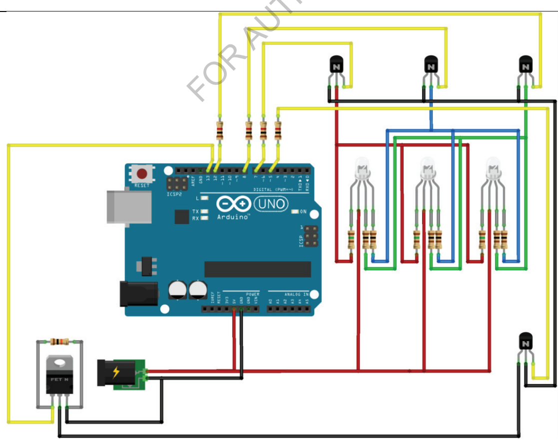

Fig 63: LED lights connection Schematic Diagram

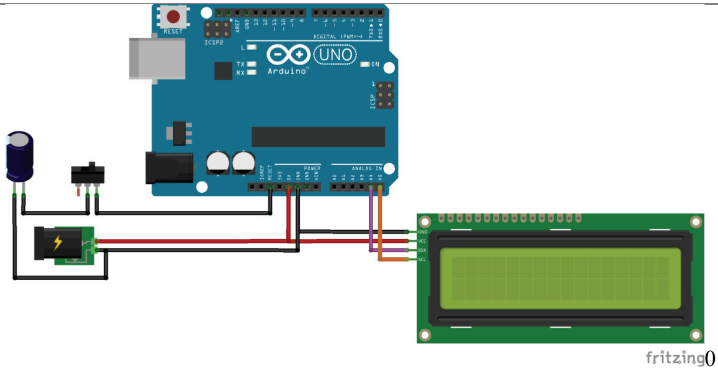

Fig 64: LCD 16*2 Connection Schematic Diagram

Chapter: 6

Conclusions:

In conclusion, this project had the main target of designing a delta robot and the construct of the delta robot applies inverse kinematics. First of all, It was necessary to design and develop the robot according to the needs of the project. Secondly, according to the structure, the inverse kinematics was designed for this robot. Finally, with the help of a Microcontroller like Arduino controlled the Delta robot.

Firstly, the robot was designed using the software Solid-works to Produce some of the parts of the robot. The manufactured parts were end-effector, arms And the fixed-based. Those parts were fabricated by 3D printing to Allow a low weight to the structure.

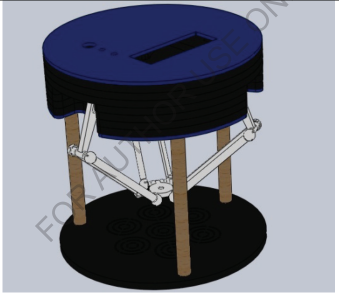

Fig 65: 3D Diagram of Delta robot

Fig 66: Layer of Delta Robot

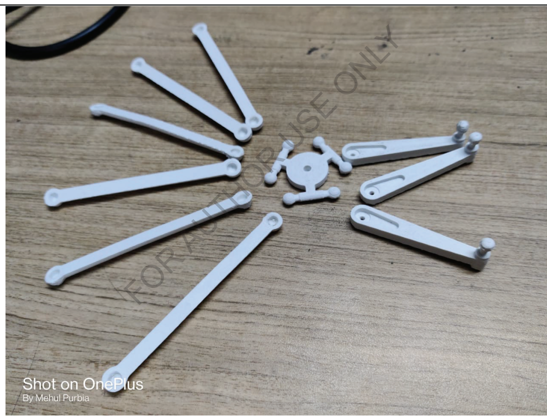

Fig 67: 3D printed servo links, effector, and effector links

After manufacturing the delta robot part, we can work on electronics systems like making PCB and soldering the all electronics parts PCB parts like resistance, MOSFET, Bluetooth device, and other electronic devices.

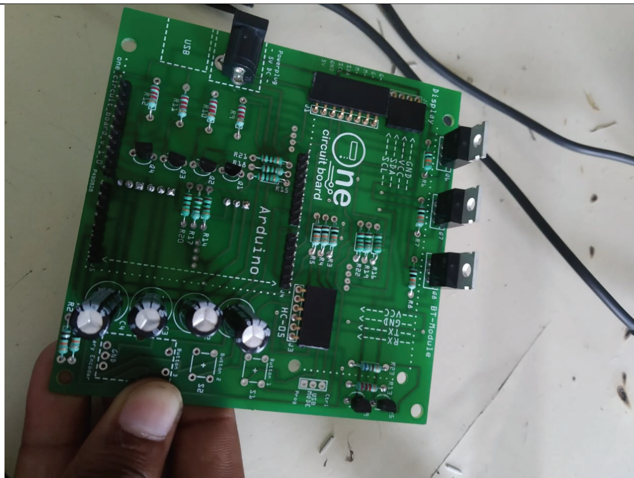

Fig 68: PCB With electronics device

Connect all electronics pieces of equipment with PCB and PCB connect with Arduino UNO board, after uploading open source programming code of delta robot; the robot will work.

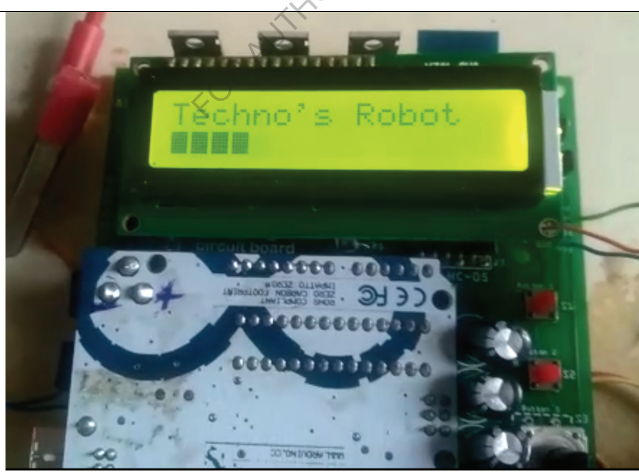

Fig 69: PCB with Display and Arduino UNO

We are combining all layers of PCB and providing a 5V power supply through the adapter.

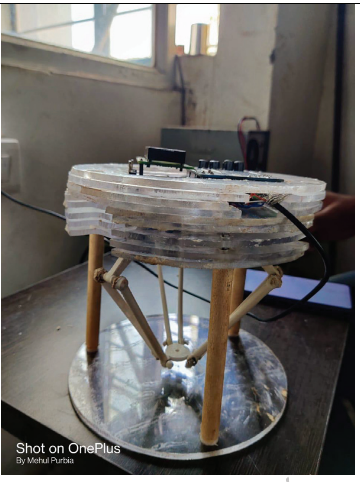

Fig 70: Model of Delta Robot

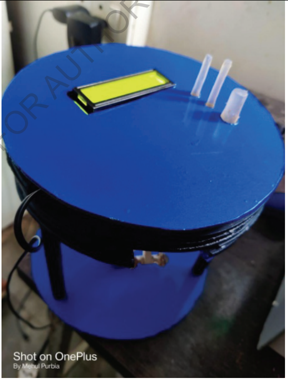

Fig 71: Final Model of Delta Robot

Chapter 7
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