A PROJECT REPORT

ON

"EXOSKELETON ARM"

Submitted by

KHAN AMIR AFZAL	18DME17
ANSARI MOHAMMED ARBAZ MOHAMMED RIYAZ	18DME05
ANSARI ZAIGAM ANWAR AHMED	18DME08
ANSARI MOHAMMED AYUB MOHAMMED LAEEQUE	16ME08
KATKAR MRUNAL KIRAN	17DME113

In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. YUSUF KHAN

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

UNIVERSITY OF MUMBAI

ACADEMIC YEAR 2020-2021

ANJUMAN-I-ISLAM
KALSEKAR TECHNICAL CAMPUS NEW PANVEL
(Approved by AICTE, recg. By Maharashtra Govt. DTE,
Affiliated to Mumbai University)
PLOT #2&3, SECTOR 16, NEAR THANA NAKA, KHANDAGAON, NEW PANVEL,NAVI MUMBAI-410206, Tel.: +91 22 27481247/48 * Website: www.aiktc.org

CERTIFICATE

This is to certify that the project entitled

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

Project Guide
(Prof.Yusuf Khan)

Project Co-Ordinator
(Prof. Rahul Thavai/Rizwan Shaikh)

Head Of Department
(Prof.Zakir Ansari)

Director
(Dr.Abdul Razak Honnutagi)

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APPROVAL OF DISSERTATION

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(Internal Examiner) **(External Examiner)**

___________________ ___________________

Date: ___________

ACKNOWLEDGEMENT

After the completion of this work, we would like to give our sincere thanks to all those who helped us to reach our goal. It's a great pleasure and moment of immense satisfaction for us to express my profound gratitude to our guide **Prof. YUSUF KHAN,** whose constant encouragement enabled us to work enthusiastically. His perpetual motivation, patience and excellent expertise in discussion during progress of the project work have benefited us to an extent, which is beyond expression.

We would also like to give our sincere thanks to **Prof. ZAKIR ANSARI**, Head Of Department, **Prof. YUSUF KHAN**, Project Co-Guide and Prof. **RAHUL THAVAI**, Project co-ordinator from Department of Mechanical Engineering, Kalsekar Technical Campus, New Panvel, for their guidance, encouragement and support during a project.

I am thankful to **Dr.ABDUR RAZAK HONNUTAGI**, Kalsekar Technical Campus New Panvel, for providing an outstanding academic environment, also for providing the adequate facilities.

Last but not the least I would also like to thank all the staffs of Kalsekar Technical Campus (Mechanical Engineering Department) for their valuable guidance with their interest and valuable suggestions brightened us.

KHAN AMIR AFZAL	18DME17
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ANSARI MOHAMMED AYUB MOHAMMED LAEEQUE	16ME08
KATKAR MRUNAL KIRAN	17DME113

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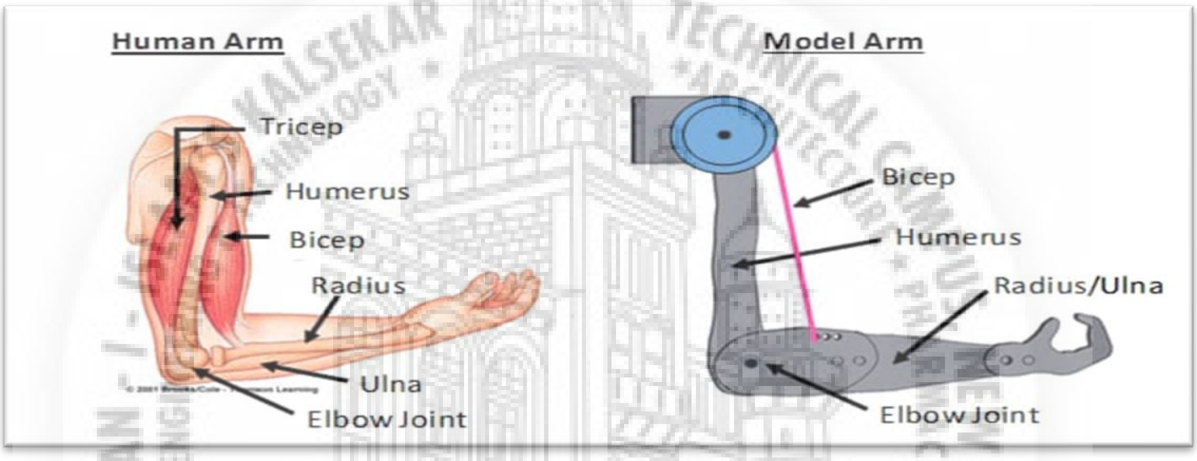
CHAPTER 01

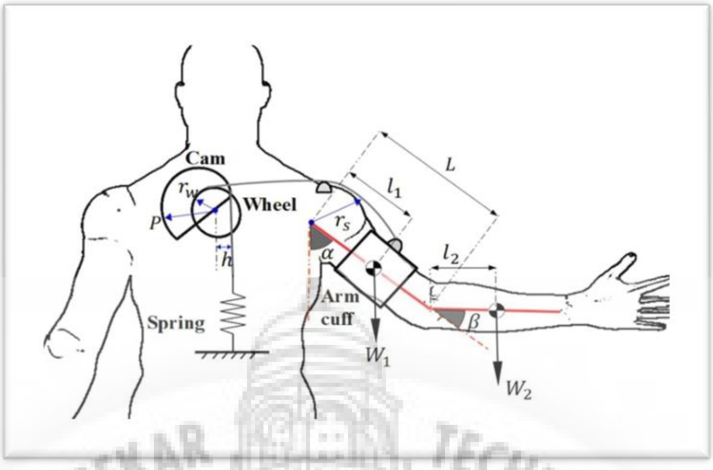
INTRODUCTION

An exoskeleton is a powered source mobile machine also known as power armor, powered armor, powered suit, cybernetic suit, cybernetic armor, exosuit, hardsuit, or exoframe.It is a small mobile machine that may be powered by electric, pneumatic or hydraulic source or maybe combination of these.



Working principle

The basic aim of exoskeleton is to assist the movement of limbs of human body either to lift the load or for movement of limbs of paralyzed or disabled persons .The exoskeleton scenes the motion of limbs and thereby sends a signal to electronic components which in turn starts the motor either for lifting load or developing desired motion of the part of exoskeleton.There maybe inactive or passive exoskeleton which may not operate on hydraulic, pneumatic or electric system but can also be used for lifting by certain linkages.



Force distribution

They are also used in **a military and force** for lifting heavy backpacks and accessories of soldiers, also to assist the movement of limbs when loaded with heavy backpacks and accessories like guns, neccessary livelihood items, tents etc.

Army exoskeleton suit

Army officials went into industry for exoskeleton which may increase the endurance , stability, resistance and fatigue or soldiers while carrying loads or doing activities which are repeated in manner. Thus by introducing this technology to the defence unit the risk of injuries have reduced to certain limit.

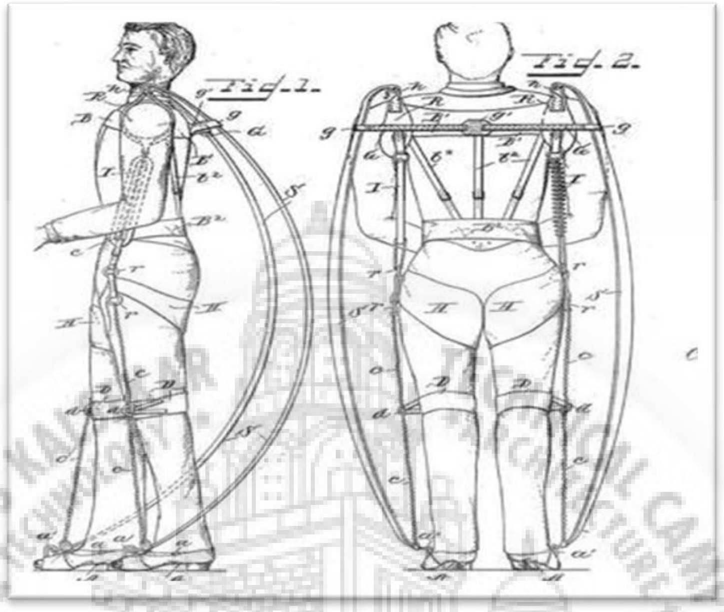
Thus from industrial to physiotheraphy this technology have moved to defence and army units allowing to increase the capabilities to run faster lift heavier climb higher and maintain efficient throughout in the working mode.

1.1 HISTORY OF EXOSKELETONS

Most of early work related to exoskeleton arm was **conceptual** and was on drawing but never putted on **physical prototype**. The earliest mention of a device resembling an exoskeleton was Yagn's running aid patented in 1890, shown below. It was a simple bow/leaf –spring operating parallel to the legs and was intended to augment running and jumping. Each leg spring was engaged during the foot contact to effectively transfer the body's weight to the ground and to reduce the forces borne by the stance leg.

In the late 1960s, General Electric Research , with Cornell University and financial support from the U.S. Office of Naval Research, constructed a full-body powered exoskeleton prototype. Dubbed "**Hardiman**" (from the "Human Augmentation Research and Development Investigation"), the exoskeleton, was an enormous hydraulically powered machine, that included components for amplifying the strength of the arms (including hands but without wrists) and legs of the wearer. It proposed to amplify the human strength drastically.

1-Yagn's Exoskeleton



Yagn's exoskeleton

Nicholas Yagn's invention, shown in above figure, comprises long leaf springs operating in parallel to the legs, and was intended to augment the running abilities of the Russian Army. Each leg spring was designed to engage at foot strike to effectively transfer the body's weight to the ground and to reduce the forces by the stance leg during each running stance period.

During the aerial phase, the parallel leg spring was designed to disengage in order to allow the biological leg to freely flex and to enable the foot to clear the ground. Although Yagn's mechanism was designed to augment running, there is no record that the device was ever built and successfully demonstrated.

The MIT Biomechatronics Group recently built an elastic exoskeleton similar to Yagn's design. However, its intended application was not for running augmentation, but for lowering the metabolic demands of continuous hopping . The exoskeleton, comprises fiberglass leaf springs that span the entire leg, and is capable of transferring body weight directly to the ground during the stance period. In distinction to Yagn's exoskeleton, the MIT device does not include a clutch to disengage the exoskeletal leaf spring during the aerial phase since such a clutching control was deemed unnecessary for hopping.

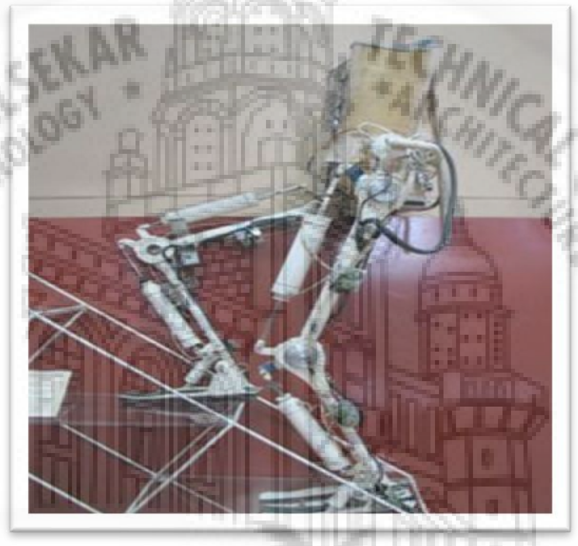
2-Hrdiman exoskeleton

Hardiman started in 1965 as a joint Army-Navy project to build a powered exoskeleton that could "amplify" human strength by a factor of 25. so hefting the maximum load of 1,500 pounds would feel to the wearer like lifting 60 pounds. The project sponsors wanted a machine that could move cargo or equipment. The exoskeleton, which itself weighted 1,500 pounds, was actually two suits, one internal "skeleton" attached to the operator and an external one that carried objects.

Hardiman's exoskeleton

The project was not successful overall. Any attempt to use the full exoskeleton resulted in a violent uncontrolled motion, and as a result, the exoskeleton was never turned on with a person inside. Mosher wrote of these difficulties in designing a powerful machine functioning as an extension of the human body, noting that a machine lacking the ability to receive and interpret force feedback would be very likely cause the machine to destroy. According to General Electric's Hardiman Project Report from 1969, "When turned on power to operate the shoulder joint, the arm lurched and the elbow would not operate. Further research concentrated on one arm. Although it could lift its specified load of 750 pounds (340 kg), it weighed three quarters of a ton, just over twice the liftable load.

3-Mihailo Pupin Institute Exoskeleton



Mui's exoskeleton

The first gait assistance exoskeleton was developed at the Mihajlo Pupin Institute during the late 1960's to the early 1970's. It was the forerunner to all modern day exoskeletons.

The kinematic walker

The kinematic walker was a lower limb exoskeleton, with foot plates and an extended spinal region for further attachment. Force sensors was placed in each of the foot plates allowing for determination of magnitude and location of ground reaction forces.It is now owned by the Polytechnic museum in Moscow and the State Museum Fund of Russian Federation, being displayed in the development of automation and cybernetics area.

The Active Suit

The active suit, was a modular semi-soft active orthotic exoskeleton. Modular meaning it could be broken down into smaller assembles localised at specific points on the body, such as an arm module. Being active meant the exoskeleton used actuators to produce motion, not a passive system which is the opposite. This exoskeleton used electromechanical actuators with electronic programming to operate. It was primarily designed to test and evaluate the feasibility of the drive system for orthotic devices.

1.2 PROBLEM DEFINITION

A lot of people are suffering from different types of muscle sickness and muscle weakness. To neither be able to lift neither everyday things nor move your body as you please is a struggle for many. The most common reason is muscle detrition due to aging, which is some degree affects all of us. Another reason is fibromyalgia which is a fairly common type of disease. Most people suffering from fibromyalgia feel exhausted, moving limbs and lifting things can be very painful. Another common reason why a person may suffer from muscle weakness is if the muscle has been crushed, for example in an accident. Whatever the reason is suffering from muscle weakness those people would gain a lot from support with lifting objects.

There are many exoskeleton arm available but they have some problems as follows.

1. The big problem in exoskeleton arm available in market is that they become stressed on wrist joint. So it is undesirable condition from application point of view,

2. Some exoskeleton arm available does not consider the muscle movement of patient.

3. One major problem is that is not properly fit to the arm or have limited size.

1.3 AIM AND OBJECTIVE

The project focused on how to construct a smart support structure for an arm. Sensors were used to monitor the user's movement and out of that data a controller was used to monitor the user’s movement and out of that data a controller was constructed for controlling the motor, which then moved the arm.

The purpose of this thesis was to find an optimal way to construct and control a product that could help those who suffer from muscle weakness or muscle sickness. The device was made out of two major parts which were connected through a motorized joint. The focus was on finding a satisfying construction that could handle the forces and with the help of sensors measure movement of the users arm relative to the construction and then control it using that information.

The device needed to b fats and reliable and react to small movements to be as comfortable for the users as possible.

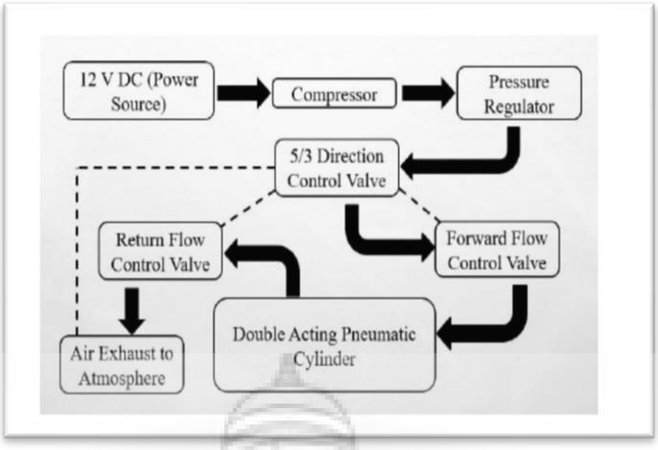
1.4 LITERATURE REVIEW

In this chapter, it is enough to use a lighter and weaker material, as they do need to handle as high stresses as the part connecting to the motor axle. The upper arm only needs to handle the tension from the weight which is easier to handle than the toque. The lower which is being bent can also be built with a weaker and lighter material as long as it is has a good fixation to the part that transfers the torque from the motor.

We have studied some paper related to exoskeleton listed below:

Paper 1: Design and fabrication of pneumatically powered exoskeleton arm by Pavana Kumara B., Krisantha Alexandra Pais, Roger Michael Pereira*, Mohammed Ashish Sahil, Varun S. Mallya

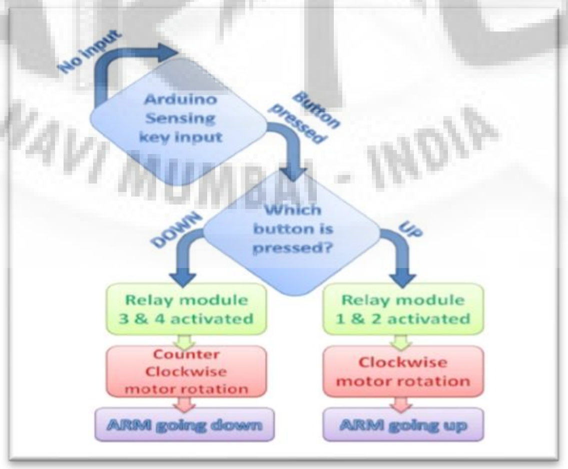
In this paper they have developed a pneumatically powered exoskeleton arm. They used Siemens NX 10 PLM package software for forearm frame, bicep frame. The frames were designed keeping in mind the average dimensions obtained from survey of various human upper limb sizes. The amount of muscle effort depends on the overall efficiency of the pneumatic cylinder.The fabricated pneumatically powered Human Exoskeleton arm is economical (costing under Rs.12,000), aesthetic, reliable, portable and ergonomic.



Mallay's Block diagram

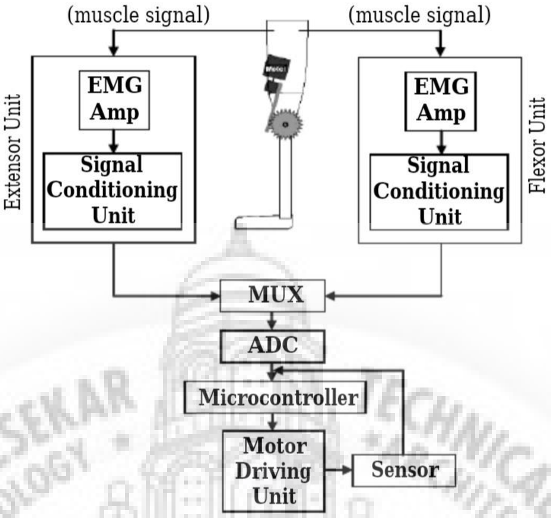
Paper 2: Exoskeleton Arm –The First Step of Real life Iron-Man suit By Md. Sadiur Rahman (ID: 10321035), Md. Tanjil Rashid Avi (ID: 10121026)

In this paper they have developed untethered, powered, upper body exoskeleton for use in the fields of rehabilitation and therapeutic application, as well as occupations requiring augmented strength. The aims of the research reported in this manuscript are to study the kinematics and the dynamics of the human arm during daily activities in a free and unconstrained environment, to study the manipulability of a 7-degree-of-freedom powered exoskeleton arm given the kinematics and the dynamics of the human arm in ADLs.



Rahman's block diagram

Paper 3: Design of cost effective EMG driven bionic-leg by Tahmid Latif, Choudhury Mahboob ellahi, K siddique-e-Rabbani, Tanveer Ahmed Choudhury.



Choudary's block diagram

In this paper they have designed a low cost prosthesis which will have an active (battery powered) limited rotational movement of the knee joint, controlled by voluntary EMG (electromyogram) signals from the opposing muscles from the thigh, one to rotate the leg backwards (flexion) and the other forwards (extension). The goal is to provide amputees with improved leg prosthesis at low cost. EMG signal was acquired and processed to control a dc servo motor operating the knee joint using a microcontroller. The designed prosthesis will allow a user not only walk with a better gait, but also to climb stairs with ease.

PAPER 4: Structural Analysis of Exoskeleton Model through Human Synchronization Parameters

Rahul R.*, Tanishq Philip Alexander, Rinkkhesh V., Vikram H.Sri Venkateswara College of Engineering, Pennalur,Bengaluru High Road, Sriperumbudur,

Kancheepuram, Tamil Nadu, India.

In this paper they have demonstrated a model of exoskeleton arm which look towards careful consideration of joints in the movement of human body. They have also considered reaction of Human muscle according with it the movement of exoskeleton is produced in this project. The test conducted on the device proves its ability to handle loads for people with problematic limbs. The model proposed here was studied with humans as passive exoskeletons. The force acted upon during the lifting action is transferred to the back of the human body lowering the risk of snapping joints.

PAPER 5: Design Considerations of a Human Arm Exoskeleton

Dumitru S., Rosca A. S., Ciurezu L. and Didu A.

In this paper we have studied that they have developed a model of exoskeleton for only upper limb of human body through specific kinetotherapy procedures. Their model is useful in following cases:

1_muscular forces recovery and increasing the muscular tonus;

2_ increasing and adapting the effort capacity;

3_ increasing the human upper limb articulations mobility;

The obtained exoskeleton prototype was designed in a compact form, in such manner that it can be placed on a mobile wheelchair and from this viewpoint it can be considered a mobile one and depends only from a 5Volts CC power supply

Upper limb exoskeleton of Rosca's

CHAPTER 02

WORKING PRINCIPLE AND COMPONENTS

2.1 WORKING PRONCIPLE

An exoskeleton work on the principle that the powered motor is used to convert rotary movement and use its torque to lift a an object in vertical axis. Hence converting rotary motion into translation motion.

2.2 STUDY OF MECHANICAL COMPONENTS

The exoskeleton arm is developed by certain linkages , connecting that linkages to make a mechanism and that mechanism to obtain movements. The various material used in this process are discussed in coming chapters along with their specifications and reasons to use them in particular places.

Selection across various materials like stainless steel , copper , fibre , wood , aluminium , brass, plastic etc.

The selection upon these materials depends on factors likes availability, cost, specific weight , density, specific gravity , etc.

The comparison of these standards are shown below and on that basis the material **aluminium and wood** is selected as a base material.

Name	Density in Kg per m3	Cost in rupees	Availability
Copper	8940	774 per kg	Widely available
Brich wood	670	36.67per kg	Easily available
Stainless steel 304	8000	170 per kg	cheaply available
Steel	7850	34 to 60 per kg	Easily available
aluminium	2700	143.67 per kg	Widely avaliable

2.2.1 Aluminium as a prime material / structure :

Hardness of aluminium

1-6061 brinell hardness = 95HB

2-6063 brinel hardness =60HB

3-6262 brinell hardness =75HB

Dimensions as per modelling and surveying in inches

Forearm	= 7 * 2 in inches
Shoulder arm	=9 * 2 in inches
Forearm support	= 7 * 2 in inches
Shoulder arm support	=9.5 * 2 in inches

3D image OF SHOULDER STRIP **ACTUAL IMAGE OF SHOULDER STRIP**

The actual calculation of these dimensions is explained in brief in the calculation module

2.2.2 wooden strips

Woods are having lighter weight as compare to other materials as well as the ranging variety makes it suitable to use for our application.

Various types of wooden strip that can be used are as follows:

Types of wood

1. Pine
2. Spruce
3. Larch
4. Juniper
5. Aspen
6. Hornbeam
7. Birch
8. Alder
9. Beech
10. Oak
11. Elm
12. Cherry
13. Pear
14. Maple
15. Linden
16. Ash

From above list we have used **birch timber** wooden strips which have following specifications:

Uses : It is most commonly used in residential flooring, gym flooring , furniture , mill works , for decoration purpose for external and study related works.

Hardness (in janka):

Yellow brich 1260

Red brich 1470

Silver brich 121

SPECIFIC GRAVITY:

Yellow birch =0.62

Sweet/red birch = 0.65

Silver/European birch = 0.66

Dimensions as per modelling and surveying

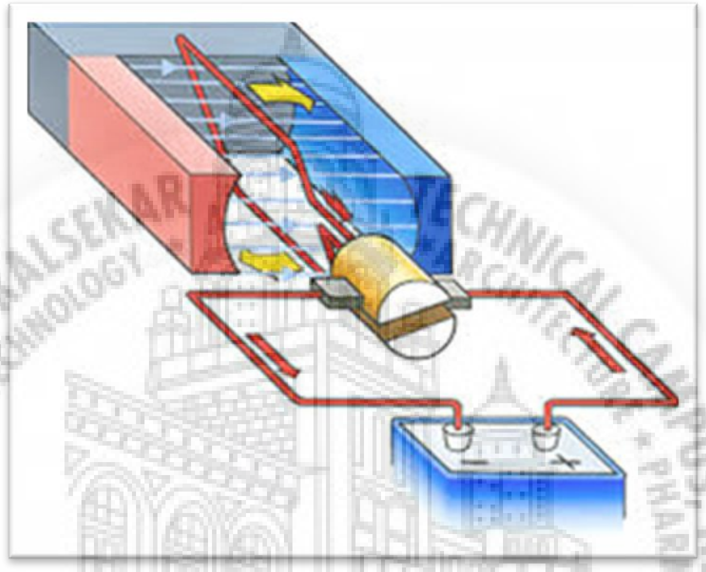
1. Forearm (8 * 1.5 in inches)
2. Shoulder arm (7.5 * 1.5 in inches)
3. Forearm support (7.5 * 1.5 in inches)
4. Shoulder arm support (11 * 1.5 in inches)

3D IMAGE OF FORE ARM **IMAGE OF FORE ARM**

2.3 THE STUDY OF ELECTRONIC COMPONENTS

In making of the exoskeleton arm we require some electronic components for proper working of arm as the electronic components are more precise and accurate then mechanical mechanism. Following are the electronic components required for the said purpose.

2.3.1 DC MOTOR



Principle of dc motor

A dc motor is electrical device which converts the direct current into mechanical rotary motion. Dc motor works on the principal of Lorentz law which states that, "If a current carrying conductor is placed in a magnetic field experiences a force called Lorentz force.

Mathematically,

$F = B \times I \times L$

Where,

F = Lorentz force

B = Flux density

I = Current flowing

L = Length of the conductor within magnetic field

There are 4 types of dc motors which are as follows

- DC series motor
- DC shunt motor/Paralleled motor
- Permanent magnet motor
- Compound DC motor

We used car's DC Wiper motor to reduce our cost as a wiper produce high torque to move the wiper on the windshield. The wiper motor is a brushed permanent magnet type DC motor .

Wiper motor

MOTOR SPECIFICATIONS

Manufacturer	Denso India LTD
Model	3101MZ6G00 P12
Sr No	SR059050-8050
Voltage	12 VDC
Current	2.3 A
RPM	50
Power	2.5 W

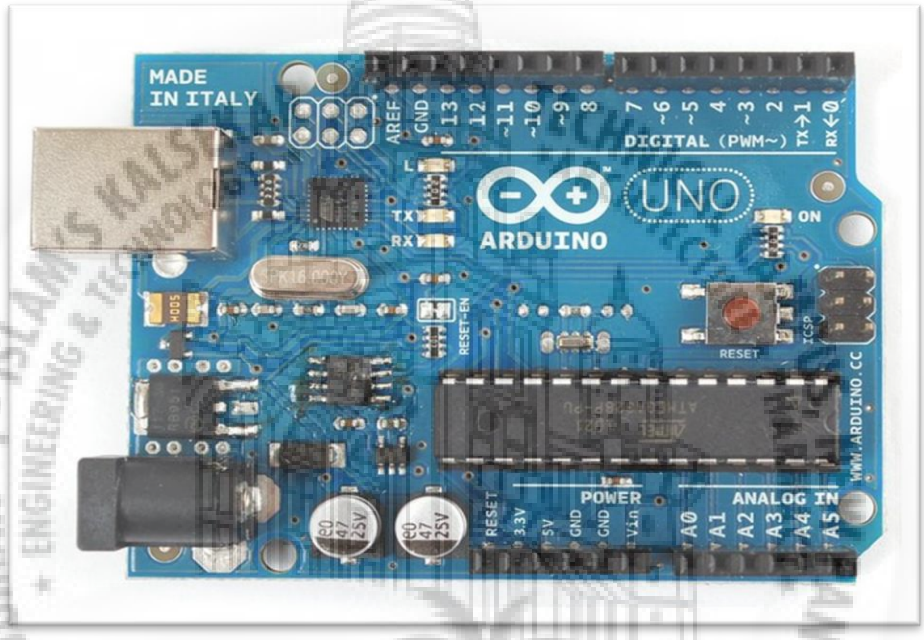
2.3.2 ARDUINO

Arduino is a microcontroller board use to control mechanical devices, actuators and sensors according to user. It has to be programmed accordingly before use. A software called Arduino IDE is used to programme the Arduino board. Arduino can be programmed by C and C++, it also have a standard API language called “Arduino language”. Arduino is widely used by students for projects and understanding how electronics and mechanics interact. It’s very easy to learn and user friendly. Arduino IDE software has sample programs called “libraries” like blink etc to understand how the programme works. It has separate library for stepper motor and servo motor.

There are different types of Arduino boards available

- Arduino UNO

It has 14 digital input/output pins in which 6 pins can be used as PWM pins 6 analogue pins. It is based on ATmega328P. It has power connection and USB connection and 16Mhz Quartz crystal.



ARDUINO

There are different type of Arduino board available names as follows

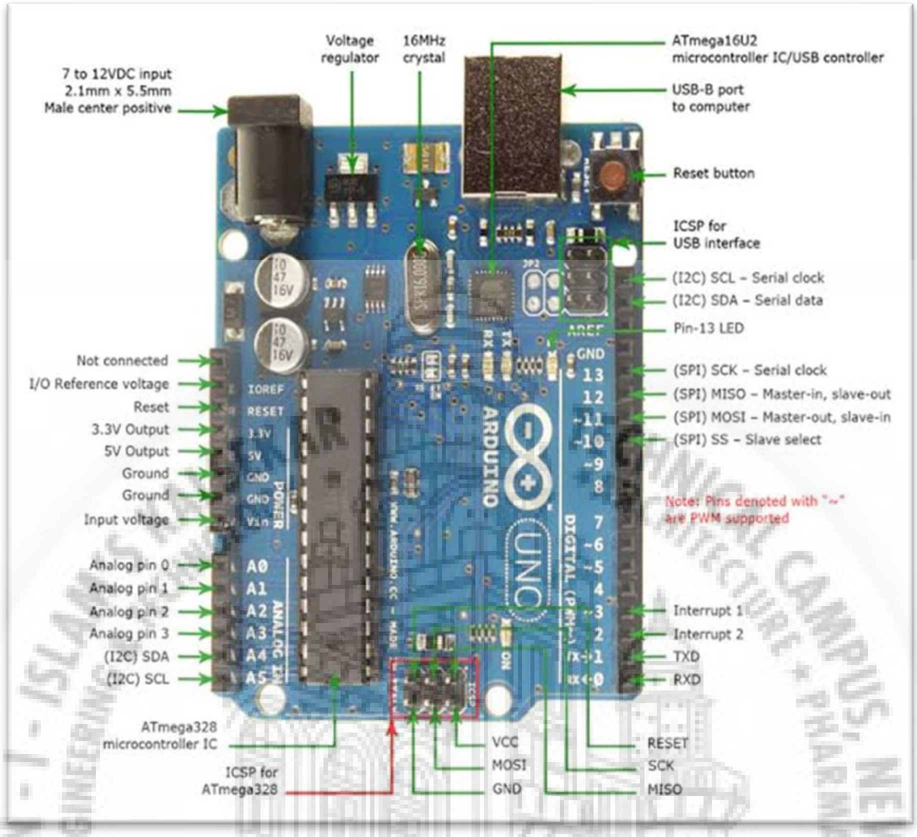
- Arduino UNO
- Arduino Mega
- Arduino Micro
- Arduino Mini
- Arduino Nano
- Arduino Lilypad

These Arduinos are used according to project like for small dc motors or led we can use Arduino Mini or Arduino Micro and for medium and large projects like robotics we use Arduino UNO or Arduino Mega. For our project we have 12v dc motor and for this Arduino Uno is sufficient to control the motor.

- **Specifications of Arduino UNO**

Microcontroller	ATmega328P
Input Voltage	6-20V
Input Voltage (recom)	7-12V
Operating Voltage	5V
Digital I/O Pins	14
PWM Pins	6
Analog Pins	6
DC current per I/O Pin	20mA
DC current on 3.3V Pin	50mA
Flash Memory	32 KB
SRAM	2 KB
EEP ROM	1 KB
Clock speed	16MHz

- **ARDUINO UNO PINOUT DIAGRAM**



CIRCUIT DIAGRAM OF ARDUINO

2.3.3 MOTOR DRIVER

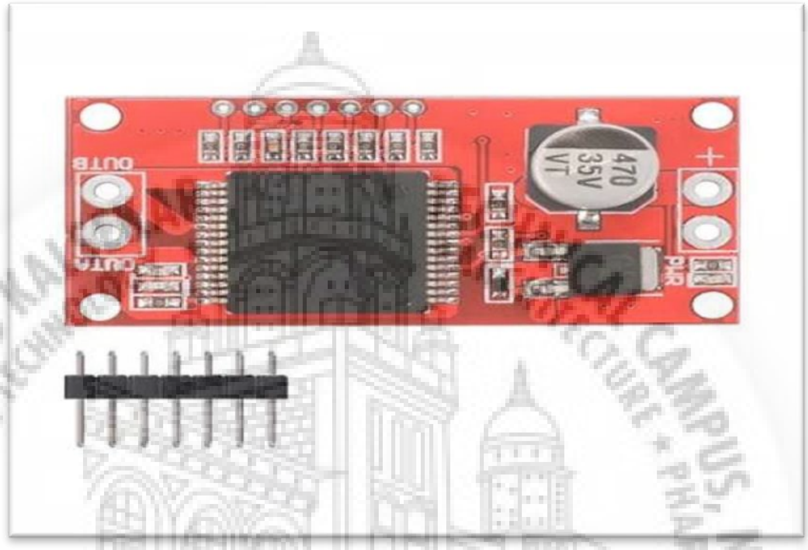
We cannot directly connect dc motor to Arduino pins because Arduino output current on digital pins are 20mA and normally a dc motor draws more than 1A which may damaged the pins or heat up the IC of the board. That's why we required something between the Arduino and the motor for this purpose we use a motor driver. A motor driver is a device which acts as an interface between motor and motor control circuits. Motor driver also acts as an amplifier which amplifies the output current of circuit and gives it to the motor

There are different motor driver available for different value of output current required for motor which are as follows

- L298N
- L293D
- L9110S

- VNH2SP30
- VNH5019
- VNH3ASP30

For our project we used VNH2SP30 mini motor shield motor driver. It is a full bridge motor driver intended for wide range of application. It can control one motor only.

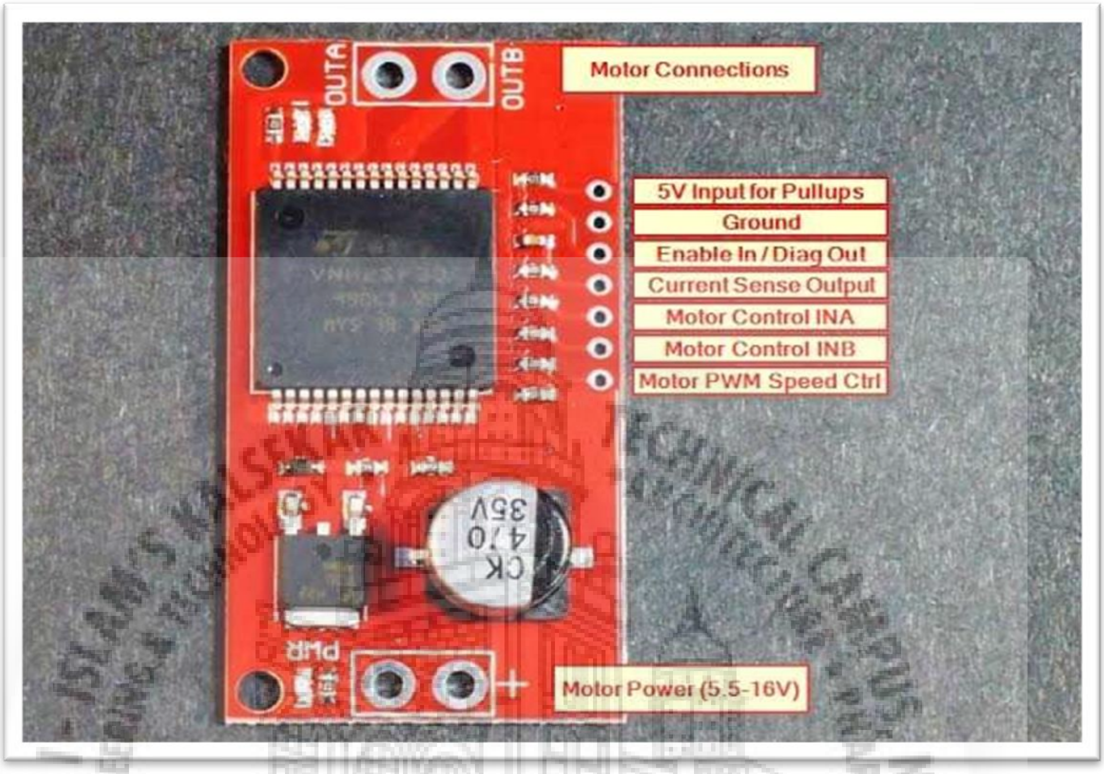


DRIVER IC

It can control both speed and direction of motor.

1. **Specifications of VNH2SP30**
   1. OUTPUT CURRENT: 30A
   2. 5V LOGIC LEVEL COMPATIBLE INPUTS
   3. UNDERVOLTAGE AND OVERVOLTAGE SHUT-DOWN
   4. OVERVOLTAGE CLAMP
   5. THERMAL SHUT DOWN
   6. CROSS-CONDUCTION PROTECTION
   7. LINEAR CURRENT LIMITER
   8. VERY LOW STAND-BY POWER CONSUMPTION
   9. PWM OPERATION UP TO 20 KHz
   10. PROTECTION AGAINST:LOSS OF GROUND AND LOSS OF VCC
   11. CURRENT SENSE OUTPUT PROPORTIONAL TO MOTOR CURRENT
   12. IN COMPLIANCE WITH THE 2002/95/EC EUROPEAN DIRECTIVE

2. PINOUT DIGRAM OF VNH2SP30



DRIVER PIN DIAGRAM

2.3.4 BATTERY

We required a 12V battery as our motor is 12V. For this we used a 12V lead acid battery.

ACTUAL BATTERY

3.Specifications

Standby use 13.5-13.8 V

Cycle use. 14.4-15 0 V

Initial current 0.39 A

Output Voltage 12 V

Output current. 1.3 Ah

2.3.5 POTENTIOMETER

A potentiometer is a device used to change the current supply in the circuit by increasing or decreasing resistance in the circuit. To control the speed of motor we used a 10K ohms potentiometer.

POTENTIOMETER

2.3.6 BASIC ELECTRONIC EQUIPMENTS

- TWO TACTILE BUTTONS
- WIRES
- MULTIMETER
- SOLDERING MACHINE

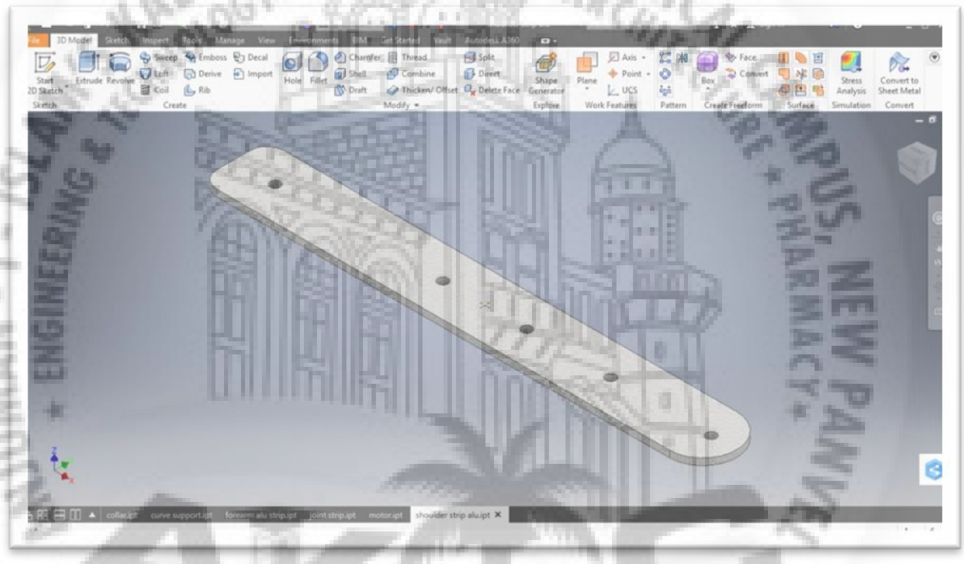
CHAPTER 03

DESIGN AND CALCULATION

3.1 3D CAD MODEL

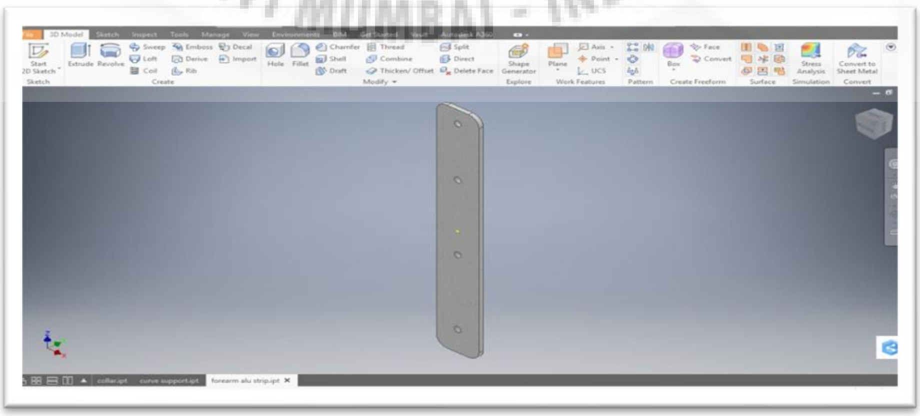
Before creating directly project we have created a 3d model of the project in AutoCad Inventor for better understanding of the project and for further analysis. In the modelling we instead of human arm we have created a stand for exoskeleton arm. Below are the photos of our exoskeleton parts.

- Aluminium shoulder strip



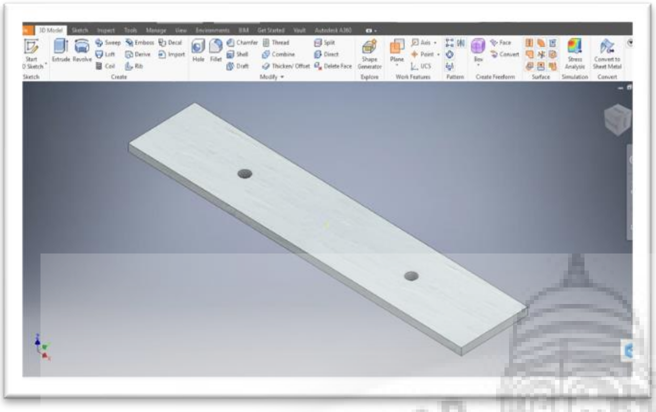
SHOULDER ON INVENTOR

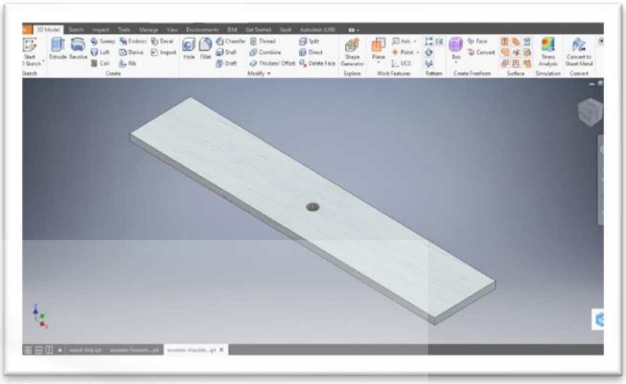
- Aluminium forearm strip



FOREARM SUPPORT ON INVENTOR

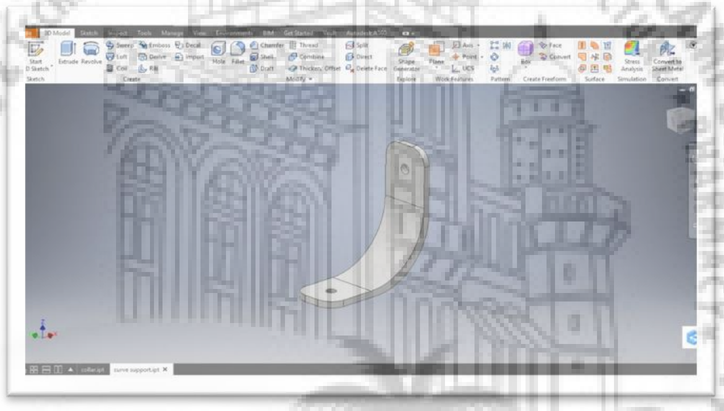
- Wooden support strip





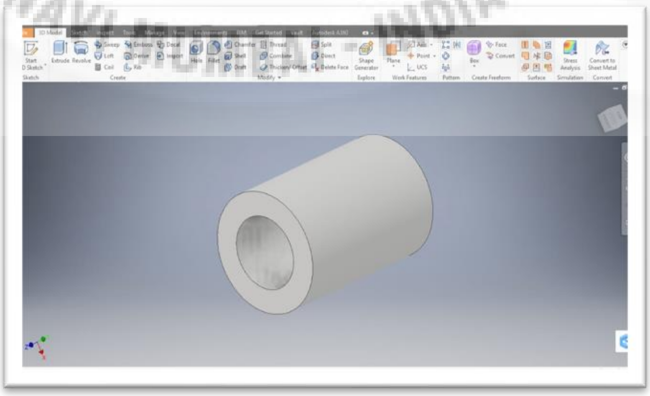
WOODEN STRIP ON INVENTOR **WOODEN SUPPORT ON INVENTOR**

- Bend connecting strip



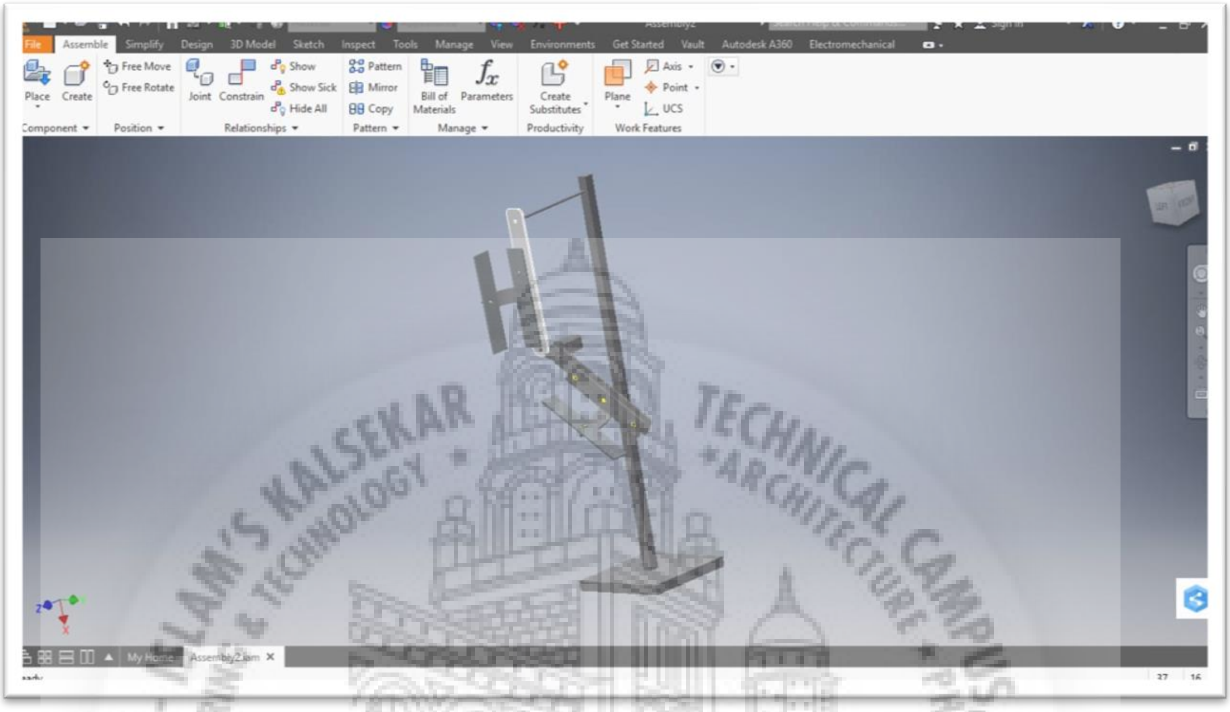
JOINING BEND ON INVENTOR

- Cylindrical collar



COLLAR ON INVENTOR

- Final assembly



ACTUAL ASSEMBLY ON INVENTOR

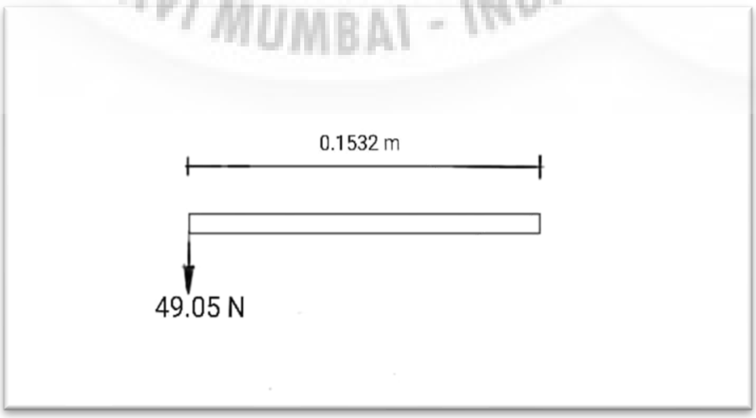
3.2 CALCULATION

1. Selection of motor

To lift a load of 5 KG

5KG = 49.05N

Length of forearm strip is 0.1532m



LOAD DIAGRAM

TORQUE = F × D

= 49.05 × 0.1532

= 4.514 N-M

We know that

P = 2ΠNT/60

Taking N = 30RPM

= 2π30T/60

= 23.60 WATTS

Maximum power required is 23.60 WATTS

TAKING CONSIDERATION OF POWER AND RPM (REVOLUTION PER MINUTE)

We have selected a 12V DC MOTOR whose specifications are as follows

V = 12V & I = 2.3A

P = V × I

= 12 × 2.3

= 27.6 WATTS

Therefore selected motor shown is suitable to lift a load of 5KG.

CHAPTER 04

FABRICATION

The very first part we decided to make is frame of the exoskeleton arm as we have to make an optimum size which can be easily wearable and comfortable to a broad range of age group. We need a light weight material for supporting frame and a tough but light weight material for main frame to withstand most of the load without fail or crack. For supporting member we used birch wood as it is light in weight and also non corrosive. For main frame we used aluminium as it is both light in weight and tough. Below are the parts we fabricated.

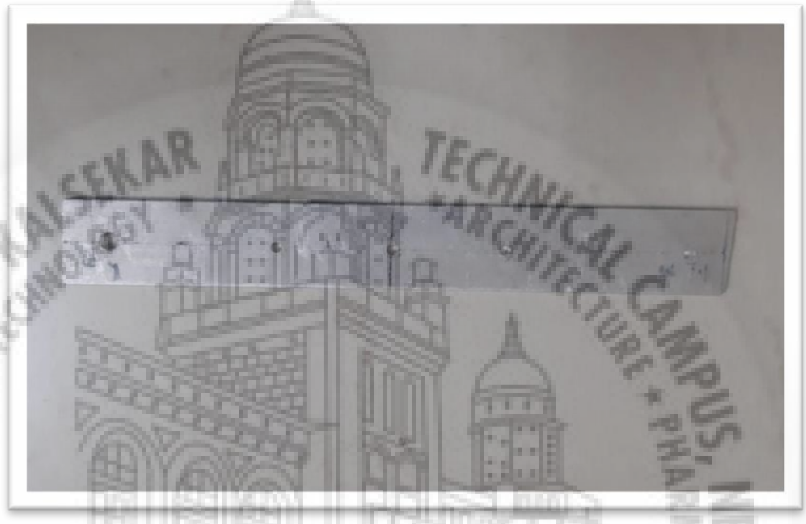
1. Wooden support arm

Support arm will be directly in contact with the person hand so it needs to be perfectly finished. We cut 4 equal size wooden strip whose size is 200 × 40 × 5 mm. For cutting of wooden strip we used a hacksaw we manually cut it. Then we need to drill holes in the strip 2 holes on two strips and 1 hole on each of the remaining 2 strip. For drilling holes of 1/8 inch we used a bench drill machine.

ACTUAL WOODEN SUPPORT CUTTED

2. Shoulder aluminium strip

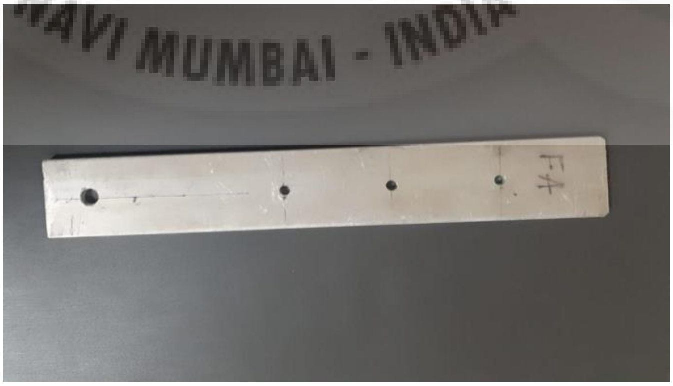
Shoulder aluminium strip is the main frame which will be connected to the upper body of the person using exoskeleton arm we cut a 300 × 50 × 5 mm size aluminium strip. For cutting we used a automated circular cutting saw. We need to drill 5 holes on the shoulder strip of which on end will be connected to posture corrector and other end we be connected to motor.



ACTUAL SHOULDER STRIP

3. Forearm aluminium strip

Forearm aluminium strip will be the main strip which will be connected to motor and will bear the main load which is to be lifted. The size of the forearm is 200 × 40 × 5 mm same as wooden strip. We need to drill 4 holes on aluminium by using bench drill machine of which one end of the strip is connected to motor shaft



ACTUAL FOREARM STRIP

4. Bend connecting strip

For connecting wooden support strip and aluminium strip we made 2 bend connecting strip. For bending the strip at desired angle we used hammer and anvil and bend it manually. We drilled two holes on each bend strip of which one will be connected to wooden strip and one will be connected to aluminium strip.

ACTUAL BEND STRIP

5. Collar

We used copper pipe to create collars of length 15 mm to make gap between wooden support and aluminium strip. This collar provide space for wires too.

ACTUAL COLLARS

6. Wooden motor support

We created a circular support for a motor to hold the motor and to prevent creation of unbalanced forces the internal diameter of support is the same as the diameter of motor casing.

ACTUAL WOODEN SUPPORT

7. V-shaped part

The motor has 3 holes on it for mounting purpose so we created an extra part to connect to of the mounting holes and instead of connecting the shoulder aluminium strip direct we connect it with this part and a V-shaped clearance was created to allow the motor shaft space.

ACTUAL V SHAPED SUPPORT

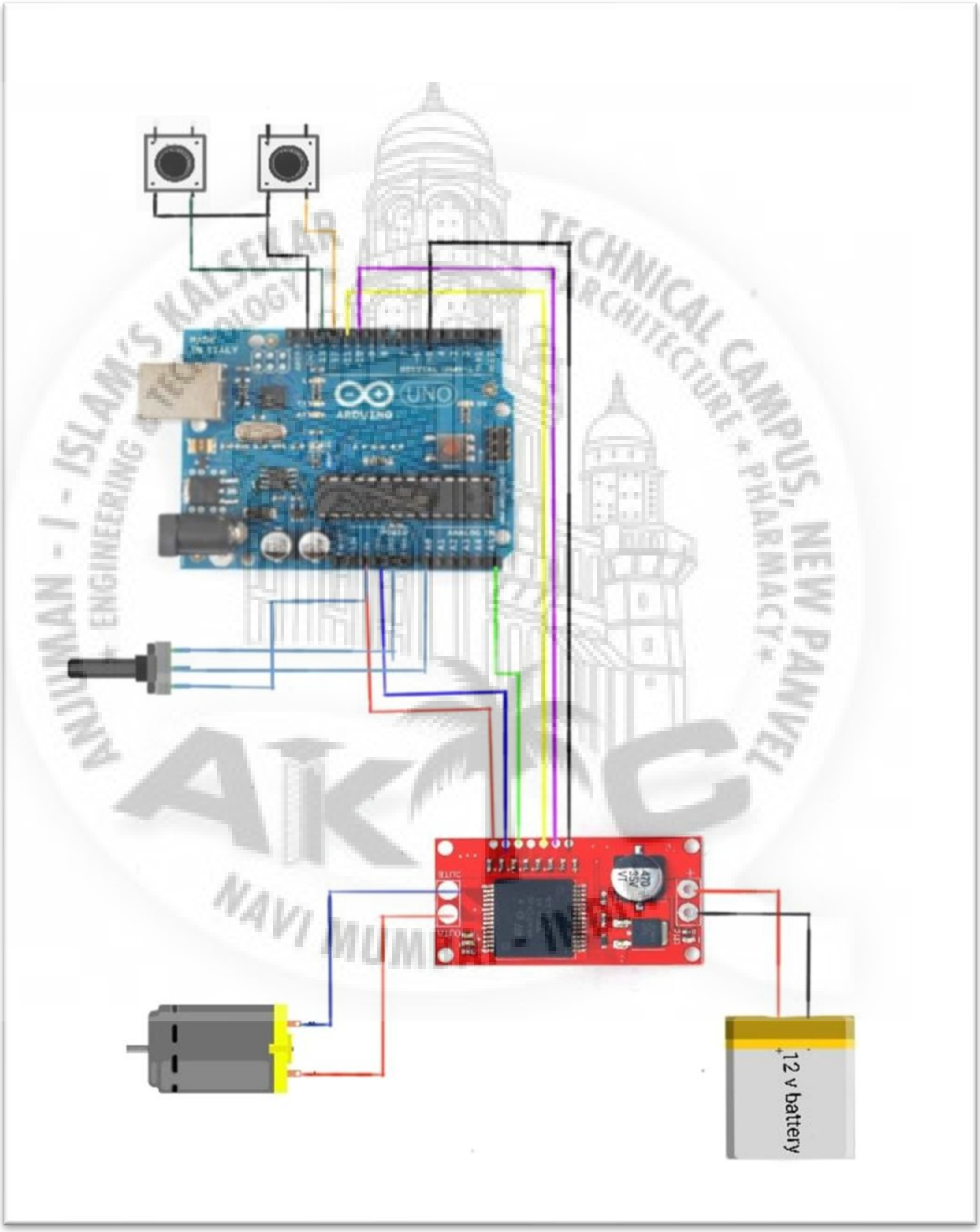
8. After finishing the frame we used a hard fabric like dog leash and connect the shoulder aluminium strip with the posture corrector by using a nut and bolt arrangement. After this all the electronic parts are attached to the back of the posture corrector.

POSTURE CORRECTOR

CHAPTER 05

INTERFACING AND COSTING

5.1 CONNECTION DIAGRAM



CONNECTION DIAGRAM

5.2 ARDUINO PROGRAMMING

```
const int potPin = A0;

const int fwbuttonPin = 13;

const int bwbuttonPin = 12;

const int INAPin = 11;

const int INBPin = 10;

const int ENPin = A5;

const int PWMPin = 5;



int potValue = 0;

int motorValue = 0;

int fwbuttonState = 1;

int bwbuttonState = 1;


void setup() {

pinMode(fwbuttonPin, INPUT_PULLUP);

pinMode(bwbuttonPin, INPUT_PULLUP);

pinMode(INAPin, OUTPUT);

pinMode(INBPin, OUTPUT);

pinMode(ENPin, OUTPUT);

pinMode(PWMPin, OUTPUT);


}
```

```
void loop() {
potValue = analogRead(potPin);
motorValue = map(potValue, 0, 1023, 0, 255);
fwbuttonState = digitalRead(fwbuttonPin);
bwbuttonState = digitalRead(bwbuttonPin);

if (fwbuttonState == LOW)
{
  digitalWrite(INAPin, motorValue);
  digitalWrite(INBPin, LOW);
  digitalWrite(ENPin, HIGH);
}
else if (bwbuttonState == LOW)
{
  digitalWrite(INBPin, motorValue);
  digitalWrite(INAPin, LOW);
  digitalWrite(ENPin, HIGH);
}
else
{
  digitalWrite(INAPin, LOW);
  digitalWrite(INBPin, LOW);
  digitalWrite(ENPin, LOW);
```

}

}

5.3 COSTING

Sr.No.	Name	Cost	Specification
1	Wiper motor	350	12V
2	Arduino	490	Single board micro controller
3	Driver	590	VNH2SP30
4	Tactile button	20	Basic (Push type)
5	Bread board	50	-
6	Jumpers	100	male to female & male to male
7	Battery	450	1.2Amp,12V
8	Aluminium strips	150	36 Inch 1Pcs
9	Wooden strips	50	36 Inch 1 Pcs
10	Nut bolt	50	3/8″ 12 Pcs
11	Posture corrector	300	Velcro type 1 Pcs
12	Coppers collars	50	0.5″ ,5/8″ dia 6 Pcs
13	Cusion spounge	100	Rubber type single row 1Pcs

CHAPTER 06

FUTURE SCOPE

- Changes of servo motors can added according to movement control of each finger.
- Mode of actuation can be change to pneumatic. Wrist control can be further increased to finger control. Backpack setup can be adjusted to minimize weight.
- Weight carrying capacity can be adjusted .
- Circuit can be used for both pair of hands.
- Can be made for different parts of body like legs, thighs, etc.
- Passive exoskeleton can be made which will not require supply source, helps in posture, light and easy to use.
- Powered exoskeleton which will have power supply, no human effort require, can do jobs which are not possible with human hands.
- Haptic exoskeleton used in graphics, used to capture motion accurately, can be used in virtual reality.
- Different arrangements can be adopted to minimize cost of alteration , because heavy loads requires a heavy motor arrangement.
- implementation of an exoskeleton arm introduces the challenge of producing the motion of the human arm, which is one of the very difficult joints of the body.
- In future we can see exoskeleton used in diseases like (ALS) Amyotrophic Lateral Sclerosis in which nerve cell breakdown due to this its reduces functionality in the muscles that they supply , which has no cure currently, but using this technology may give a new way of life for those individuals.
- Exoskeleton are often wearable for while with none issue to the wearer, more light weight easy to hold everyone can afford it. By using this technology individuals can work with none risk of life in industry or construction site or in logistic department.

CONCLUSION

We will propose an approach to develop an exoskeleton forearm for the elders and people who have weak forearm movement due to injury. Arm will be design to reduce the stress on the wrist by providing supporting frame or servo motor at joints. Different age groups can use the product so it will be more user friendly as it can be adjustable.

The exoskeleton will also consist of sensor like EGM sensor and Arduino for processing. The code provided to Arduino will be encrypted so that the safety of the product is also taken into consideration. Our near future perspective work includes more servomotors for better movement of forearm.

For betterment of product the user can also install more number of motors so that it can be used for another hands as such in same construction.

The movement control can be more defined by using advanced heriechal drivers used in automation

The system can be reached towards the **IOT** based systems

REFERENCES

[1] Kwok-Hong Chay "Upper Extremity Robotics Exoskeleton: Application Structure and Actuation," International Journal of Biomedical Engineering and Science (IJBES), Vol. 1, Issue No. 1, pp 35-45, April 2014.

[2] Arjun Kurunji and Team, "Project Report on Design and Fabrication of Exoskeleton Arm," St. Joseph Engineering College, Mangalore, Karnataka, 2014.

[3] Joel C. Perry, Jacob Rosen and Stephen Burns, "Upper-Limb Powered Exoskeleton Design," IEEE/ASME Transactions on Mechatronics, Vol. 12, Issue No. 4, pp 408-417, August 2007, Publisher: IEEE.

[4] Md. Sadiur Rahman, Md. Tanjil Rashid Avi, "Exoskeleton Arm - The First Step of Real Life Iron Suit," School of Engineering and Computer Science BRAC

[5] Xiao, Zhen Gang, Ahmed M. Elnady, and Carlo Menon. "Control an exoskeleton for forearm rotation using FMG." In *5th IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics*, pp. 591-596. IEEE, 2014.

[6] Martinez, John A., Paul Ng, Son Lu, McKenzie S. Campagna, and Ozkan Celik. "Design of wrist gimbal: A forearm and wrist exoskeleton for stroke rehabilitation." In *2013 IEEE 13th international conference on rehabilitation robotics (ICORR)*, pp. 1-6. IEEE, 2013.

[7] Petrich, Kyle L., Jaime S. Vargas, Joe Wagner, Mark Yim, and James F. Kramer. "Forearm-supported exoskeleton hand-tracking device." U.S. Patent 6,104,379, issued August 15, 2000.

[8] Rahman, M. H., M. Saad, J. P. Kenné, and P. S. Archambault. "Exoskeleton robot for rehabilitation of elbow and forearm movements." In *18th Mediterranean Conference on Control and Automation, MED'10*, pp. 1567-1572. IEEE, 2010.

[9] Kiguchi, Kazuo, Ryo Esaki, and Toshio Fukuda. "Development of a wearable exoskeleton for daily forearm motion assist." *Advanced Robotics* 19, no. 7 (2005): 751-771.