DESIGN & FABRICATION OF MECANUM WHEELS FOR FORKLIFT APPLICATIONS

BACHELOR OF TECHNOLOGY

PROJECT REPORT

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Under the Guidance of

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SYMBIOSIS SKILLS AND PROFESSIONAL UNIVERSITY
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CERTIFICATE

This is to certify that the Project entitled, **“DESIGN & FABRICATION OF MECANUM WHEELS FOR FORKLIFT APPLICATIONS”**, which is being submitted herewith for the award of B.TECH., is the result of the work completed by **Karan S. Tomar, Kishan Gohel, Krutarth P. Gohel, Jay A. Hiran, Navodit Sankhyan** under my supervision and guidance and the same has not been submitted elsewhere for the award of any degree.

Mr. Rajkumar Baghel	Mr. Sanjay Arole
Guide	Director
Asst. Prof. in Automobile Engineering	Head of Automobile Engineering

Examiner

DECLARATION

I hereby declare that the project entitled, "**Design & Fabrication of Mecanum Wheels for Forklift Applications**" was carried out and written by us under the guidance of Mr. Rajkumar Baghel, Assistant Professor, School of Automobile Engineering, Symbiosis Skills and Professional University. This work has not been previously formed the basis for the award of any degree or diploma or certificate nor has been submitted elsewhere for the award of any degree or diploma.

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Place: Pune

Date:

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to Mr. Rajkumar Baghel, for his invaluable guidance, support, and encouragement throughout the course of this project. Their expertise and insights have been instrumental in shaping my understanding of the subject matter and have helped me to develop the necessary skills to complete this project successfully.

We would also like to thank Mr. Sanjay Arole, for his valuable inputs and feedback, which have greatly contributed to the quality of this project.

We perceive this opportunity as a milestone in our career development. We will strive to use these gained skills and knowledge in best possible manner in order to attain the desired career objectives. We hope to continue cooperation with all of you in future.

Thank you all for your invaluable contributions to this project.

ABSTRACT

This project aims to design and fabricate Mecanum wheels for forklift applications. Mecanum wheels are omnidirectional wheels that allow forklifts to move in any direction, making them ideal for tight spaces and complex manoeuvres. The design process involved selecting appropriate materials, determining the wheel dimensions, and creating a 3D model using CAD software. The fabrication process included machining and assembly of the Mecanum wheels. The performance of the Mecanum wheels was evaluated through testing on a forklift prototype, and the results indicated the improved manoeuvrability and efficiency as compared to traditional forklift wheels. Overall, this project demonstrates the feasibility and benefits of using Mecanum wheels for forklift applications. Additionally, the project highlights the importance of considering the design and fabrication of specialized wheels for specific applications. The Mecanum wheels designed and fabricated in this project can be used in various industries, including manufacturing, warehousing, and logistics. The project also provides insights into the challenges and considerations involved in designing and fabricating Mecanum wheels, such as the need for precise machining and assembly. The results of this project can be used as a basis for further research and development of Mecanum wheels for various applications. Overall, this project contributes to the advancement of the field of material handling and logistics by introducing a new and innovative solution for forklift mobility.

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1. INTRODUCTION

One of the common omni-directional wheel designs is Mecanum Wheel or Ilon wheel. Mecanum wheel was design and invented in Sweden in 1975 by Bengt Ilon, an engineer with Swedish company Mecanum. Mecanum wheel is based on the principle of a central wheel with a number of rollers placed at an angle around the periphery of the wheel. The angled peripheral roller translates a portion of the force in the rotational direction of the wheel to force normal to the wheel directional. Depending on each individual wheel direction and speed, the resulting combination of all these forces produces a total force vector in any desired direction thus allowing the platform to move freely in direction of resulting force vector, without changing the direction of the wheel. Figure 1 shows a traditional Mecanum wheel design by Ilon with the peripheral roller with 45°-degree slope held in place from the outside.

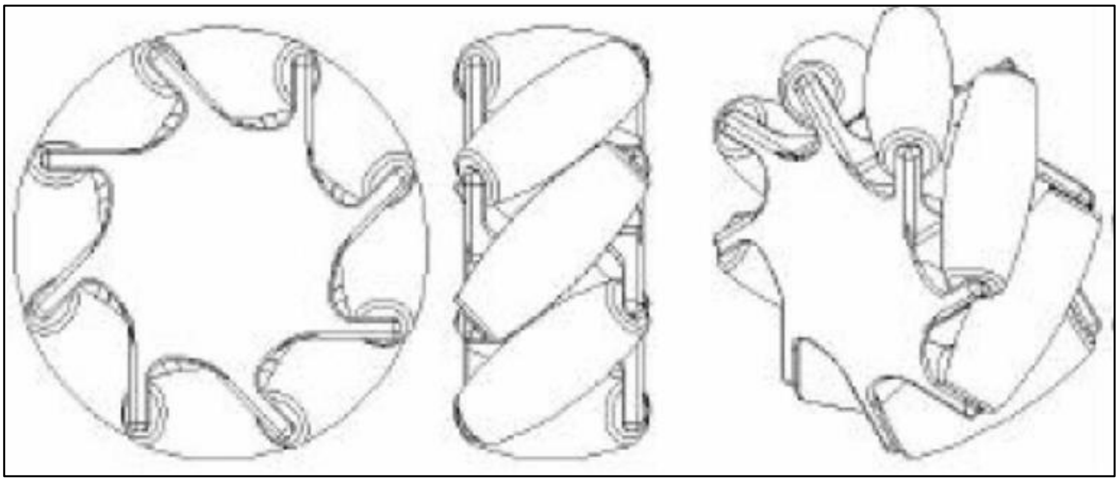


Figure 1: Mecanum Wheel based on Ilon's Concept

This design only can operate in even work surface. When encountering an inclined or an uneven work surface, the rim of the wheel can make contact with the surface instead of the roller, thus preventing the wheel from operating correctly. To encounter this problem a simple alternative design, also proposed by Ilon, which consist two spilt rollers mounted centrally on the periphery of the wheel.

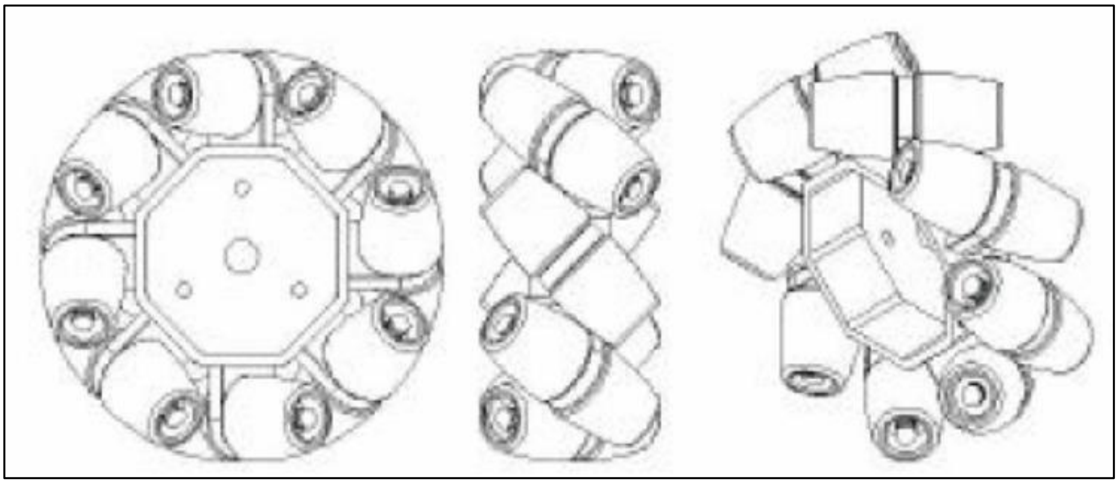


Figure 2 Mecanum Wheel with Centrally Mounted Rollers

This design ensures that the rollers are always in contact with the work surface, thus allowing better performance on uneven surfaces. Using four of Mecanum wheels provides omni-directional movement for a vehicle without needing a conventional steering system. Slipping is a common problem in the Mecanum wheel as it has only one roller with a single point of ground contact at any one time. Due to the dynamics of the Mecanum wheel, it can create force vectors in both the x and y-direction while only being driven in the y-direction. Positioning four Mecanum wheels, one at each corner of the chassis (two mirrored pairs), allows net forces to be formed in the x, y and rotational direction. A difficulty with this strategy is that there are four variables to control three degrees-of-freedom. In this case the system is said to be over determined and it is possible to create conflicts in the actuation. As a result of the constraints associated with the Mecanum wheel some form of controller is required to produce satisfactory motion.

1.1. PROBLEM STATEMENT

The problem statement for Mecanum wheels in a forklift is to design a control system that can accurately and reliably control the movement of the forklift while ensuring stability and safety. Mecanum wheels offer the advantage of omnidirectional movement, which can be particularly useful in tight spaces where manoeuvrability is limited. However, the use of Mecanum wheels in a forklift presents unique challenges due to the weight and size of the vehicle, as well as the need to lift and transport heavy loads. The control system must be able to accurately control the speed and direction of each wheel, while also ensuring that the forklift remains stable and balanced during lifting and transport operations.

This involves developing algorithms for motion planning, trajectory generation, and feedback control, as well as designing hardware components such as motor controllers and sensors to interface with the Mecanum wheels. Additionally, the control system must be designed to ensure the safety of the operator and any personnel in the vicinity of the forklift, by incorporating safety features such as obstacle detection and emergency stop mechanisms.

1.2. OBJECTIVE

- To be able to design Mecanum wheel
- To able use the wheel to help the vehicle manoeuvre in different directions.
- To develop a low-cost prototype model of Mecanum Wheel.

1.3. PLAN OF EXECUTION

Table 1 Plan of Execution

Sr. No.	Project Milestone	January	February	March	April	May
1	Literature Review					
2	Data Compilation					
3	Designing of Mecanum Wheel					
4	CAD Modelling of Forklift					
5	CAD Model Drafting					
6	Material Selection					
7	Forklift Fabrication					
8	Mecanum Wheel Fabrication					
9	Project Optimization & Simulation					
10	Project Report Generation					

1.4. COST ESTIMATION

Table 2 Cost Estimation

Sr. No.	Part Name	Material	Quantity	Cost (₹)
1.	PM-DC Motor 12 V	STD	4 Nos	2400
2.	Sheet Metal	GI	1 Sheet	900
3.	Shaft 10 mm	C-45	1 Kg	150
4.	Rollers	WOOD	48 Nos	1500
5.	DC Gear Motor for Fork Lift	STD	1 Nos	950
6.	Chain	HS	1 m	300
7.	Sprocket	HS	1 Nos	250
8.	Nut Bolt Washer	MS	10 Nos	75
9.	Arduino Board	STD	1 Nos	3500
10.	Battery 12 V	DRY	1 Nos	900
11.	Miscellaneous	-	-	1000
12.	Wiring	CU	5 m	150
13.	MS Angle	MS	5 Kg	400
TOTAL				**13075**

Cost = Raw Material Cost + Standard Parts Cost + Direct Cost

= ₹ 13075 + ₹ 6720 + ₹ 2100

Total Cost of Project = ₹ 21895 /-

1.5. PROJECT FLOW CHART

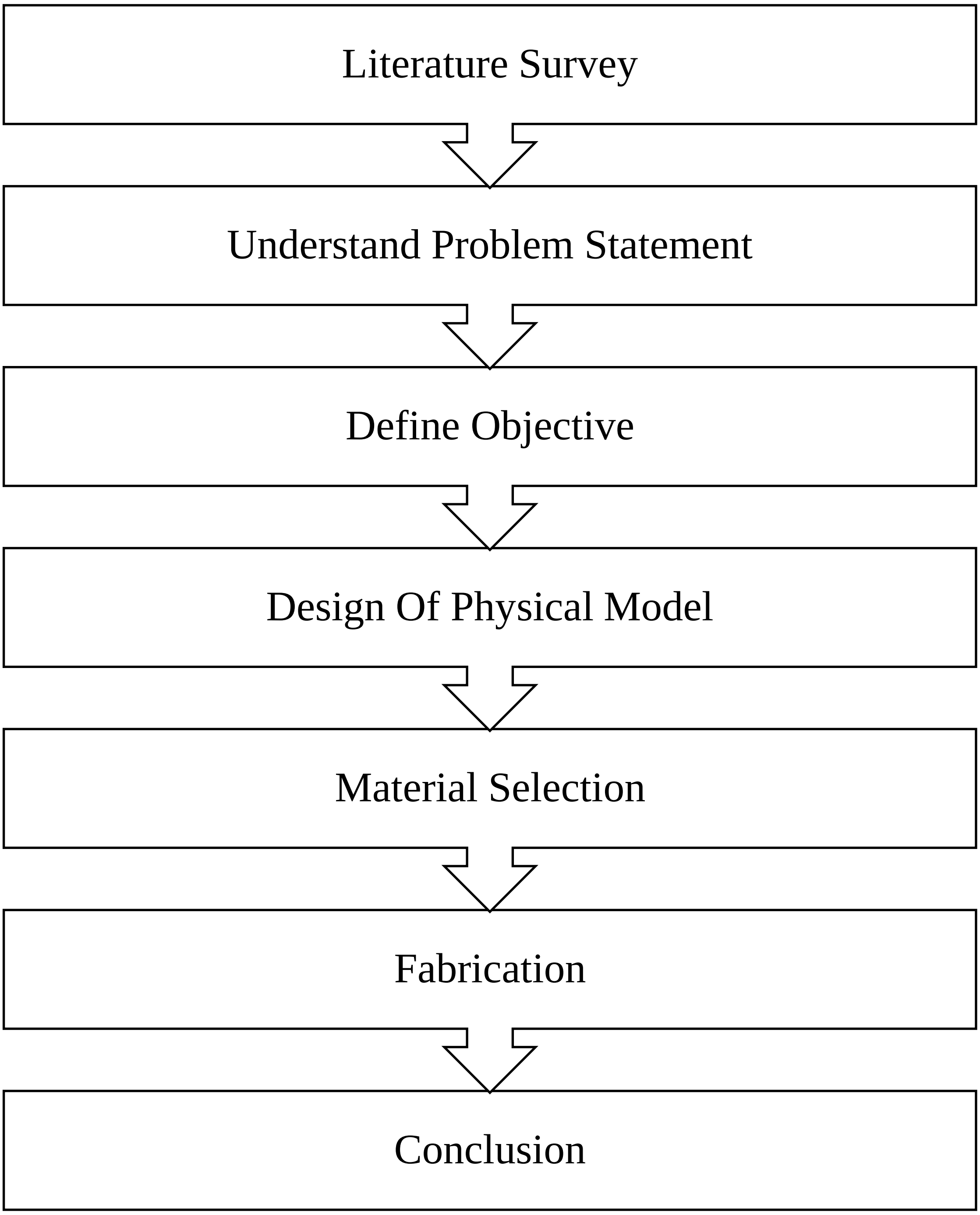


Figure 3 Flow Chart

2. LITERATURE REVIEW

2.1 BACKGROUND

Mecanum wheel is based on the principle of a central wheel with a number of rollers placed at an angle around the periphery of the wheel. The angle between rollers axis and central wheel axis could have any value, but in **the case of conventional Mecanum wheel it is 45°**. The rollers are shaped such that the silhouette of the omni directional wheel is circular. The angled peripheral rollers translate a portion of the force in the rotational direction of the wheel to a force normal to the wheel direction. Depending on each individual wheel direction and speed, the resulting combination of all these forces produces a total force vector in any desired direction, thus allowing the platform to move freely in direction of the resulting force vector, without changing the direction of the wheel.

The Mecanum wheel is a design for a wheel which can move a vehicle in any direction. It is sometimes called the Ilon wheel after its inventor, Bengt Erland Ilon, who came up with the idea in when he was an engineer with the Swedish company Mecanum AB. The US-Patent was filled on the 13 November 1972.

By alternating wheels with left and right-handed rollers, in such a way that each wheel applies force roughly at right angles to the wheelbase diagonal the wheel is on, the vehicle is stable and can be made to move in any direction and turn by varying the speed and direction of rotation of each wheel. Moving all four wheels in the same direction

Figure 4 Mecanum Wheel

causes forward or backward movement, running the wheels on one side in the opposite direction to those on the other side causes rotation of the vehicle, and running the wheels on one diagonal in the opposite direction to those on the other diagonal causes sideways movement.

Before starting our work, we have undergone through many research papers which indicates that for a material handling based industries it was a tricky task as many factors being associated with Mecanum wheels. Some research papers which have led us to approach to the idea of a machine which may give solution to all these factors are as follows:

Table 3 Finding out of Literature Review

PAPER NAME	RESEARCH PAPER DEATIL	FINDINGS
Atlas Motion Platform Mecanum Wheel Jacobian In The Velocity And Static Force Domains	Jonathan J. Plumpton, M. John D. Hayes, Robert G. Langlois and Bruce V. Burlton, Department of Mechanical and Aerospace Engineering, Carleton University, Ottawa, ON, Canada	In this paper, novel generalized kinematic and static force models for the Atlas spherical platform, actuated with Mecanum wheels, has been presented. The model was first formulated at the static force level leading
Omni-Directional Mobile Robot with Mecanum Wheel	Jefri Efendi Mohd Salih,Profesor Dr Sazali Yaacob,Prof. Madya Dr Mohd Rizon Mohd Juhari. School of Mechatronics Engineering Kolej Universiti Kejuruteraan Utara Malaysia	In this paper, we review researches on omni-directional mobile robot design which Mecanum wheel as component in mobile robot propulsion. Omni-directional mobile robot has vast advantages over conventional design likes differential drive-in term of mobility in congested environments. Omni-directional mobile robot could perform important tasks in environments congested with static and/or dynamic obstacle and narrow aisles, such as those commonly found in manufacturing floor, warehouses, offices and hospitals.
Kinematic Model of a Four Mecanum Wheeled Mobile Robot	International Journal of Computer Applications (0975 – 8887) Volume 113 – No. 3, March 2015 Hamid Taheri College of Electronic and Information NUAA Nanjing China	This paper introduces omnidirectional Mecanum wheels and discusses the kinematic relations of a platform used four Mecanum wheels. Forward and Inverse kinematic is been derived in this paper. Experimental and analytically results are obtained and 8 different motions without changing the robot's orientation is achieved
The Design and Development of an Omni-Directional Mobile Robot Oriented to an Intelligent Manufacturing System	Jun Qian 1, Bin Zi 1,×, Daoming Wang 1 ID , Yangang Ma 1 and Dan Zhang 2 1 School of Mechanical Engineering, Hefei University of Technology, 193 Tunxi Road, Hefei 230009.	The mechanical system of the mobile robot is made up of three separable layers so as to simplify its combination and reorganization. Each modularized wheel was installed on a vertical suspension mechanism, which ensures the moving stability and keeps the distances of four wheels invariable. Experimental results show that the omni-directional mobile robot can move stably and autonomously in an indoor environment and in industrial fields.

2.2 DIFFERENT DRIVES

Mecanum Drive is a type of omnidirectional drive system that uses a set of wheels with rollers mounted at a 45-degree angle to the wheel's rotation axis. These rollers allow the wheels to move in any direction, making it possible for the robot to move sideways, diagonally, or even spin in place. Mecanum Drive is often used in applications where precise manoeuvrability is required, such as in robotics competitions or industrial automation.

Holonomic Drive is another type of omnidirectional drive system that uses a set of wheels arranged in a specific pattern to allow the robot to move in any direction. Unlike Mecanum Drive, Holonomic Drive uses a specific wheel arrangement to achieve omnidirectional movement. This arrangement typically involves three or more wheels arranged in a triangular or square pattern. Holonomic Drive is often used in applications where precise manoeuvrability is required, such as in robotics competitions or industrial automation.

Swerve Drive is a type of omnidirectional drive system that uses a set of wheels that can rotate independently of each other. This allows the robot to move in any direction, similar to Mecanum Drive and Holonomic Drive. However, Swerve Drive offers greater precision and control over the robot's movement, as each wheel can be independently controlled. Swerve Drive is often used in applications where precise manoeuvrability is required, such as in robotics competitions or industrial automation.

- In terms of specifications, Mecanum Drive typically requires four wheels with rollers mounted at a 45-degree angle to the wheel's rotation axis. Holonomic Drive typically requires three or more wheels arranged in a specific pattern, such as a triangular or square pattern. Swerve Drive typically requires four or more wheels that can rotate independently of each other.
- Overall, the choice between Mecanum Drive, Holonomic Drive, and Swerve Drive depends on the specific application and the level of precision and control required. Each drive system has its own advantages and disadvantages, and it's important to carefully consider these factors when selecting a drive system for a particular robot or automation application.

Comparison between different types of drives

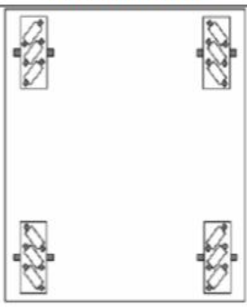
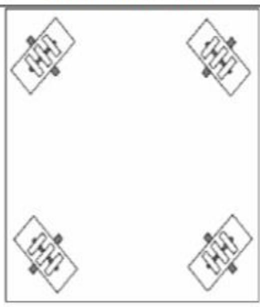
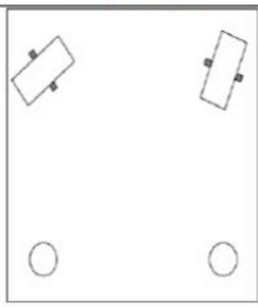
	Mecanum drive	Holonomic drive	Swerve drive
Description	 Wheels with angled rollers	 Wheels with "straight" rollers (omniwheels)	 Independently steered drive modules
Advantages	- compact design - high load capacity - simple to control - less speed and pushing force when moving diagonally	- low weight - compact design - simple to control - less speed and pushing force when moving diagonally	- simple conceptually - simple wheels - continuous wheel contact - high load capacity - robust to floor conditions
Disadvantages	- very complex conceptually - discontinuous wheel contact - high sensitivity to floor irregularities - complex wheel design	- more complex conceptually - discontinuous wheel contact or variable drive-radius - sensitive to floor irregularities - lower traction	- complex mechanical design - heavy and massive design - complex to program and control - high friction and scrubbing while steering

Figure 5 Different Types of Drives

2.3. METHODOLOGY

Mecanum drive is a type of holonomic drive base; meaning that it applies the force of the wheel at a 45° angle to the robot instead of on one of its axes. By applying the force at an angle to the robot, you can vary the magnitude of the force vectors to gain translational control of the robot.

Direction of Movement	Wheel Actuation
Forward	All wheels forward same speed
Reverse	All wheels backward same speed
Right Shift	Wheels 1, 4 forward; 2, 3 backward
Left Shift	Wheels 2, 3 forward; 1, 4 backward
CW Turn	Wheels 1, 3 forward; 2, 4 backward
CCW Turn	Wheels 2, 4 forward; 1, 3 backward

Figure 6 Direction and Wheel Actuation

Control Algorithm

To get the most out of a Mecanum drive system you will need to have the following information available to control it:

- Desired Angle – What angle the robot needs to translate
- Desired Magnitude – What speed the robot must move
- Desired Rotation – How quickly to change the direction the robot faces

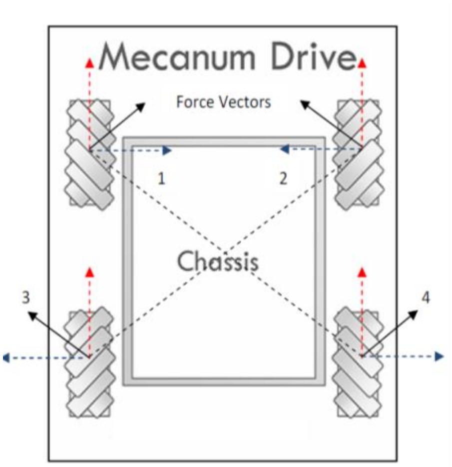


Figure 7 Resultant Force Diagram

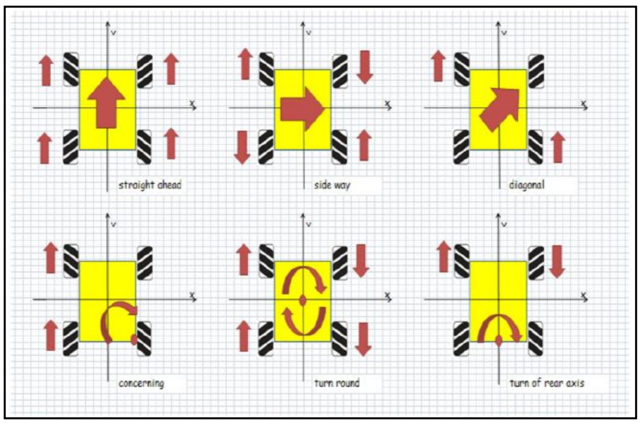


Figure 8 Control Algorithm

2.4. ADVANTAGES

- Can help the vehicle move in any direction.
- There is no additional friction while turning.
- It allows for in-place rotation with minimal ground friction.
- It also allows for in-place rotation with low torque.
- It is much simpler and more reliable than crab drive system.

2.5 APPLICATIONS

To transport materials flexibly and smoothly in a tight plant environment.

1.2.1. Military Field

The manoeuvrability provided by Omni-directional vehicles can be utilized and can be very important in numerous outdoors applications, such as search and rescue missions, military activities, planetary explorations and Mine-Operations.

Characterized by Omni-directional wheels especially suited to tackle rocky terrain, it travels at a speed of 5-10 km/h. This design incorporates: hub less wheels (which allowed ingress/egress for the astronaut crew for extra-vehicular activities and access to other surface modules and rovers), Mecanum wheels, a linear motor drive and a single point rotary shock absorber/suspension system.

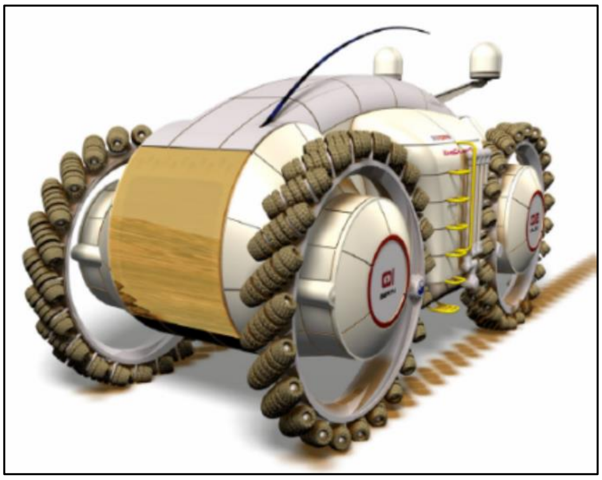


Figure 9 Mecanum Wheel Vehicle for USA Navy

1.2.2. Industrial Field

Airtrax ATX-3000 industrial forklifts (Figure 14) excel in applications requiring tight manoeuvring or transporting long loads sideways through standard sized doors or narrow aisle ways. The ATX's unique, Omni-Directional movement allows it to travel in all directions thus making it an ideal vehicle to work in tight spaces where turns are not possible and finite control is a necessity. The truck features 48-volt transistor controls with state-of-the-art technology, infinitely variable travel, lift and lower speeds, excellent visibility, ergonomic controls and operator comfort. The unique design of the four 21x12 independently driven Mecanum wheels enables the ATX's Omni Directional capabilities. Each wheel is directly driven by individual transaxles. The wheels consist of a large, heavy-duty hub with 12 uniquely designed polyurethane rollers. The wheel and roller design provides the Omni-Directional movement of the vehicle based on the speed and direction of each wheel as determined by the operation of the traction joystick. Each roller incorporates bearings that do not require periodic greasing or maintenance under most conditions. Since each roller rotates freely, scrubbing against the floor is minimized while turning or moving sideways.

Figure 10 Airtrax Sidewinder Lift Truck

1.2.3. Medical Field

Powered wheelchairs are known to provide benefits for older adults by enabling them to have a means of independent mobility. These benefits include: participation in self-care, productivity, and leisure occupations; as well as, socialization opportunities, and positive self-worth. Overall powered wheelchairs are linked to an improved quality of life for older adults who have a reduced ability to walk and do not have the stamina, strength, or ability to propel themselves in a manual wheelchair. Without a powered wheelchair these older adults would be dependent on others to complete life tasks, and unable to have independent mobility. The OMNI (Office Wheelchair for High Manoeuvrability and Navigational Intelligence for People with Severe Handicap) is a standalone wheelchair developed with two goals in mind:

1) To allow high mobility in complex environments; and
2) To have modes of operation that will help the user have higher degrees of independence. This wheelchair has been designed for individuals with severe mental and physical disabilities. It consists of Mecanum wheels that provide 3-DOF (degrees of freedom) for the wheelchair; a specialized joystick for 3-DOF movement; a sensor ring around the wheelchair that has IR (infrared) and

Figure 11 Omnidirectional Wheelchairs

ultrasound sensors to provide obstacle detection capabilities; a bumper sensor for fail-safe detection of collisions; wheel odometers for knowledge of the wheelchair's location; an elevating seat to raise the user; and a specialized display for the user select modes of operation. The omnidirectional wheelchair being developed at the University of Western Australia's Centre for Intelligent Information Processing Systems (CIIPS) allows the user to easily manoeuvre in what would otherwise be an extremely complicated environment. This project made improvements to the Mecanum wheels, batteries, motor driver cards, human interface, control software, chassis and suspension system. These improvements transformed the partially working prototype into a fully usable wheelchair. The result is much higher driving accuracy and a greatly improved overall experience for the user in both comfort and ease of use. On the whole, the project was extremely successful and will provide a very solid test bed for advanced driving and mapping projects in the future.

3. DESIGN

3.1. CONSTRUCTION

The frame is usually made of mild steel. It is strong enough to withstand all types of loads in working condition. All other parts are fitted to the frame. Frame is helping the supporting of the various light load support. Frame shows the good aesthetic loop. every machine should have required the good frame design. Frame material should have high strength because frame balancing of another machine load. in ours project the frame showing important role. the vertical pulley and sprocket are mounted on vertical support of the frame. Main whole project assembly our project mounted on frame. The proper selection of material for the different part of a machine is the main objective in the fabrication of machine. For a design engineer it is must that he be familiar with the effect, which the manufacturing process and heat treatment have on the properties of materials. The Choice of material for engineering purposes depends upon the following factors:

1. Availability of the materials.
2. Suitability of materials for the working condition in service.
3. The cost of materials.
4. Physical and chemical properties of material.
5. Mechanical properties of material.

The mechanical properties of the metals are those, which are associated with the ability of the material to resist mechanical forces and load. We shall now discuss these properties as follows:

1. Strength: It is the ability of a material to resist the externally applied forces
2. Stress: Without breaking or yielding. The internal resistance offered by a part to an externally applied force is called stress.
3. Stiffness: It is the ability of material to resist deformation under stresses. The modules of elasticity of the measure of stiffness.
4. Elasticity: It is the property of a material to regain its original shape after deformation when the external forces are removed. This property is desirable for

material used in tools and machines. It may be noted that steel is more elastic than rubber.

5. Plasticity: It is the property of a material, which retain the deformation produced under load permanently. This property of material is necessary for forging, in stamping images on coins and in ornamental work.
6. Ductility: It is the property of a material enabling it to be drawn into wire with the application of a tensile force. A ductile material must be both strong and plastic. The ductility is usually measured by the terms, percentage elongation and percent reduction in area. The ductile materials commonly used in engineering practice are mild steel, copper, aluminium, nickel, zinc, tin and lead.
7. Brittleness: It is the property of material opposite to ductile. It is the property of breaking of a material with little permanent distortion. Brittle materials when subjected to tensile loads snap off without giving any sensible elongation. Cast iron is a brittle material.
8. Malleability: It is a special case of ductility, which permits material to be rolled or hammered into thin sheets, a malleable material should be plastic but it is not essential to be so strong. The malleable materials commonly used in engineering practice are lead, soft steel, wrought iron, copper and aluminium.
9. Toughness: It is the property of a material to resist the fracture due to high impact loads like hammer blows. The toughness of the material decreases when it is heated. It is measured by the amount of absorbed after being stressed up to the point of fracture. This property is desirable in parts subjected to shock an impact load.
10. Resilience: It is the property of a material to absorb energy and to resist rock and impact loads. It is measured by amount of energy absorbed per unit volume within elastic limit. This property is essential for spring material.
11. Creep: When a part is subjected to a constant stress at high temperature for long period of time, it will undergo a slow and permanent deformation called creep. This property is considered in designing internal combustion engines, boilers and turbines.
12. Hardness: It is a very important property of the metals and has a wide verity of meanings. It embraces many different properties such as resistance to wear scratching, deformation and match inability etc. It also means the ability of the

metal to cut another metal. The hardness is usually expressed in numbers, which are dependent on the method of making the test. The hardness of a metal may be determined by the following test:

a) Brinell hardness test
b) Rockwell hardness test
c) Vickers hardness (also called diamond pyramid) test and
d) Share Scaleroscope

The science of the metal is a specialized and although it overflows in to realms of knowledge it tends to shut away from the general reader. The knowledge of materials and their properties is of great significance for a design engineer. The machine elements should be made of such a material which has properties suitable for the conditions of operations. In addition to this a design engineer must be familiar with the manufacturing processes and the heat treatments have on the properties of the materials. In designing the various part of the machine, it is necessary to know how the material will function in service. For these certain characteristics or mechanical properties mostly used in mechanical engineering practice are commonly determined from standard tensile tests. In engineering practice, the machine parts are subjected to various forces, which may be due to either one or more of the following.

- Energy transmitted
- Weight of machine
- Frictional resistance
- Inertia of reciprocating parts
- Change of temperature
- Lack of balance of moving parts

The selection of the materials depends upon the various types of stresses that are set up during operation. The material selected should with stand it. Another criterion for selection of metal depend upon the type of load because a machine part resist load more easily than a live load and live load more easily than a shock load.

Selection of the material depends upon factor of safety, which in turn depends upon the following factors.

- Reliabilities of properties
- Reliability of applied load
- The certainty as to exact mode of failure
- The extent of simplifying assumptions
- The extent of localized
- The extent of initial stresses set up during manufacturing
- The extent loss of life if failure occurs
- The extent of loss of property if failure occurs

3.2. MATERIAL USED

3.2.1. Mild Steel

❖ Reasons:

- Mild steel is readily available in market.
- It is economical to use.
- It is available in standard sizes.
- It has good mechanical properties i.e., it is easily machinable.
- It has moderate factor of safety, because factor of safety results in unnecessary wastage of material and heavy selection. Low factor of safety results in unnecessary risk of failure.
- It has high tensile strength.
- Low co-efficient of thermal expansion.

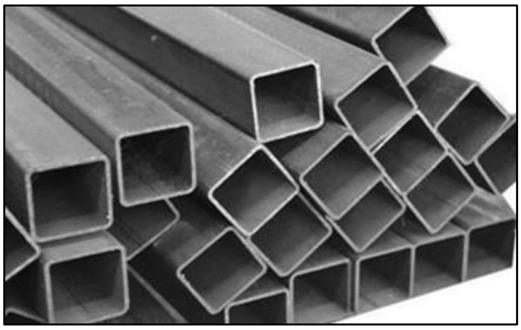


Figure 12 Square Pipe

❖ Properties of Mild Steel:

M.S. has a carbon content from 0.15% to 0.30%. They are easily wieldable thus can be hardened only. They are similar to wrought iron in properties. Both ultimate tensile and compressive strength of these steel increases with increasing carbon content. They can be easily gas welded or electric or arc welded. With increase in the carbon percentage weld ability decreases. Mild steel serves the purpose and was hence was selected because of the above purpose

Basic Frame: The hollow square pipes of material of mild steel are selected for the frame. The pipes are cut into required size by cutting machine. The end of the pipes cut into 45 degrees (angle) to form rectangular frame. After cutting, the end of the square pipes is grinded so that it became smooth and convenient for welding. The square pipes are welded together to form a rectangular basic frame.

3.2.2. Mild Steel Sheet Metal

These mild steel sheets confirm to various standards like ANSI, API, MSS, BS, DIN, JIS & IS standards. We can provide these mild steel sheets in different grades, thickness, length and weight as per the requirements. Sheet metal is metal formed by an industrial process into thin, flat pieces. Sheet metal is one of the fundamental forms used in metalworking, and it can be cut and bent into a variety of shapes. Countless everyday objects are fabricated from sheet metal. Thicknesses can vary significantly; extremely thin sheets are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate steel or "structural steel". Sheet metal is available in flat pieces or coiled strips. The coils are formed by running a continuous sheet of metal through a roll slitter.

Table 4 Sheet Metal Size Selection

Gauge	Thickness (mm)	Weight (kg/sq.m)
13	2.25	17.6
14	2	15.7
15	1.8	14.15
16	1.6	12.55
17	1.4	11
18	1.25	9.8
19	1.12	8.8
20	1	7.85
21	0.9	7.05
22	0.8	6.3
24	0.63	4.95
26	0.5	3.9
28	0.4	3.15

3.2.3. MS Flat

MS Flats are generally used in Industrial gratings, various fabrication works & domestically, it is used in grills outside window. Representation of M.S. Flats is done by the Width (W) & the Thickness (T) of the Flat.

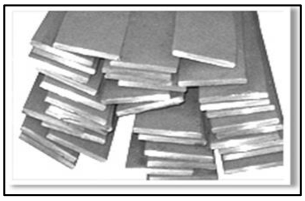


Figure 13 MS Flat

For example: When we say 25 X 5 FLAT, it means Width = 25mm & Thickness = 5mm. The weight of flat bar is easily calculated. Simply multiply the appropriate alloy density by the length, width, and thickness of the required part for taking weight of each component.

Table 5 MS Flat Weight

Size (mm)	Weight (kg/ft)	Weight (Kg/mtr)
12 x 3	0.086	0.282
12 x 5	0.143	0.470
18 x 4	0.180	0.585
20 x 3	0.143	0.470
20 x 5	0.241	0.790
20 x 6	0.287	0.942
25 x 3	0.183	0.600
25 x 5	0.305	1.000
25 x 6	0.365	1.197
25 x 8	0.470	1.550
25 x 10	0.609	1.998

Cross-Sectional size of link used is 18x4 mm

Representation of M.S. Flats is done by the Width (W) & the Thickness (T) of the Flat. Weight (Kg/mtr)

3.2.4. Rubber Rollers

In this project the roller is used to rotate the wheel mechanism. There are 12 rollers are used to rotate the single. They are made up of hard rubber for good grip on road.

3.2.5. DC Wiper Motor

The standard voltage requirement for the wiper motor is 12 volts DC. The electrical system in a running automobile usually puts out between 13 and 13.5 volts, so it's safe to say the motor can handle up to 13.5 volts with no problem. The minimum required current for the motor is 1.6 amps at 70 rpm, 0.9 amps at 41 rpm (and 4 amps if you elect to run it at 106 rpm). Direct-current motors transform electrical energy into mechanical energy. They drive devices such as hoists, fans, pumps, punch-presses, and cars. These devices may have a definite torque-speed characteristic or a highly variable one. The torque-speed characteristic of the motor must be adapted to the type of the load it has to drive.

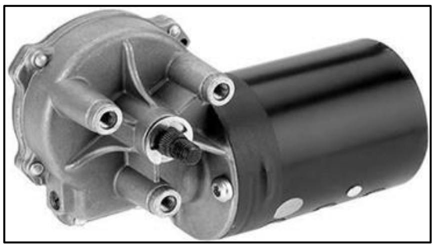


Figure 14 Wiper Motor

The reason is that the torque-speed characteristics of dc motors can be varied over a wide range while retaining high efficiency.

It takes a lot of force to accelerate the wiper blades back and forth across the windshield so quickly. In order to generate this type of force, a worm gear is used on the output of a small electric motor. The worm gear reduction can multiply the torque of the motor by about 50 times, while slowing the output speed of the electric motor by 50 times as well. The output of the gear reduction operates a linkage that moves the wipers back and forth.

3.2.6. Fasteners (Nut & Bolt)

A nut is a type of fastener with a threaded hole. Nuts are almost always used in conjunction with a mating bolt to fasten two or more parts together. The two partners are kept together by a combination of their threads' friction, a slight stretching of the bolt, and compression of the parts to be held together. Bolts use a wide variety of head

Figure 15 Nut-Bolts

designs, as do screws. These are designed to engage with the tool used to tighten them. Some bolt heads instead lock the bolt in place, so that it does not move and a tool is only needed for the nut end.

3.2.7. Spray Paint Can

Spray paint, also known as aerosol paint, is paint that's stored in a pressurized container and dispensed using a valve to release a mixture of paint and a propellant, usually pressurized gas or compressed air. The result is a fine, even mist that is easily applied to a variety of surfaces. Spray painting is one of three primary methods for paint application besides using a paintbrush or a roller, and is generally quicker, cleaner, and easier to achieve a uniform coat.

Figure 16 Spray Paint Can

3.3. CIRCUIT DETAILS

Arduino Uno

3.3.1. Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

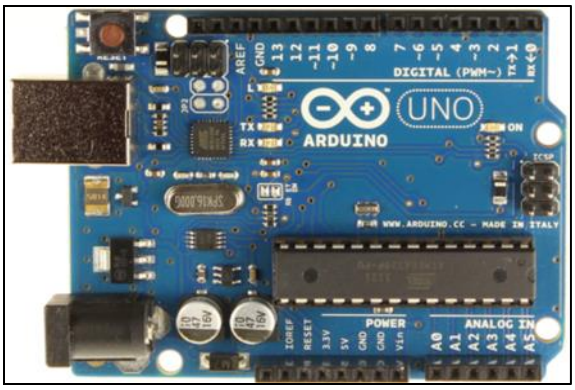


Figure 17 Arduino Uno R3 (Atmega328)

Table 6 Arduino Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

The power pins are as follows:

- VIN.

The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can

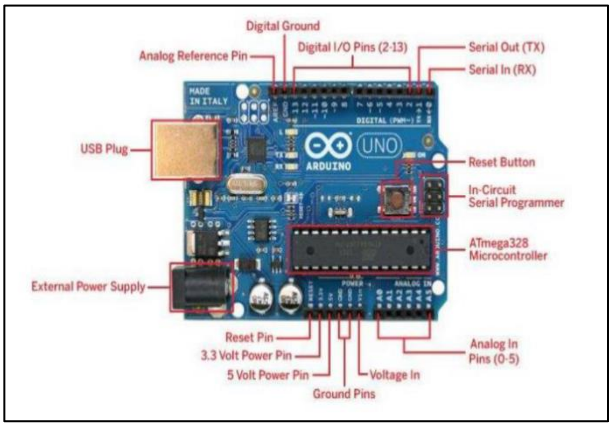


Figure 18 Arduino Uno Part Name

supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

- 5V.

This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

- 3.3V.

3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

GND. Ground pins. This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

- LED 13.

There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

3.3.2. Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board).

The ATmega328 on the Arduino Uno comes pre-burned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

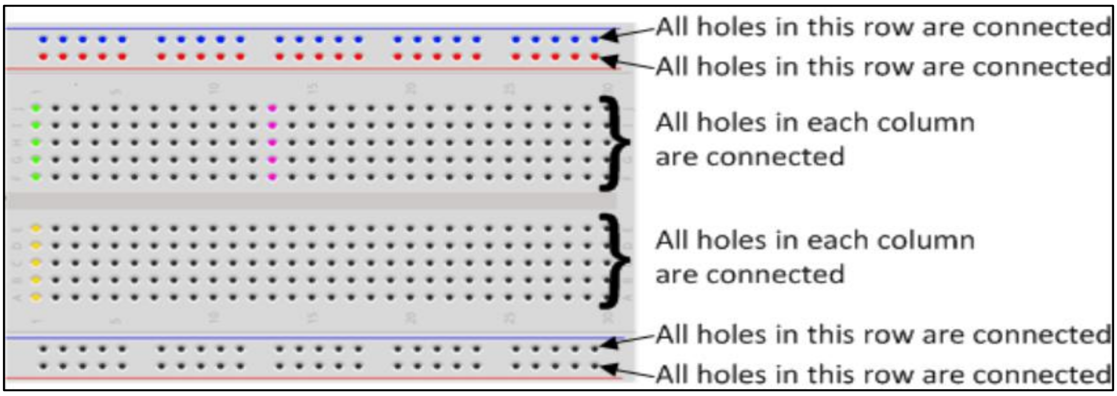


Figure 19 Breadboard Instructions

The most important advantage with Arduino is the programs can be directly loaded to the device without requiring any hardware programmer to burn the program. This is done because of the presence of the 0.5KB of Bootloader which allows the program to be burned into the circuit. All we have to do is to download the Arduino software and writing the code.

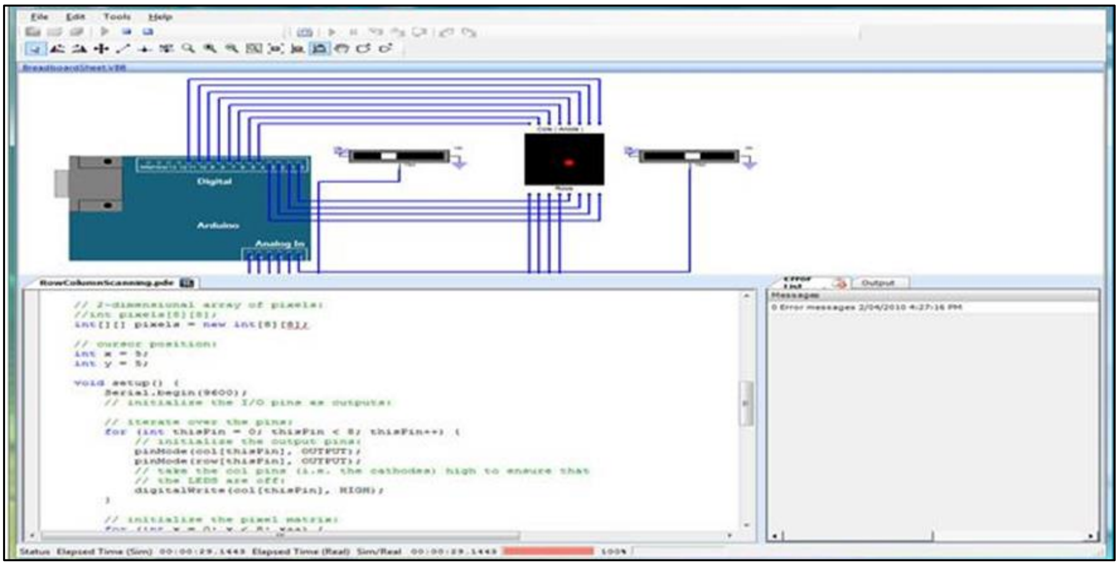


Figure 20 Arduino Tool Window

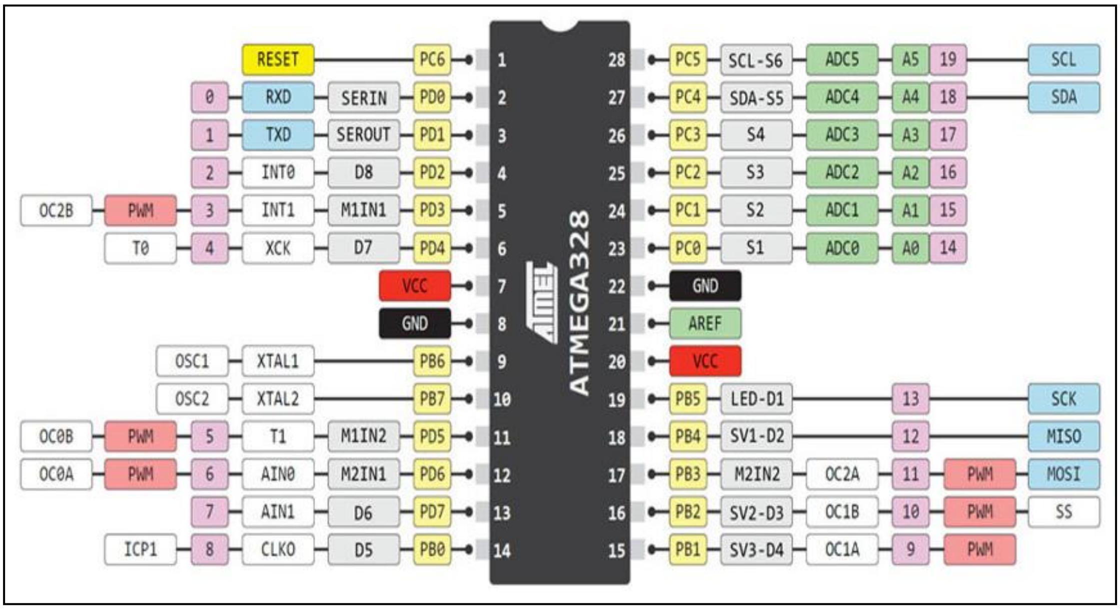


Figure 21 AT Mega328 Microcontroller

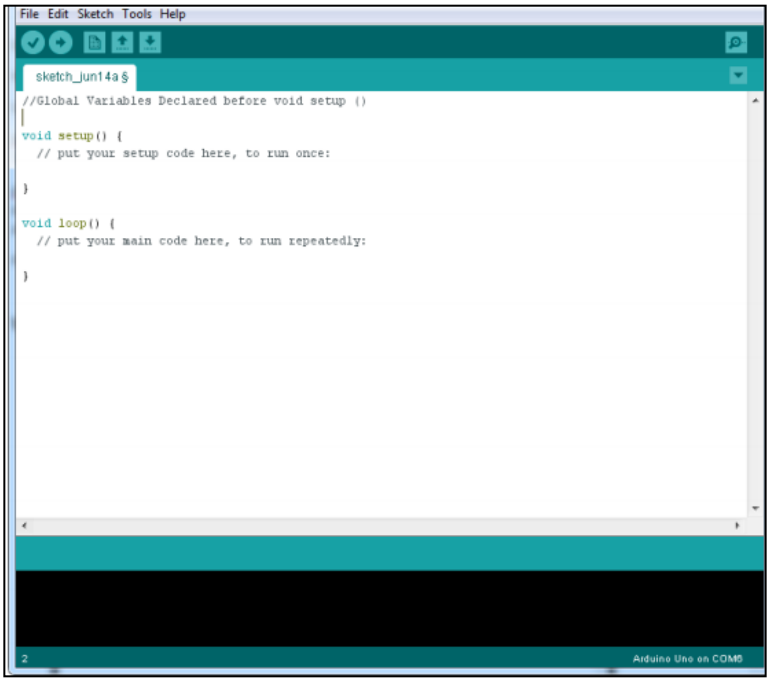


Figure 22 Arduino Software

3.3.3. LCD Display

An LCD presents information on a small display panel or screen by using one or more segments that change their appearance in response to an AC voltage.

MECHANICAL DATA		
ITEM	STANDARD VALUE	UNIT
Module Dimension	146.0 x 62.5	mm
Viewing Area	123.5 x 43.0	
Dot Size	0.92 x 1.10	
Dot Pitch	0.98 x 1.16	
Mounting Hole	139.0 x 55.5	
Character Size	4.84 x 9.22	

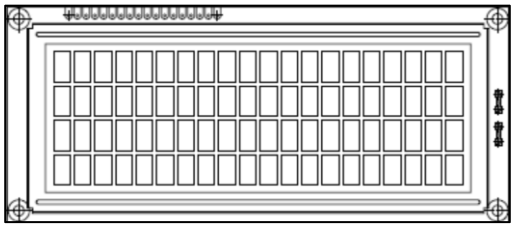


Figure 23 LCD Data

Here, we have used a basic monochrome LCD because of its low power consumption. In an LCD, incoherent light emerges from the backlight panel and then enters a vertical polarizing filter that limits the electric field vector.

The polarized light then enters a liquid crystal which is a liquid composed of molecules organized in a regular helical structure that rotates the polarity by 90 degrees when no voltage is applied to it. The light then passes through a horizontal polarizing filter and is visible to the user. Liquid crystal Display (LCD) displays temperature of the measured element, which is calculated by the microcontroller. CMOS technology makes the device ideal for application in hand held, portable and other battery instruction with low power consumption.

INTERFACE PIN FUNCTION		
PIN NO.	SYMBOL	FUNCTION
1	V_{SS}	Ground
2	V_{DD}	+ 3 V or + 5 V
3	V_0	Contrast adjustment
4	RS	H/L register select signal
5	$R/\overline{W}$	H/L read/write signal
6	E	H → L enable signal
7	DB0	H/L data bus line
8	DB1	H/L data bus line
9	DB2	H/L data bus line
10	DB3	H/L data bus line
11	DB4	H/L data bus line
12	DB5	H/L data bus line
13	DB6	H/L data bus line
14	DB7	H/L data bus line
15	A	Power supply for LED (4.2 V)
16	K	Power supply for B/L (0 V)
17	NC/V_{EE}	NC or negative voltage output
18	NC	NC connection

Figure 25 LCD Pin Function

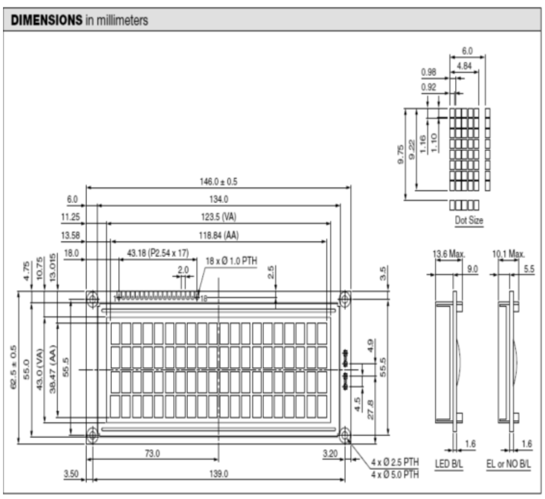


Figure 24 LCD Dimension

20 x 4 Character LCD

FEATURES

- Type: Character
- Built-in controller: ST 7066 (or equivalent)
- Duty cycle: 1/16
- 5 x 8 dots include cursor
- + 5 V power supply
- LED can be driven by pin 1, pin 2, pin 15, pin 16 or A and K
- N.V. optional for + 3 V power supply

3.3.4. Power Supply

There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function.

For example, a 5V regulated supply:

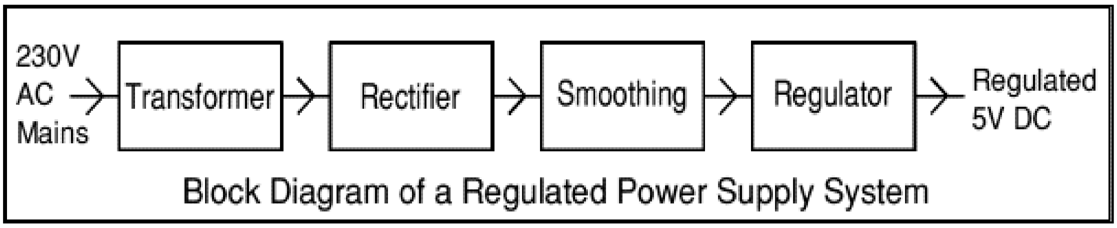


Figure 26 Regulated Supply 5V

Each of the blocks is described in more detail below:

- Transformer - Steps down high voltage AC mains to low voltage AC.
- Rectifier - Converts AC to DC, but the DC output is varying.
- Smoothing - Smoothens the DC from varying greatly to a small ripple.
- Regulator - Eliminates ripple by setting DC output to a fixed voltage.

3.3.5. Transformer

The low voltage AC output is suitable for lamps, heaters and special AC motors. It is not suitable for electronic circuits unless they include a rectifier and a smoothing capacitor.

The transformer used in this circuit has secondary rating of 7.5V. The main function of the transformer is to step down the AC voltage available from the main. The main connections are given to its primary winding through a switch connected to a phase line. The transformer provides a 7.5V AC output at its secondary terminals and the maximum current that can be drawn from the transformer is 1 Amp which is well above the required level for the circuit.

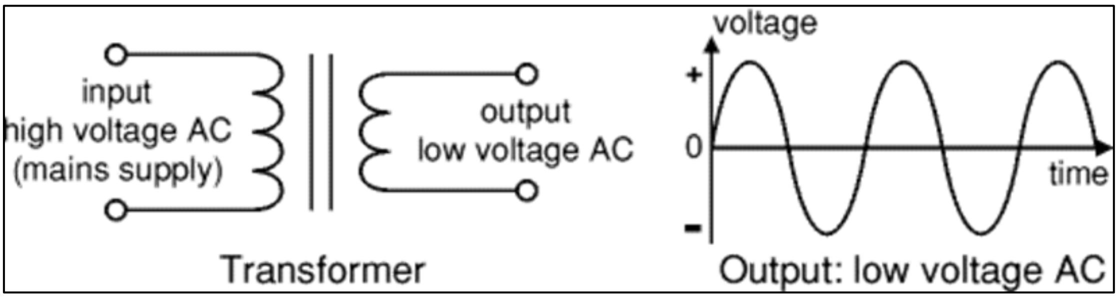


Figure 27 Transformer

The bridge rectified the AC voltage available from the secondary of the transformer, i.e., the bridge rectifier converts the AC power available into DC power but this DC voltage available is not constant. It is a unidirectional voltage with varying amplitude.

To regulate the voltage from the bridge rectifier, capacitors are connected. Capacitors C1 filter the output voltage of the rectifier but their output is not regulated and hence 7805 is connected which is specially designed for this purpose.

Although voltage regulators can be designed using op-amps, it is quicker and easier to use IC voltage regulator. Furthermore, IC voltage regulators are available with features such as programmable output current/ voltage boosting, internal short circuit current limiting, thermal shut down and floating operation for high voltage applications. The 78 XX series consists of three terminals viz, input, output & ground. This is a group of fixed positive voltage regulator to give and output voltage ranging from 5V to 24V.

These ICs are designed as fixed voltage regulators and with adequate heat sinking, can delivery output current in excess of 1 Amp although these devices do not require external components and such components can be used to obtain adjustable voltage and current limiting.

In addition, the difference between the input and output voltages (V in Vo) called the dropout voltage must be typically 2V even from a power supply filter. Capacitors C2, C3, C4, and C5 are small filters which are used for extra filtering. LED1& LED2 are used for Power ON indicator for IC1 and IC2, current-limiting resistors R2&R4, which prevents the LED's from getting heated and thus damaged.

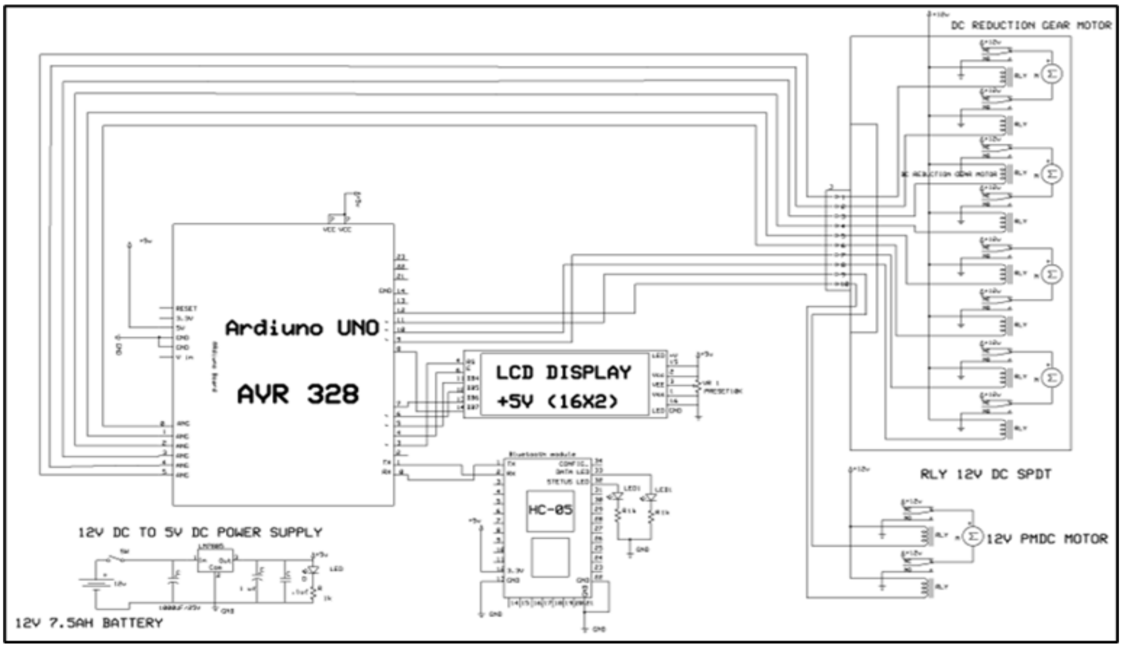


Figure 28 Project Circuit Diagram

3.3.6. Relays

The basis for relays, is the simple electromagnet. A nail, some wire, and a battery are all that is needed to make one, with no power applied to the coil, the nail is NOT magnetized Connect this to a power source, and it will now grab and hold small pieces of metal.

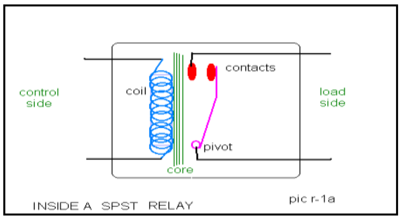


Figure 29 Relays

So, herein lies the concept. If we take an electromagnet, it will interact with metals in its vicinity. now let's take this one step further... If we were to place a piece of metal, near the electromagnet, and connect some contacts, so that when the electromagnet is energized, the contacts close, we have a working relay.

The simplest relay, is the Single Pole, Single Throw (SPST) relay. It is nothing more than an electrically controlled on-off switch. It's biggest property, is the ability to use a

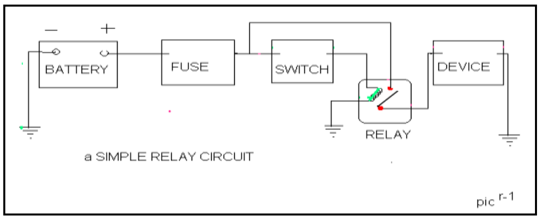


Figure 30 Sample Relay Control

very small current, to control a much larger current. this is desirable because we can now use smaller diameter wires, to control the current flow through a much larger wire, and also to limit the wear and tear on the control switch.

Above is a simple relay control. Now, here is what is happening......

The control circuit (GREEN) powers the coil inside the relay, using a small amount of

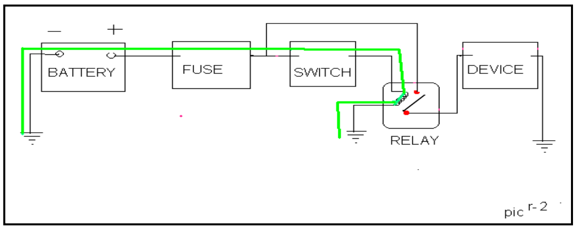


Figure 31 Sample Relay Control 2

current. It flows from the battery, through the fuse (for protection) to a switch, (say, a light switch) then to the coil in the relay, energizing it.

The coil, now energized becomes an electromagnet, and attracts the metal strip with the contacts, which closes, providing a secondary heavy current path (RED) to the device (say, the fog lights). Turning off the switch, opens the circuit to the coil, removes current flow, and the electromagnet is no longer a magnet, the secondary path is opened, and the lights extinguish.

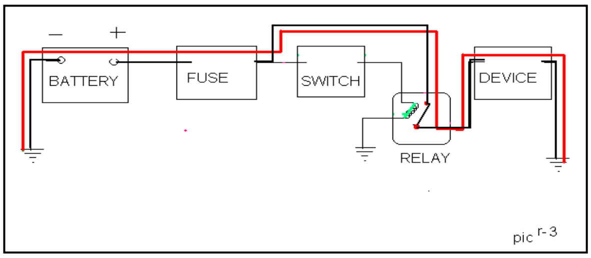
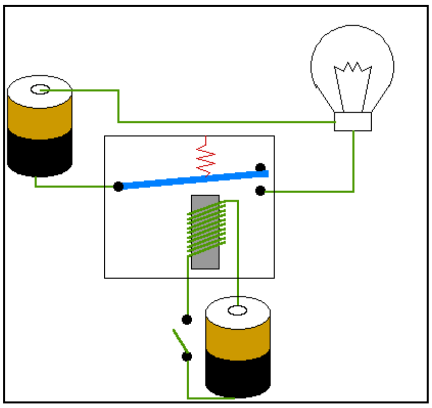


Figure 33 Sample Relay Control 3



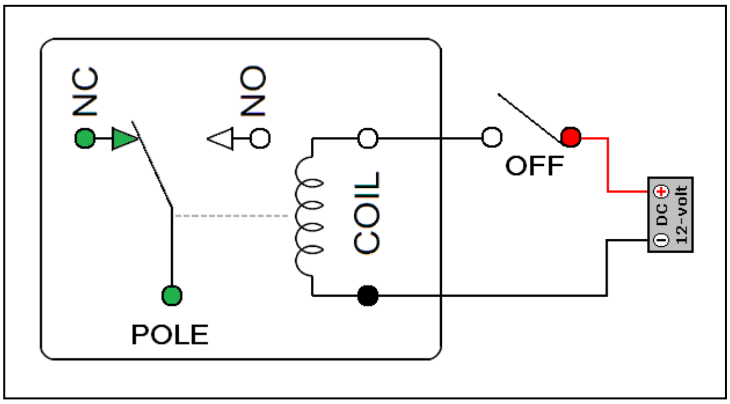


Figure 32 Electro-Mechanical Relay

4. FABRICATIONS

4.1. PROCESS SHEET

The various machining operations conducted after material selection are as follows:

4.1.1. Cutting

Cutting is the separation or opening of a physical object, into two or more portions, through the application of an acutely directed force.

Implements commonly used for cutting are the knife and saw, or in medicine and science the scalpel and microtome. However, any sufficiently sharp object is capable of cutting if it has a hardness sufficiently larger than the object being cut, and if it is applied with sufficient force. Even liquids can be used to cut things when applied with sufficient force (see water jet cutter).

The material as our required size. The machine used for this operation is power chop saw. A power chop saw, also known as a drop saw, is a power tool used to make a quick, accurate crosscut in a work piece at a selected angle. Common uses include framing operations and the cutting of moulding. Most chop saws are relatively small and portable, with common blade sizes ranging from eight to twelve inches.

Figure 34 Cutting Operation

4.1.2. Welding

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool causing fusion. Welding is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal.

In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that, based on weld configuration (butt, full penetration, fillet, etc.), can be stronger than the base material (parent metal). Pressure may also be used in conjunction with heat, or by itself, to produce a weld.Square pipes of different lengths to make frame. The machine used for this operation is electric arc welding. Electrical arc welding is the procedure

Figure 35 Welding Operation

used to join two metal parts, taking advantage of the heat developed by the electric arc that forms between an electrode (metal filler) and the material to be welded. The welding arc may be powered by an alternating current generator machine (welder). This welding machine is basically a single-phase static transformer Suitable for melting RUTILE (sliding) acid electrodes. Alkaline electrodes may also be melted by alternating current.

The welding current is continuously regulated (magnetic dispersion) by turning the hand wheel on the outside of the machine, which makes it possible to select the current value, indicated on a special graded scale, with the utmost precision. To prevent the service capacities from being exceeded, all of our machines are fitted with an automatic overload protection which cuts of the power supply (intermittent use) in the event of an overload.

4.1.3. Drilling

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work-piece, cutting off chips (swarf) from the hole as it is drilled.

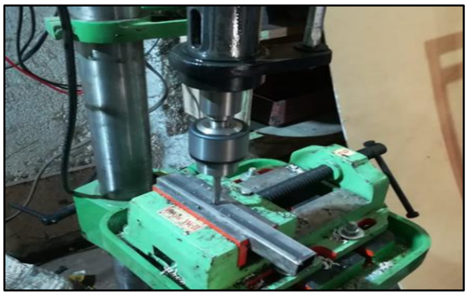


Figure 36 Drilling Operation

In rock drilling, the hole is usually not made through a circular cutting motion, though the bit is usually rotated. Instead, the hole is usually made by hammering a drill bit into the hole with quickly repeated short movements. The hammering action can be performed from outside the hole top-hammer drill or within the hole (down-the-hole drill, DTH). Drills used for horizontal drilling are called drifter drills.

In rare cases, specially-shaped bits are used to cut holes of non-circular cross-section; a square cross-section is possible. Drilled holes are characterized by their sharp edge on the entrance side and the presence of burrs on the exit side (unless they have been removed). Also, the inside of the hole usually has helical feed marks.

Drilling may affect the mechanical properties of the work piece by creating low residual stresses around the hole opening and a very thin layer of highly stressed and disturbed material on the newly formed surface. This causes the work piece to become more

Figure 37 Drilling Tool

susceptible to corrosion and crack propagation at the stressed surface. A finish operation may be done to avoid these detrimental conditions.

For fluted drill bits, any chips are removed via the flutes. Chips may form long spirals or small flakes, depending on the material, and process parameters. The type of chips formed can be an indicator of the machinability of the material, with long chips suggesting good material machinability.

4.1.4. Finishing

Finishing is a broad range of industrial processes that alter the surface of a manufactured item to achieve a certain property. Finishing processes may be employed to: improve appearance, adhesion or wettability, solder ability, corrosion resistance, tarnish resistance, chemical resistance, wear resistance, hardness, modify electrical conductivity, remove burrs and other surface flaws, and control the surface friction. In limited cases some of these techniques can be used to restore original dimensions to salvage or repair an item.

An unfinished surface is often called mill finish. The edges with grinder using grinding wheel. The machine used for this operation is hand grinder. An angle grinder, also known as a side grinder or disc grinder, is a handheld power tool used for cutting, grinding and polishing. Angle grinders can be powered by an electric motor, petrol engine or compressed air.

The motor drives a geared head at a right-angle on which is mounted an abrasive disc or a thinner cut-off disc, either of which can be replaced when worn. Angle grinders typically have an adjustable guard and a side-handle for two-handed operation. Certain

Figure 38 Finishing Operation

angle grinders, depending on their speed range, can be used as sanders, employing a sanding disc with a backing pad or disc. The backing system is typically made of hard plastic, phenolic resin, or medium-hard rubber depending on the amount of flexibility desired. The time required for this operation is 20 minutes.

4.1.5. Polishing

Polishing is the process of creating a smooth and shiny surface by rubbing it or using a chemical action, leaving a surface with a significant specular reflection (still limited by the index of refraction of the material according to the Fresnel equations.) In some materials (such as metals, glasses, black or transparent stones), polishing is also able to reduce diffuse reflection to minimal values. When an unpolished surface is magnified thousands of times, it usually looks like mountains and valleys. By repeated abrasion, those "mountains" are worn down until they are flat or just small "hills." The process of polishing with abrasives starts with coarse ones and graduates to fine ones.

Figure 39 Polishing Operation

The welded joints with hand grinder using grinding wheel. The machine used for this operation is hand grinder. With refinement, grinding becomes polishing, either in preparing metal surfaces for subsequent buffing or in the actual preparation of a surface finish, such as a No. 4 polish in which the grit lines are clearly visible.

Grinding employs the coarser grits as a rule while most polishing operations are conducted with grits of 80 and finer. If polishing is required, start with as fine a grit as possible to reduce finishing steps. There is a wide range of grinding and polishing tools on the market and advice is available from ASSDA members to assist in particular applications. Polishing operations are conducted with the abrasive mounted either on made-up shaped wheels or belts which provide a resilient backing. The base material may be in either a smooth rolled or a previously ground condition. If the former, the starting grit size may be selected in a range of 80 to 100. If the latter, the initial grit should be one of sufficient coarseness to remove or smooth out any residual cutting lines or other surface imperfections left over from grinding. In either case, the treatment with the initial grit should be continued until a good, clean, uniform, blemish-free surface texture is obtained. The initial grit size to use on a pre-ground surface may be set at about 20 numbers finer than the last grit used in grinding, and changed, if necessary, after inspection. Upon completion of the initial stage of polishing, wheels or belts are changed to provide finer grits. Polishing speeds are generally somewhat higher than those used in grinding. A typical speed for wheel operation is 2500 meters per minute. The time required for this operation is 20 minutes.

4.1.6. Turning

Turning is a metal cutting process for producing a cylindrical surface with a single point tool. The work piece is rotated on a spindle and the cutting tool is fed into it radially, axially or both. Producing surfaces perpendicular to the work piece axis is called facing. Producing surfaces using both radial and axial feeds is called profiling.

A lathe is a machine tool which spins a block or cylinder of material so that when abrasive, cutting, or deformation tools are applied to the work piece, it can be shaped to

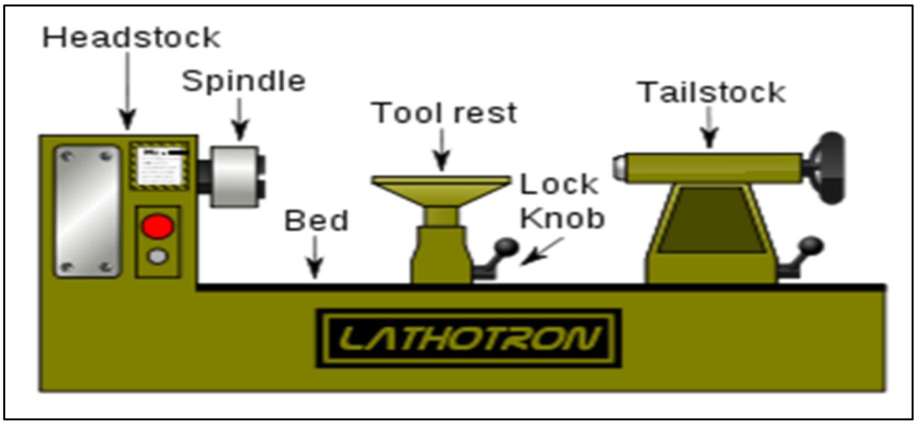


Figure 40 Lathe

produce an object which has rotational symmetry about an axis of rotation. Examples of objects that can be produced on a lathe include candlestick holders, table legs, bowls, baseball bats, crankshafts, camshafts, and bearing mounts. Lathes have three main components:

4.1.7. Headstock

The headstock's spindle secures the work piece with a chuck, whose jaws (usually three or four) are tightened around the piece. The spindle rotates at high speed, providing the energy to cut the material. While historic lathes were powered by belts from the ceiling, modern examples use electric motors. The work piece extends out of the spindle along the axis of rotation above the flat bed.

4.1.8. Carriage

The carriage is a platform that can be moved, precisely and independently, horizontally parallel and perpendicular to the axis of rotation. A hardened cutting tool is held at the desired height (usually the middle of the work piece) by the tool post. The carriage is then moved around the rotating work piece, and the cutting tool gradually shaves material from the work piece

4.1.9. Tailstock

The tailstock can be slid along the axis of rotation and then locked in place as necessary. It may hold centres to further secure the work piece, or cutting tools driven into the end of the work piece.

4.2. CAD DRAWING

Procedure

- The entire model has been designed with the help of designing software solid works.
- With the help of colour feature the colours are given to the entire model.
- Figure- Cad model of the assembled project is designed on SolidWorks 2020 software

SOLID MODELING

The entire model has been designed with the help of designing software solid works.

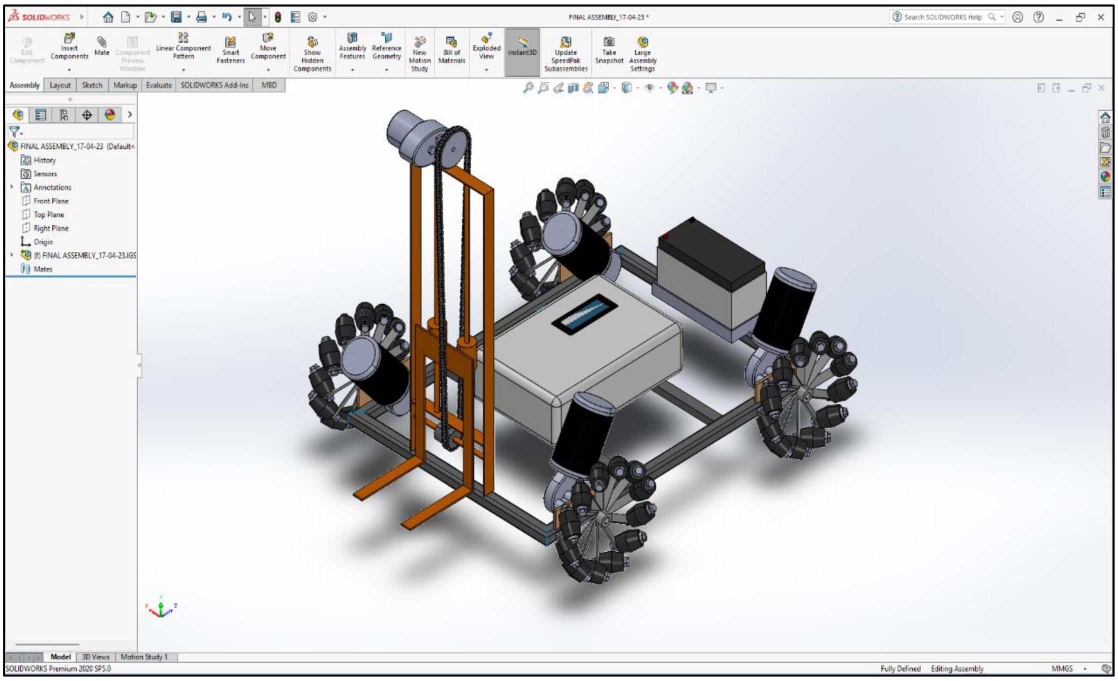


Figure 41 Isometric View

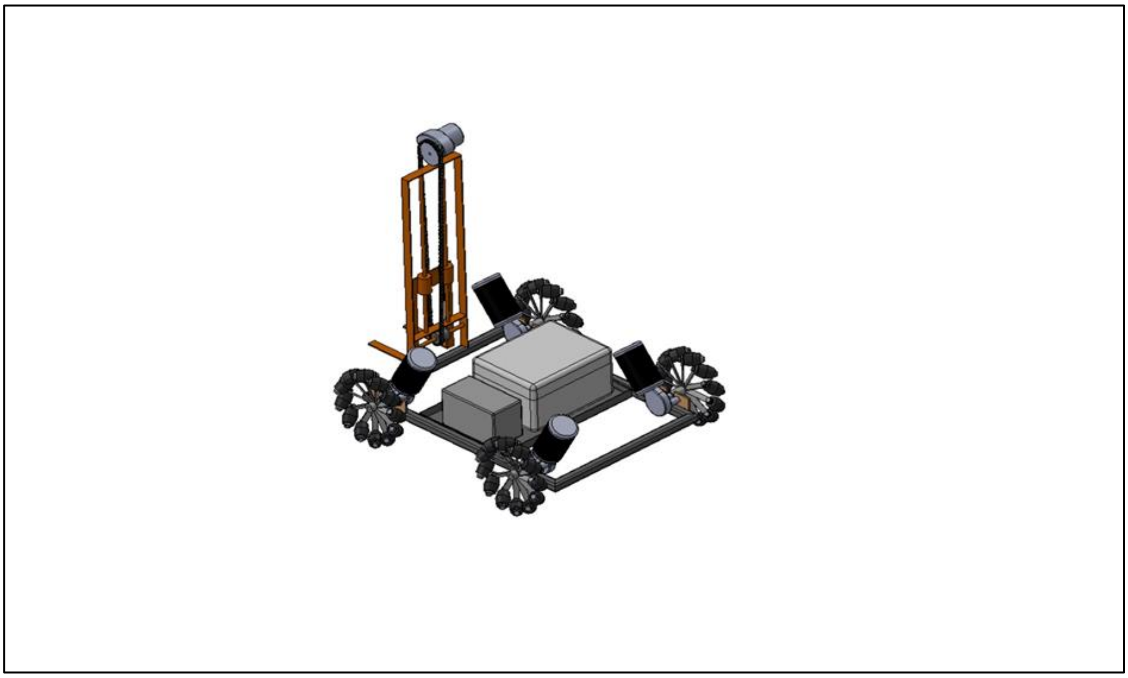


Figure 42 Isometric View

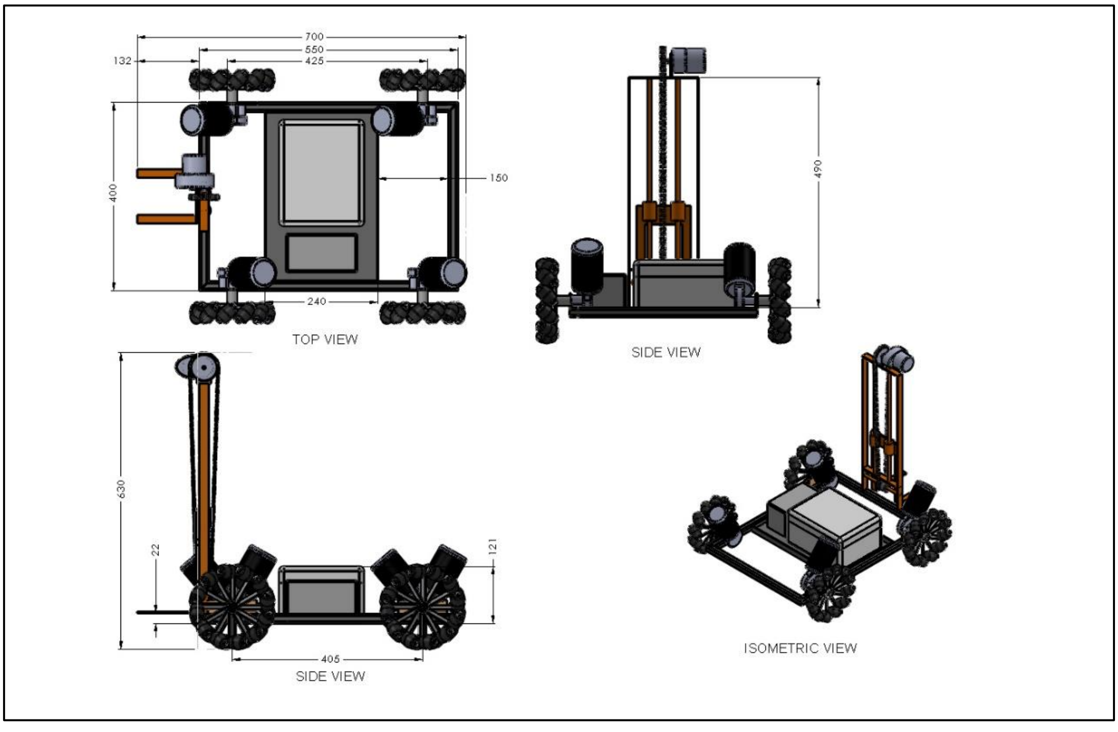


Figure 43 Drafting

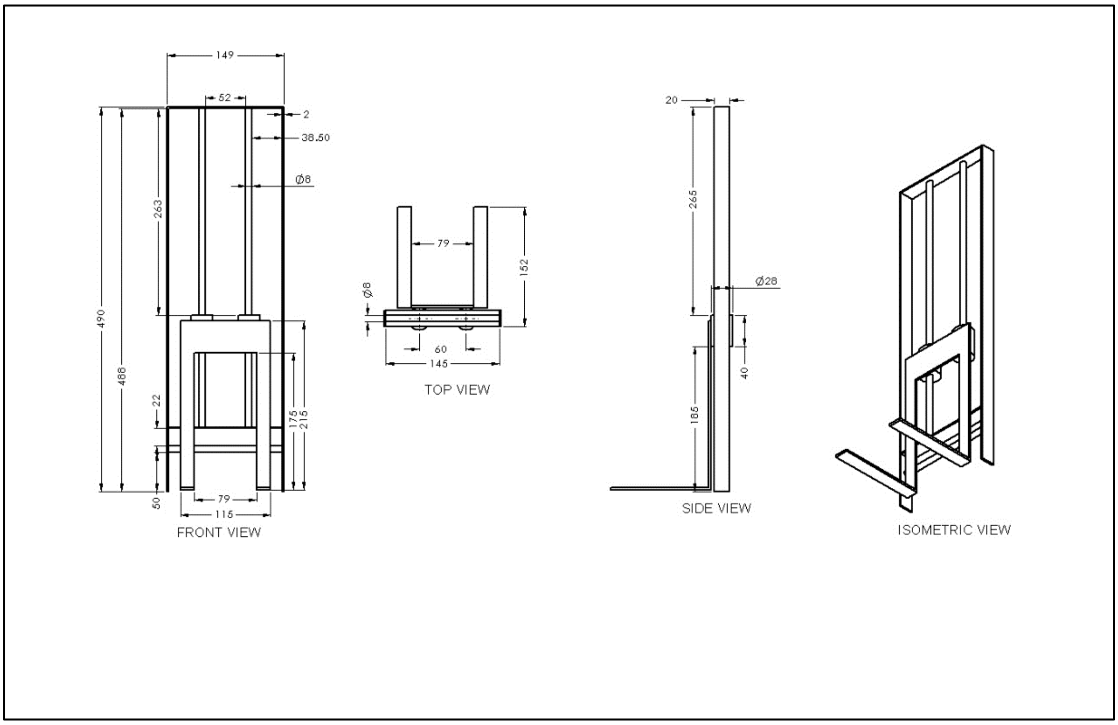


Figure 44 Forklift

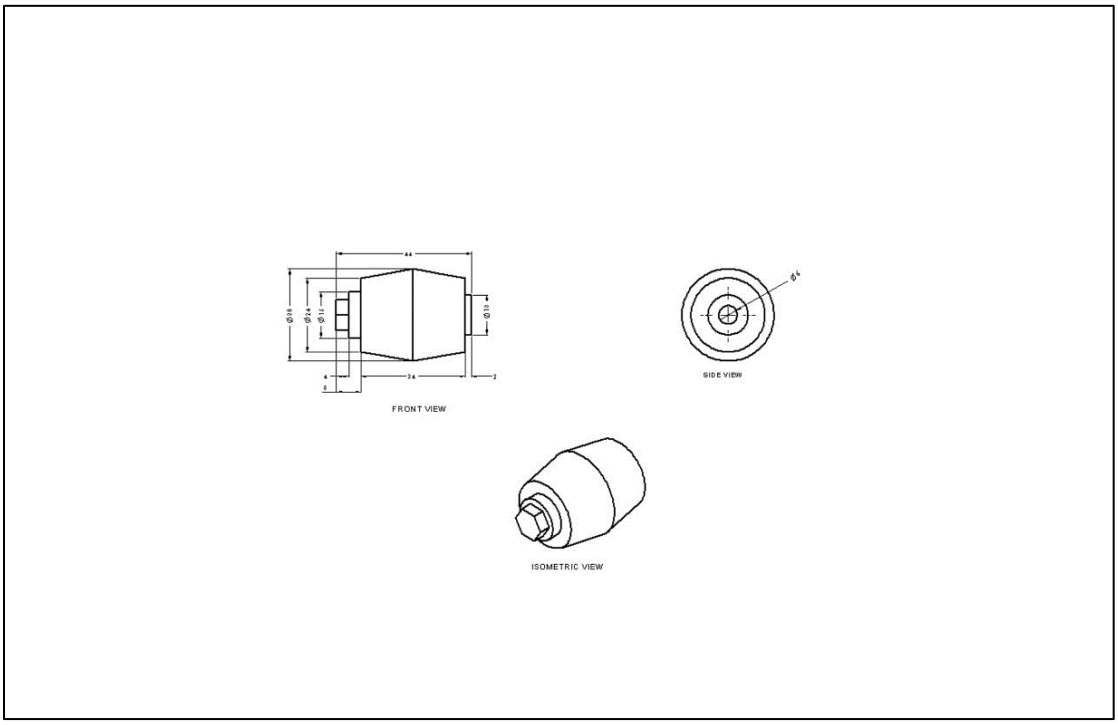


Figure 45 Rubber Roller

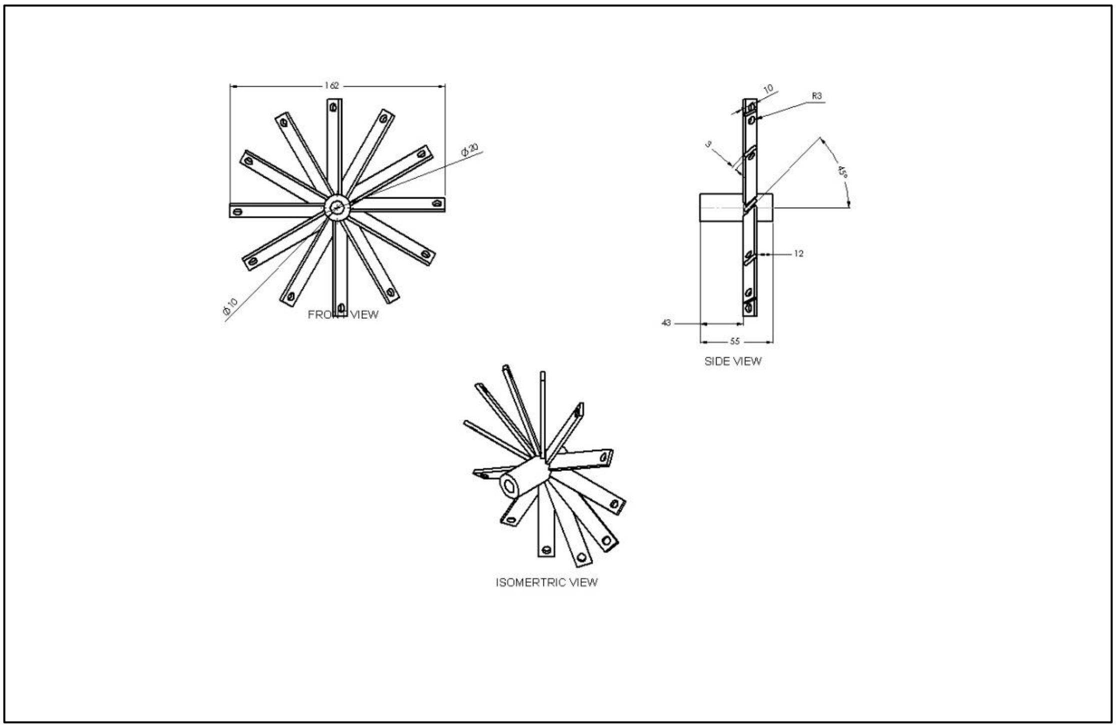


Figure 46 Wheel

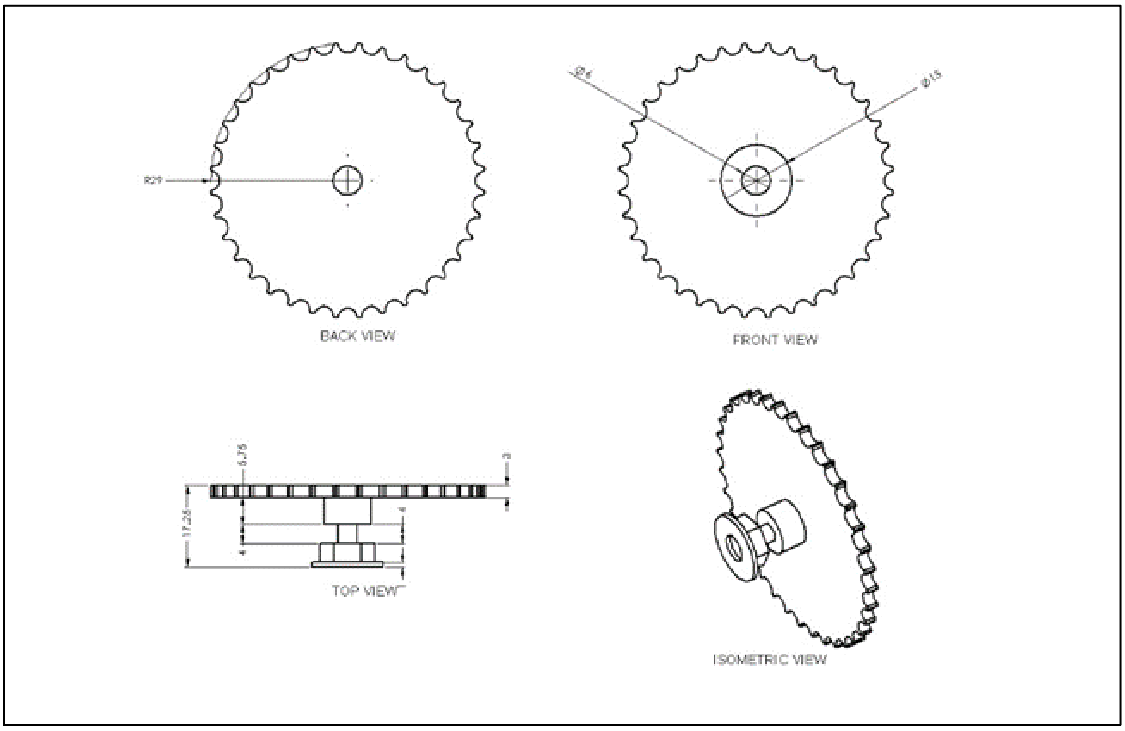


Figure 47 Sprocket

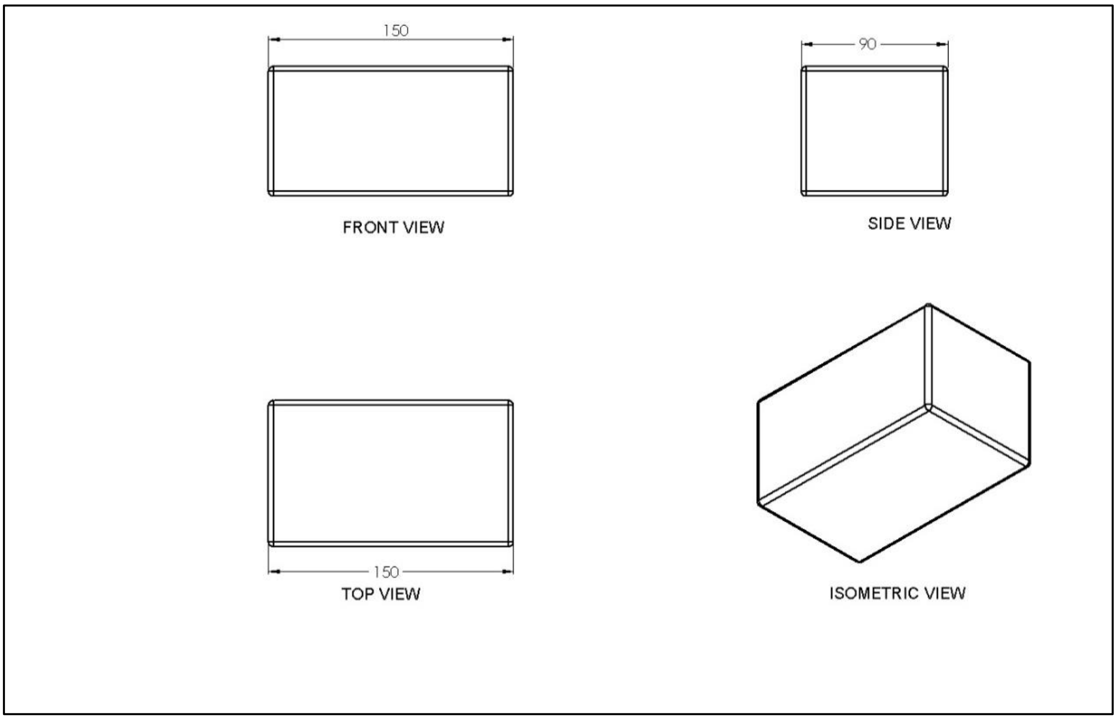


Figure 48 Battery Pack

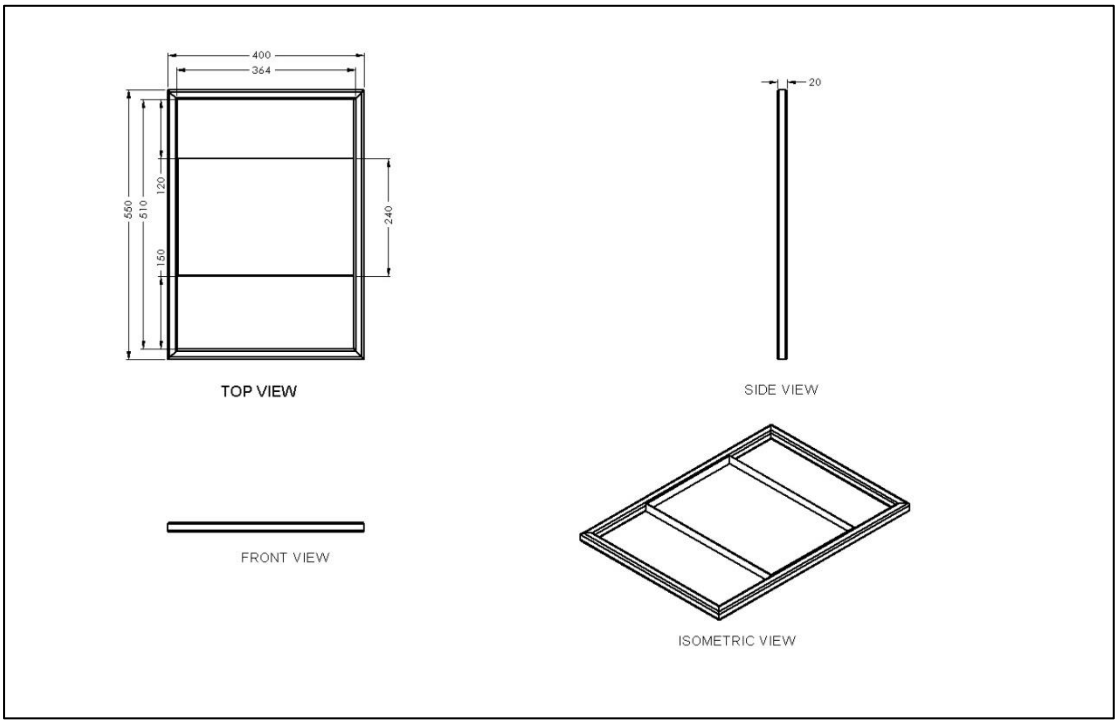


Figure 49 Frame

4.3. CODE OF ARDUINO UNO

The first step is to include the SoftwareSerial library in your code, which will allow you to communicate with the Bluetooth module. You will also need to define the pins that you are using for the Bluetooth module's RX and TX connections.

Next, you will need to set up the Bluetooth module by sending it commands through the Arduino. This will involve sending AT commands to the module to configure it for use. Once the module is set up, you can start sending and receiving data over Bluetooth.

To send data over Bluetooth, you will need to use the Serial.write() function in your code. This function will send the data to the Bluetooth module, which will then transmit it over Bluetooth. To receive data, you will need to use the Serial.read() function, which will read the data that is being received by the Bluetooth module.

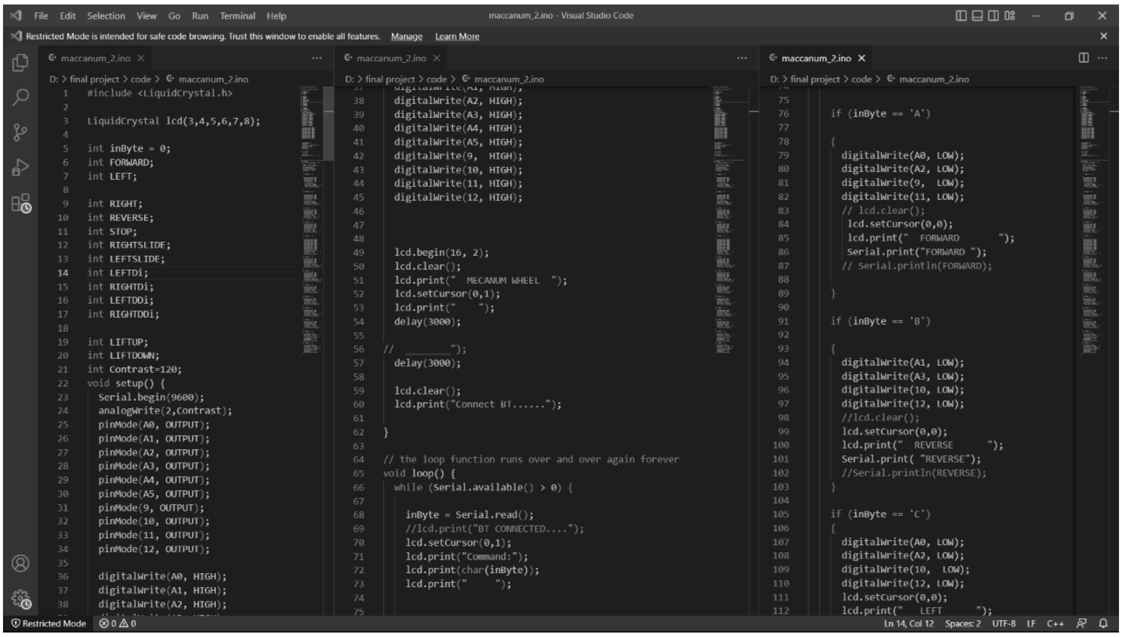


Figure 50 Coding A

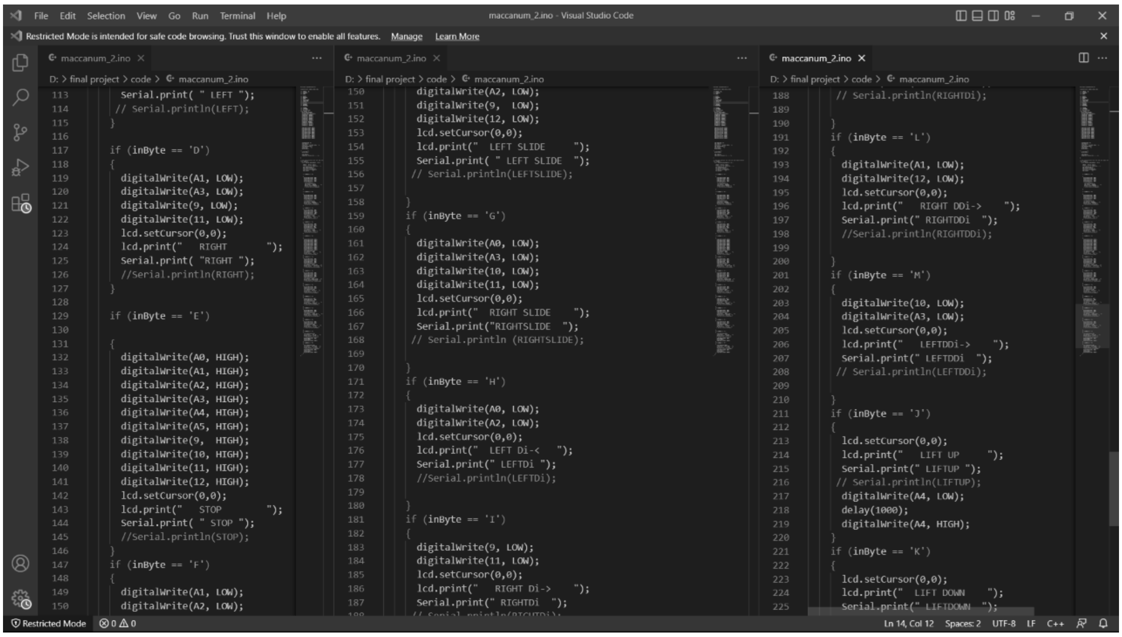


Figure 51 Coding B

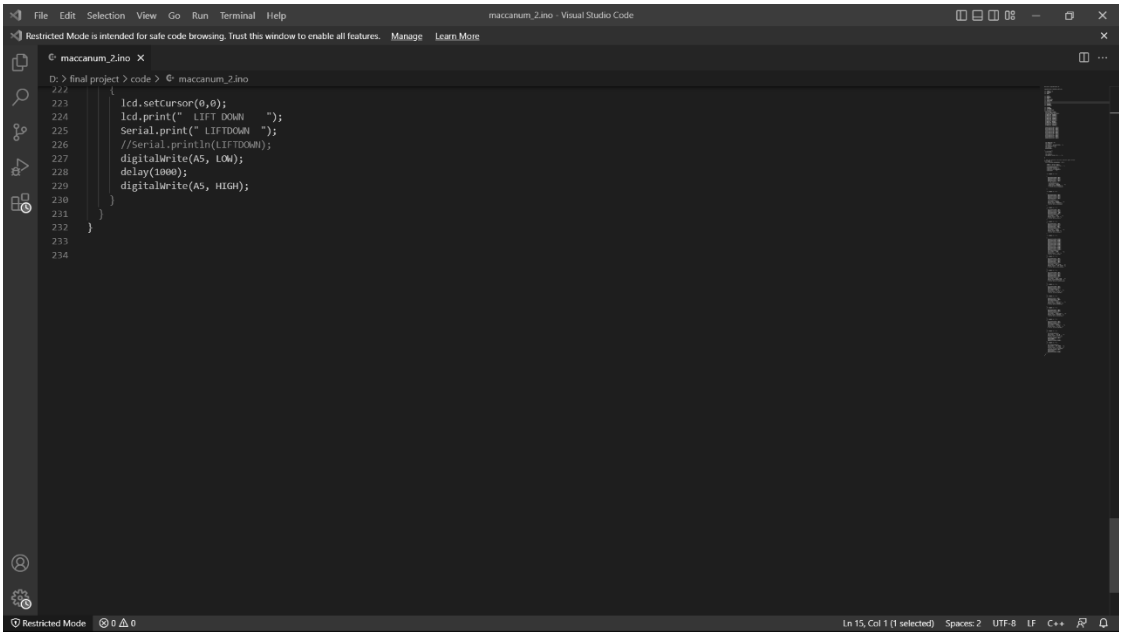


Figure 52 Coding C

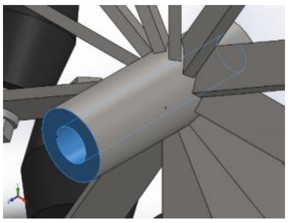
5. RESULT

5.1. STRESS ANALYSIS

Table 7 Material Properties

Name:	Plain Carbon Steel
Model type:	Linear Elastic Isotropic
Default failure criterion:	Max von Mises Stress
Yield strength:	2.20594e+08 N/m^2
Tensile strength:	3.99826e+08 N/m^2
Mass density:	7800 kg/m^3
Elastic modulus:	2.1e+11 N/m^2
Poisson's ratio:	0.28
Thermal expansion coefficient:	1.3e-05 /Kelvin

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		Entities: 2 face(s) Type: Fixed Geometry

Load name	Load Image	Load Details
Torque-1		Entities: 12 face(s) Reference: Face< 1 > Type: Apply torque Value: 8 N.m

Figure 53 Loas & Fixtures

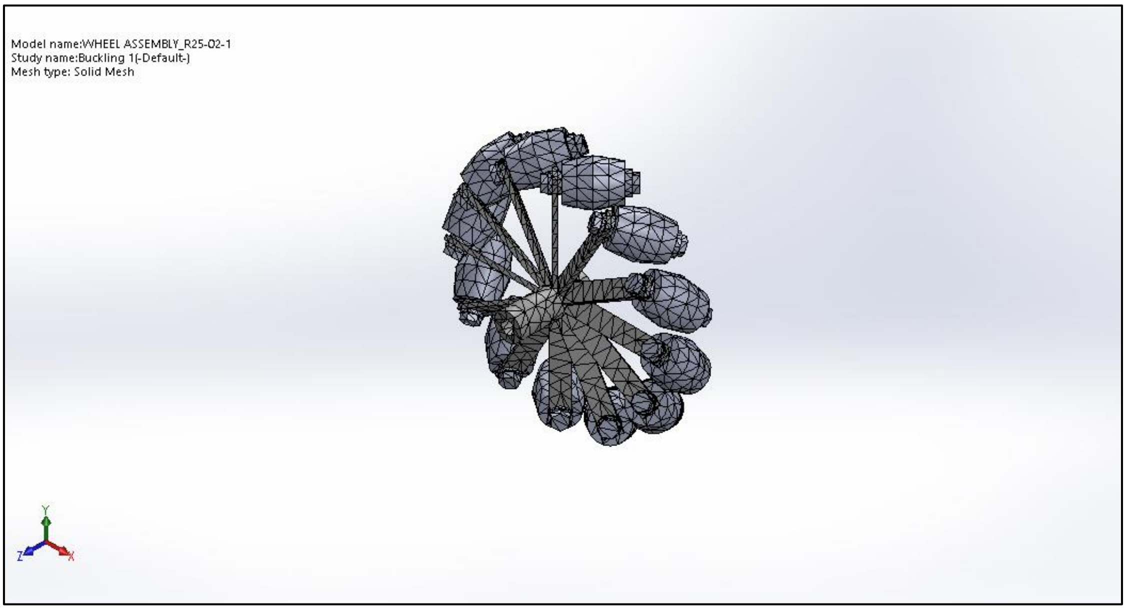


Figure 55 Meshing

Mesh information

Mesh type	**Solid Mesh**
Mesher Used:	**Standard mesh**
Automatic Transition:	**Off**
Include Mesh Auto Loops:	**Off**
Jacobian points	**4 Points**
Element Size	**9.23011 mm**
Tolerance	**0.461505 mm**
Mesh Quality Plot	**High**
Remesh failed parts with incompatible mesh	**Off**

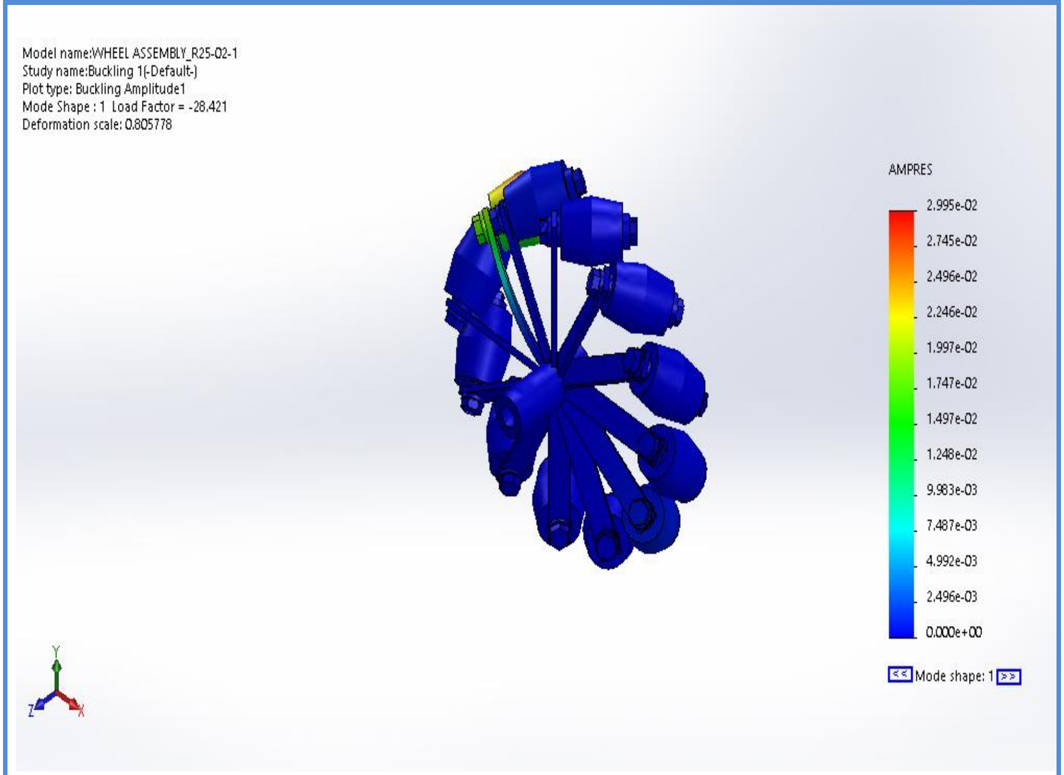
Mesh information - Details

Total Nodes	**22697**
Total Elements	**12357**
Maximum Aspect Ratio	**23.625**
% of elements with Aspect Ratio < 3	**82.9**
% of elements with Aspect Ratio > 10	**0.397**

Figure 54 Meshing Information

Study Results

Name	Type	Min	Max
Amplitude1	AMPRES: Resultant Amplitude Plot for Mode Shape: 1(Load Factor = -28.4211)	0.000e+00 Node: 18770	2.995e-02 Node: 9771



WHEEL ASSEMBLY_R25-02-1-Buckling 1-Amplitude-Amplitude1

Name	Type
Amplitude2	Deformed shape Plot for Mode Shape: 1(Load Factor = -28.4211)

Figure 56 Results

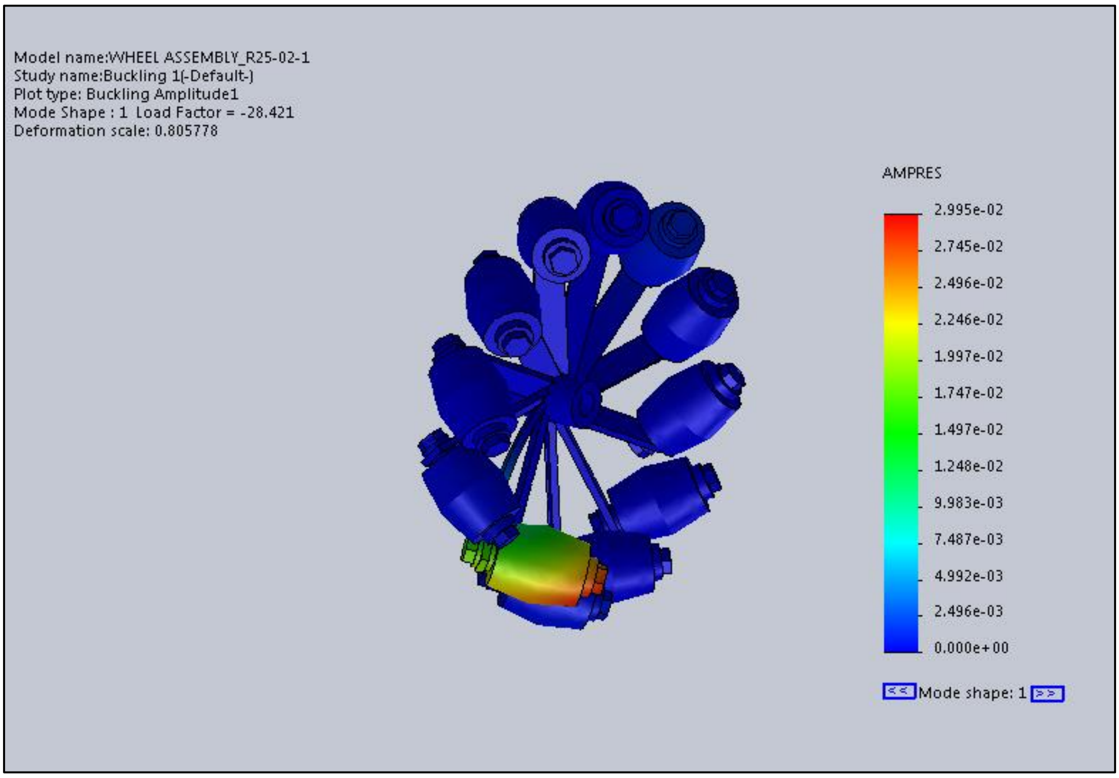


Figure 57 Stress Analysis

5.2. CALCULATIONS

- EN 10083 C45 Steel Carbon Steel

C45 is a Medium Carbon Steel is used when greater strength and hardness is desired than in the "as rolled" condition. Extreme size accuracy, straightness and concentricity combine to minimize wear in high-speed applications. Turned, ground and polished.

Soft Annealing - Heat to 680-710oC, cool slowly in furnace. This will produce a maximum Brinell hardness of 207.

Table 8 Steel Grades

C45 EN 10083-2 Number: 1.0503	
Comparison of Steel Grades	
JIS G 4051	S 45 C
DIN 17200	C 45
NFA 33-101	AF65-C 45
UNI 7846	C 45
BS 970	070 M 46
UNE 36011	C 45 k
SAE J 403-AISI	1042/1045

.

Normalizing - Normalizing temperature: 840-880oC/air.

Hardening - Harden from a temperature of 820-860oC followed by water or oil quenching.

Tempering - Tempering temperature: 550-660oC/air.

C45 steel plate, EN 10083 C45 steel plate, under EN 10083 standard, we can regard C45 steel plate as high carbon steel.

C45 steel plate is one mainly of high carbon steel, EN 10083 C45 steel plate is for quenching and tempering. Technical delivery conditions for non-alloy steels, these steels are for general engineering purposes.

❖ Chemical Composition of EN C45 Steel

Table 9 Chemical Composition

Grade	C45
C(%)min-max	0.42-0.50
Si(%)min-max	0.15-0.35
Mn(%)min-max	0.50-0.80
P(%)max	0.025
S(%)max	0.025
Cr(%)min-max	0.20-0.40

❖ Mechanical Properties of EN C45 Steel

Table 10 Mechanical Properties of EN C45 Steel

Grade	Condition	Yield Strength R°(Mpa)	Tensile Strength Rm (Mpa)	Elon- gation A5(%)	Hardness HRC	Quenching Temperature (°C)	Bendability	Nominal Thickness,t 1.95mm≤t≤10.0m Rolled	Annealed
C45	Rolled	460	750	18	58	820	Min.recommended	2	1.0×t
	Annealed	330	540	30	55	860	Bending radius	×t	
	Water-quenched		2270				(≤90°)		
	Oil quenched		1980						

❖ Properties of Steel C45 (1.0503)

- Weld ability: Due to the medium-high carbon content it can be welded with some precautions.
- Hardenability: It has a low hardenability in water or oil; fit for surface hardening that gives this steel grade a high hardness of the hardened shell.

❖ Why Mild Steel C-45 is selected in our project.

1. Easily available
2. Welding ability
3. Machinability
4. Cutting Ability
5. Cheapest

- Material = C 45 (mild steel)

Take fos = 2

$\sigma t = \sigma b = 540 / fos$

$= 270\ N/mm^2$

$\sigma s = 0.5\ \sigma t$

$= 0.5 \times 270$

$= 135\ N/mm^2$

- Design of Motor Shaft.

The total weight of machine is not more than 20kg, this weight is distributed on all four wheels. So, weight on each wheel(W) is 5 kg.

Power of motor is 12V, 15Watts & 20 rpm.

Figure 58 Permanent Magnet DC Motor

– Calculations for Motor Selection

W =5 kg = 5 × 9.8 = 50N say

$M = F \times L$

$M = 50 \times 25 = 1250$ N-mm

$P = 2\ \pi\ N\ T / 60$

$T = 15 \times 60/2 \times \pi \times 20$

T = 7.16 N-m = 7162 N-mm

$T_e = \sqrt{(M^2+T^2)} = \sqrt{1250^2+7162^2}$

$= \sqrt{1562500+51294244}$

$= \sqrt{52.86 \times 10^6}$

$T_e = 7270.26 = 7.27 \times 10^3$ N-mm

$T_e = \pi/16 \times \sigma_s \times d^3$

$d^3 = 7.27 \times 10^3 \times 16 / \pi \times 135 = 274.26$

$d = 3\sqrt{274.26} = 6.49$mm

d = 7mm

But we are using **10 mm shaft** so our shaft is safe.

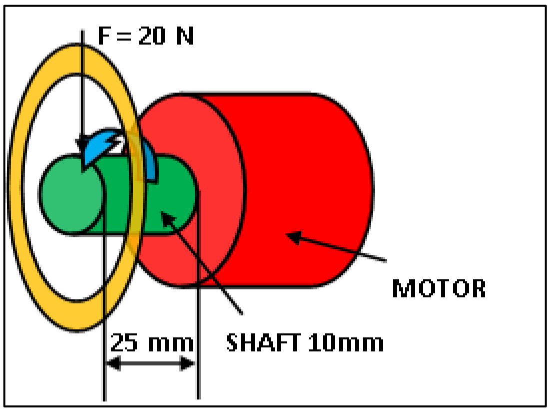


Figure 59 Diagram of Motor

❖ Design of Rubber Roller Pin

The rollers are mounted on pins of 6mm dia.

M = W x L = 50×40

= 2000 N-mm

$Z = \pi / 32 \times d^3 = \pi / 32 \times 6^3$

$Z = 21.2$ mm^3

σb (induced)= M / Z = 2000 / 21.2 = 94.33 N/mm²

As induced bending stress is less then allowable bending stress i.e., 270 N/mm^2 design is safe.

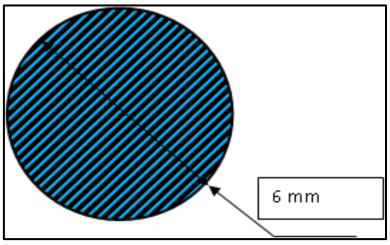


Figure 60 Pin Cut Section

- Design of MS Flat Linkages of Wheel

Now, rollers are mounted on MS flat of size 12 × 3 and length is 74 mm

W = maximum force applied = 50 N

M = W × L

M = 50 × 74 = 3700 N-mm

And section modulus = Z = 1/6 bh^2 = 1/6 × 3 × 12^2

Z = 72 mm^3.

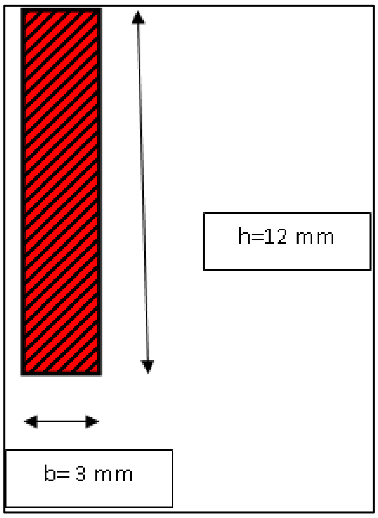


Figure 61 Link Cross-Section

σb (induced)= M/Z = 3500 / 72 = 48.61 N/mm^2

As induced bending stress is less then allowable bending stress i.e., 270 N/mm^2 design is safe.

- Design of Transverse Fillet Welded Joint

Hence, selecting weld rod size = 3.2mm

Area of Weld = 0.707 × Weld Size × L ×

= 0.707 × 3.2 × 12

= 27.15 mm^2

Figure 62 Welding

Force exerted = ____ N

Stress induced = Force Exerted / Area of Weld

21 = F / 27.15

F= 570.21 N = 58.12 kg

Maximum Allowable Stress for Welded Joints = 21 N/mm^2

- Linear Velocity of Machine

Diameter of Mecanum wheel 198

V = π D N / 60

= 3.142 × 0.198 × 20 / 60

= 0.2073 m/sec

= 0.75 km/hr

- Power Consumption Calculation

Battery 12v 7.5 amp = 90 watt

15 × 4= 60 watt

90 / 60= 1.5 hr

- Design of forklift

Fork lift motor 10-watt, 15 rpm

$P = 2 \pi N T / 60$

$T = 10 \times 60 / 2 \times \pi \times 15$

T= 6.36 N-m= 6360 N-mm

- Diameter of Sprocket

Periphery = $\pi \times$ Dia. of Sprocket

40×6.35 (pitch) $= \pi \times D$

$D = 40 \times 6.25 / \pi$

D = 80.8 mm

Torque Transmitted,

T = Force × radius

$7.16 \text{ x } 103 = F \times 40.4$

F = 177.22N

F = 177 N / 9.81

F = 18.06 Kg

Figure 63 Sprocket

❖ Design of Forklift Chain

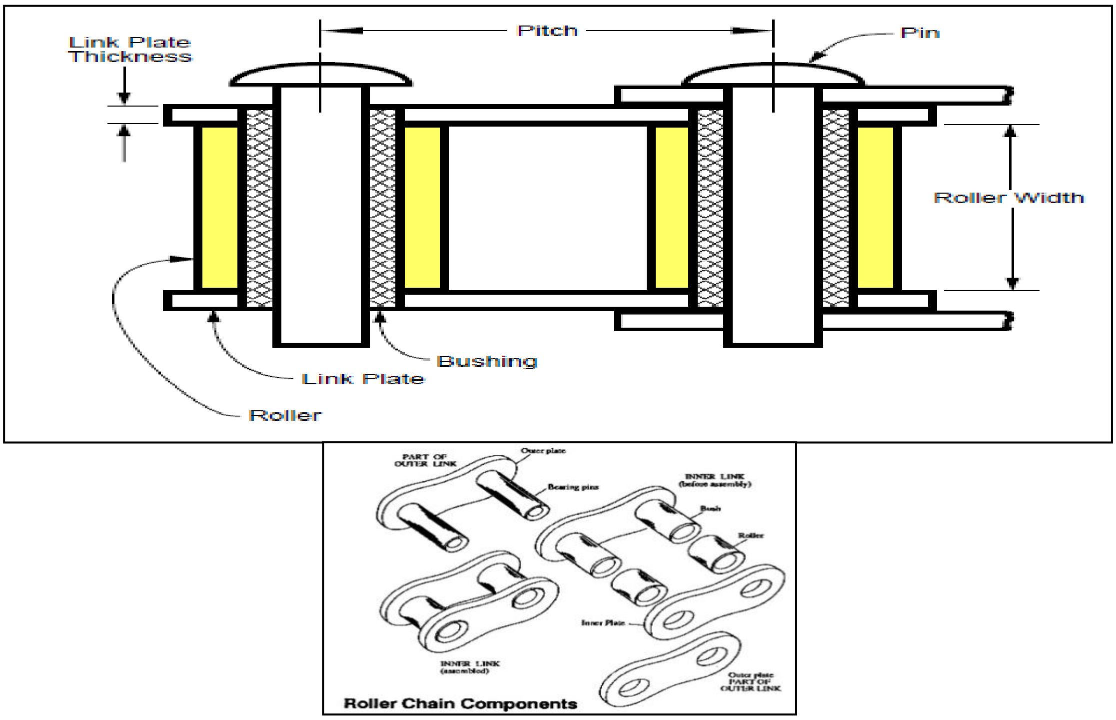


Figure 64 Chain Specifications

Table 11 Chain Size Table

OCM Chain No.	Pitch P	Roller Diam. D	Width between L.P. W	Link Plate H	 T	Pin Diam. d	Pin L
25	0.25 6.350	0.13 3.300	0.126 3.200	0.23 5.850	0.03 0.750	0.091 2.300	0.307 7.800
35	0.375 9.525	0.2 5.080	0.189 4.800	0.354 9.000	0.049 1.250	0.141 3.580	0.461 11.700
40	0.5 12.700	0.312 7.920	0.313 7.950	0.472 12.000	0.059 1.500	0.156 3.960	0.634 16.100
41	0.5 12.700	0.306 7.770	0.252 6.400	0.382 9.700	0.049 1.250	0.141 3.580	0.524 13.300

We know,

Stress = (Force / 2) / Area

Stress induced = 176 / (π × 2.32 / 4) × 2

Stress induced = 5.29 N/mm^2

As induced stress is less than allowable stress = 135 N /mm^2 design of sprocket is safe.

5.3. IMAGE OF PROTOTYPE

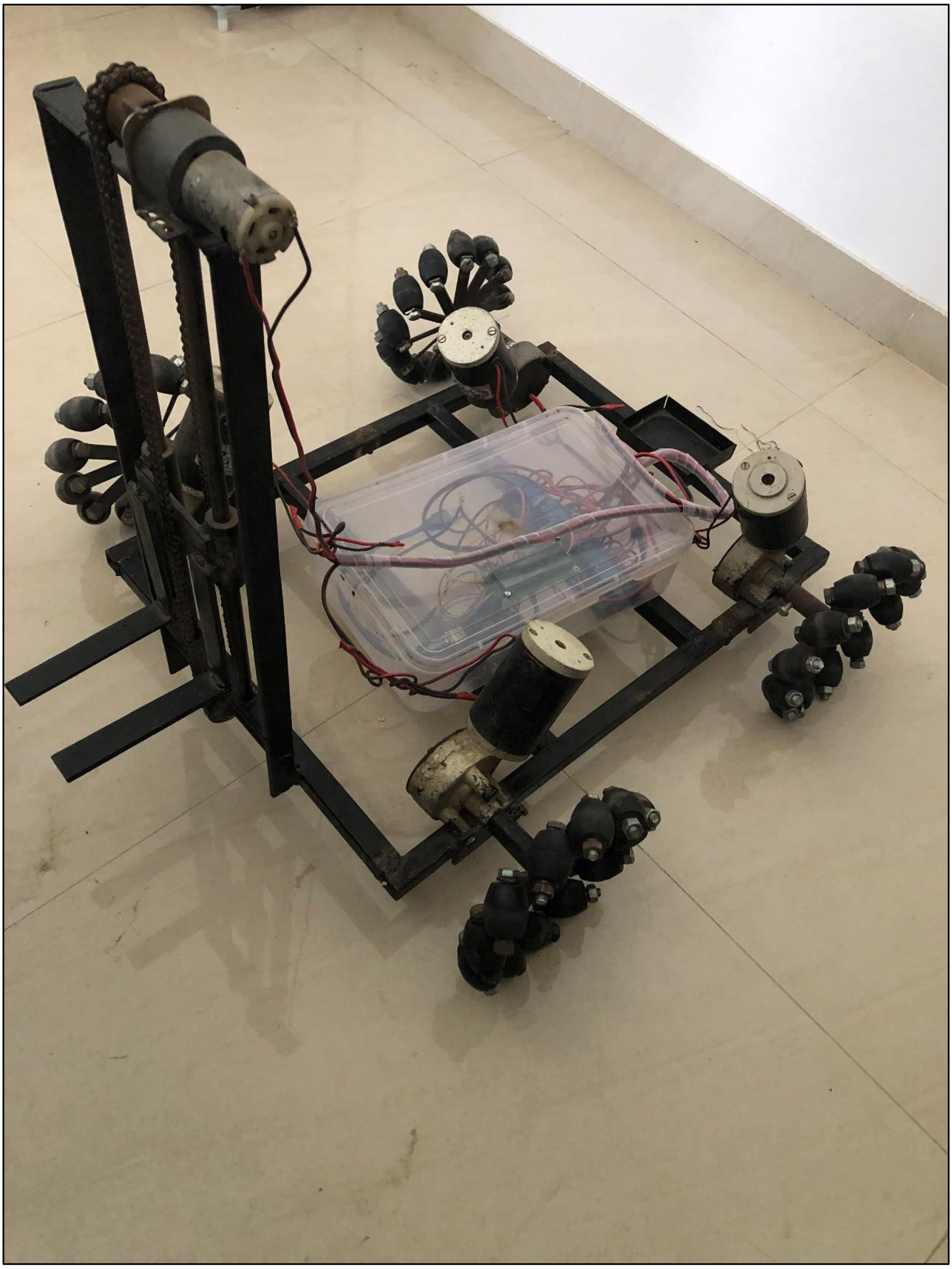


Figure 65 Final Image of Prototype

6. CONCLUSION

6.1. FUTURE SCOPE

- Mecanum Wheels are marginally heavier than their conventional counterparts.
- They cost higher.
- The smaller contact area disables its use in passenger cars.
- Used for low-speed drive.
- Vertical and horizontal vibrations.

6.2. CONCLUSION

The Mecanum wheel is a design for a wheel which can move a vehicle in any direction.

Compared to skid steer, Mecanum wheels have no additional friction when turning which is an advantage.

Tracked vehicles and skid steer vehicles utilize similar methods for turning. However, these vehicles typically drag across the ground while turning and may do considerable damage to a soft or fragile surface. The high friction against the ground while turning also requires high-torque engines to overcome the friction. By comparison, the design of the Mecanum wheel allows for in-place rotation with minimal ground friction and low torque.

Mecanum wheels will be simpler and perhaps more reliable than a swerve/crab drive system. Disadvantages are weight (commercially available wheels are ridiculously heavy) and cost. For a given tread material traction will be along the lines of 65-70% that of a regular wheel due to the smaller contact area and 45% rollers.

It cannot be used in regular car because it is usually used for low-speed drive.

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