DESIGN AND FABRICATION OF MECANUM WHEELS ROBOT WITH ARM

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ABSTRACT

Mecanum wheels, also known as Swedish wheels or Ilon wheels, are unique omnidirectional wheels designed to provide omnidirectional motion without requiring traditional steering mechanisms such as a differential. They consist of a hub with multiple rollers mounted at an angle around the circumference. Each roller is set at a 45-degree angle to the wheel's rotation axis and is free to rotate about its own axis.

When each wheel is driven independently and at different speeds, the rollers generate a combination of translational and rotational motion, allowing the vehicle to move in any direction with a high degree of agility and precision. This omnidirectional capability makes mecanum wheels well-suited for applications such as robotic platforms, material handling equipment, and omnidirectional vehicles.

The design and control of mecanum wheels require careful consideration of factors such as roller orientation, wheel diameter, roller material, and wheelbase to achieve desired performance characteristics such as speed, maneuverability, and stability. Various control algorithms, including kinematic models and feedback control systems, are often employed to achieve precise motion control and trajectory tracking.

Overall, mecanum wheels offer a versatile solution for omnidirectional motion in a wide range ofapplications, enabling vehicles and robotic systems to navigate complex environments with ease and efficiency.

INTRODUCTION

1.1 Introduction to Mecanum Wheels

When we design a simple robot or "robot car," we need to choose a steering method. Thereare a couple of popular choices:

- Skid Steering – Probably the most popular for robot cars, with skid steering two wheels are used. By changing the speed and direction of each wheel, the robot car can be steered in any direction.

Mecanum Wheels

Mecanum wheels were invented in 1972 by Swedish engineer Bengt Erland Ilon, who worked for a design firm named Mecanum AB. Mecanum wheels are omnidirectional wheels, they can be used to propel a vehicle in any direction. Instead of tires, they have a series of rubberized external rollers mounted at 45-degree angles around the wheel's.
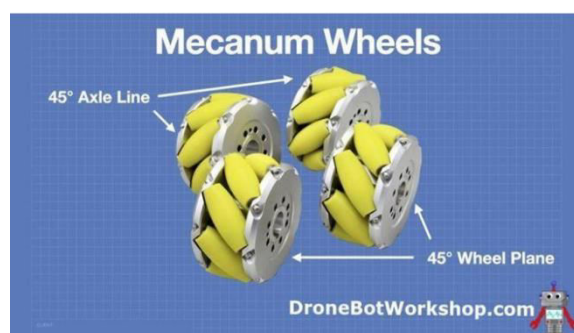

Fig 1 Mecanum Wheels 45^0 inclination

The rollers on these wheels can be oriented in two different directions, and you need two of each type for complete control. One set of wheels has the rollers mounted at a 45-degree angle to the axle. The other type uses rollers mounted at a 45-degree angle to the plane of the wheel. These four wheels (two of each type) are mounted on the robot car chassis as shown here.

Move Straight

In this mode, our Mecanum Wheel vehicle operates just like a standard robot car. We can go forwards or backward by alternating the direction we spin the wheels.
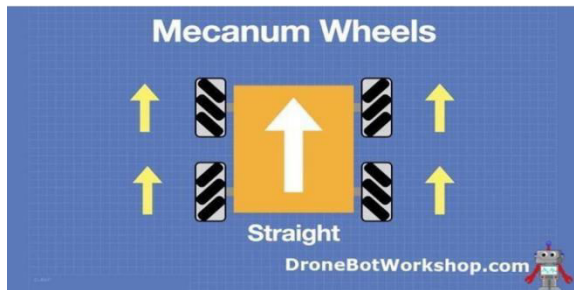

Fig 2 Move Straight

Move Sideways

By spinning the wheels on each side in opposite directions and reversing the order between sides, we can make our vehicle move sideways.

Pivot (on one side)

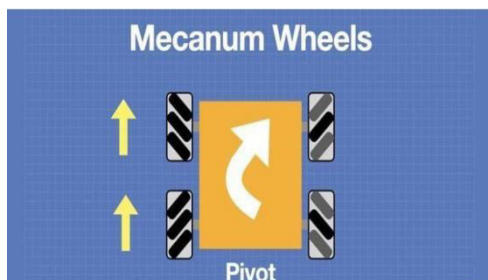Running two wheels on the same side of the vehicle in the same direction will cause it to pivot

Fig 3 Move Pivot

Rotate

By spinning the wheels on one side of the chassis in one direction and the ones on the other side in the opposite direction, we can make the vehicle rotate.
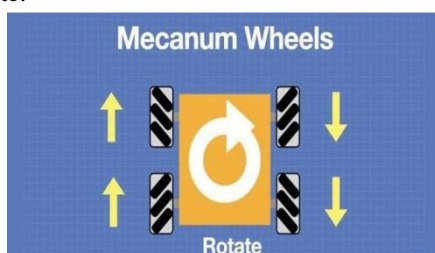

Fig 4 Move Rotate

Pivot Sideways

The final Mecanum wheel movement is a variation of the Pivot. This is the Pivot Sideways, which works in the same fashion but uses two

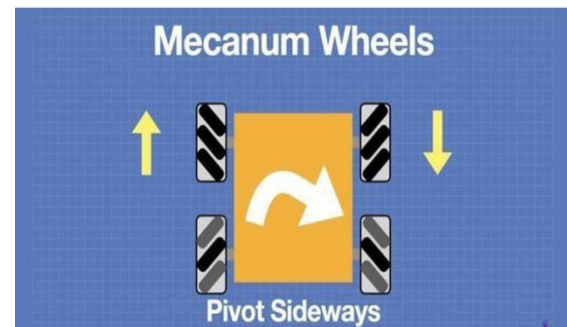wheels on the same axle, as opposed to on the same side.

Fig 5 Move Pivot Sideways

1.2 Advantages of Mecanum Wheels Robot

Omnidirectional Movement: Mecanum wheels enable robots to move in any direction without changing their orientation, offering unparalleled maneuverability.

Versatility: These wheels allow robots to navigate through complex environments, tight spaces, and around obstacles with ease, making them versatile for various applications.

Holonomic Motion: Mecanum wheel robots exhibit holonomic motion, enabling them to move instantly in any direction without needing to turn first, which is crucial for tasks requiring precise positioning.

Agility: With mecanum wheels, robots can perform agile movements such as strafing, spinning, and diagonal motion, enhancing their ability to adapt to dynamic environments.

1.3 Applications of Mecanum Wheels Robot

Warehouse Automation: Mecanum wheel robots are used in warehouses for tasks such as inventory management, goods transportation, and order picking. Their omnidirectional movement allows them to navigate efficiently through narrow aisles and around obstacles.

Material Handling: These robots are employed in factories and manufacturing facilities for material handling tasks, including transporting components between workstations and delivering finished products to storage areas or shipping docks.

2. LITERATURE SURVEY

Muhammad Sarmad Hassan et al. [1] In this paper, we presented a method of a human following robot based on tag identification and

detection by using a camera. Intelligent tracking of specified target is carried out by the use of different sensors and modules i.e. ultrasonic sensor, magnetometer, infrared sensors and camera. An intelligent decision is being made by the robot control unit based on the information obtained from the above sensors and modules, hence finding and tracking the particular object by avoiding the obstacles and withoutcollision.

Denny Irawan1 et al. [2] aims at designing a robot to track an object based on colour detection. Robots have been developed by several countries throughout the world. Among them are humanoid robots, bioloid, including the type of mobile robot. Mobile robots are widely used in several studies equipped with various sensors, including using ultrasonic sensors and cameras. This aims to help create intelligent autonomous behavior and movement control which makes it very important for the application of mobile robots discussed. The camera is one type of hardware that can be used as a sensor to help identify the surrounding environment and can be connected with C #. C # programming language functions as digital image processing and produces an output that will be used as a control reference to follow a target based on colour on human follower robots. C # also has an open source library, one of which is AForge.NET.

Chandrasekhar pati et al. [3] aims on vision based robot following using PID Control. Applications like robots which are employed for shopping, porter services, assistive robotics, etc., require a robot to continuously follow a human or another robot. This paper presents a mobile robot following another tele-operated mobile robot based on a PID (Proportional– Integral-Differential) controller. Here, we use two differential wheel drive robots; one is a master robot and the other is a follower robot.

3.METHODOLOGY

3.1   OVERVIEW ESP 32 ROBOT

The ESP32 stands out as a highly versatile microcontroller, particularly renowned for its widespread use in Internet of Things (IoT) applications. Its integration of both Wi-Fi and Bluetooth connectivity makes it
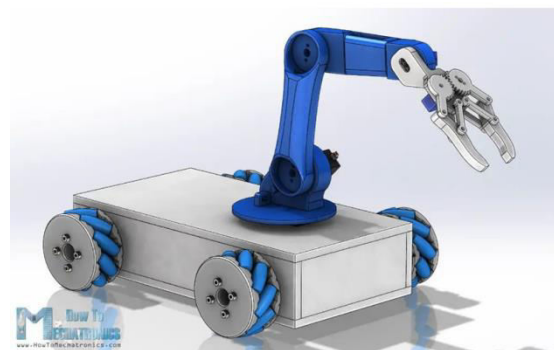An ideal solution for devices requiring wireless communication capabilities. With its dual- core

processing architecture, the ESP32 offers enhanced performance and multitasking capabilities, enabling it to handle diverse range of tasks efficiently.

3.2   3D Model and STL Download Files
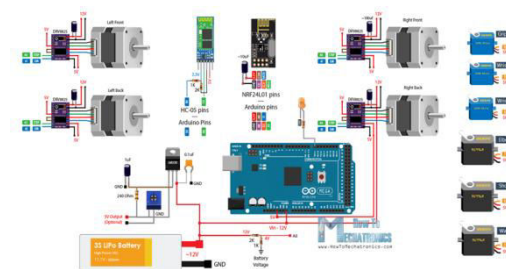
Here's the 3D model of this project.
Assembly

Fig 6 Mecanum Wheels with robotic arm

3.3   Arduino Robot Circuit Diagram

Here's the circuit diagram of this project and how everything needs to be connected.

Fig 7 Arduino Robot Circuit Diagram

4. HARDWARE COMPONENTS

4.1 POWER SUPPLY:

Block diagram:

A mecanum wheel robot integrates several key hardware components to facilitate its unique omnidirectional movement capabilities. At the heart of its mobility are the mecanum wheels themselves, each powered by a dedicated motor. These motors, often DC or stepper motors, are controlled by motor controllers, which receive commands from the robot's central processing unit. The chassis serves as the structural backbone, housing and organizing the various components. Speaking of processing, the robot relies on a microcontroller or single board computer to

interpretsensor data and issue commands. Speaking of sensors, they play a crucial role in navigation and environmental awareness, ranging from encoders for wheel rotation feedback to gyroscopes for orientation sensing. Power is supplied by a battery pack or other power source, ensuring uninterrupted operation. Depending on its purpose, the robot may feature additional components such as communication interfaces for remote control or data exchange, as well as specialized tools or payloads for specific tasks. Together, these hardware components form a cohesive system that enables the mecanum wheel robot to navigate and interact with its surroundings in a versatile and efficient manner.
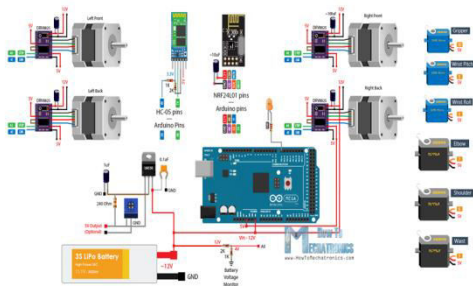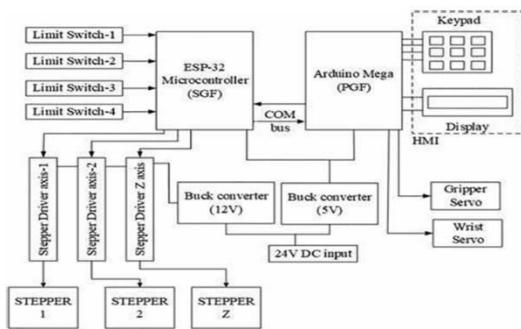

Fig 8 block diagram

Fig 9 Circuit Diagram

4.2 DC-DC Buck Converter: Basics and Operation

Working Principle:

○ The buck converter operates by switching an input voltage (Vin) on and off using a semiconductor switch (usually a MOSFET).

○ During the ON state, energy is stored in an inductor (L).

○ During the OFF state, the inductor releases energy to the output capacitor © and load.

1. *Basic Topology:*

The basic buck converter consists of:

Switch (S): Controlled by a pulse-width modulation (PWM) signal. Inductor (L): Stores energy during the ON state.
Diode (D): Allows current flow during the OFF state.

4.3 The Half-wave Rectifier

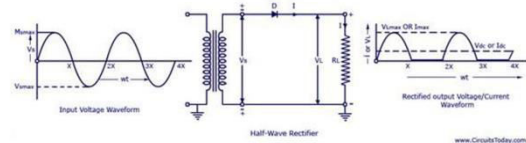The half-wave rectifier is the simplest type of rectifier since it only uses one diode, asshown in figure.

Figure 10 Half Wave Rectifier

Figure 2 shows the AC input waveform to this circuit and the resulting output. As you can see, when the AC input is positive, the diode is forward-biased and lets the current through. When the AC input is negative, the diode is reverse-biased and the diode does not let any current through, meaning the outputis 0V. Because there is a 0.7V voltage loss across the diode, the peak output voltage will be 0.7V less than Vs.
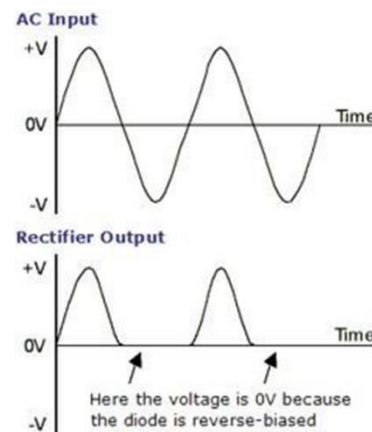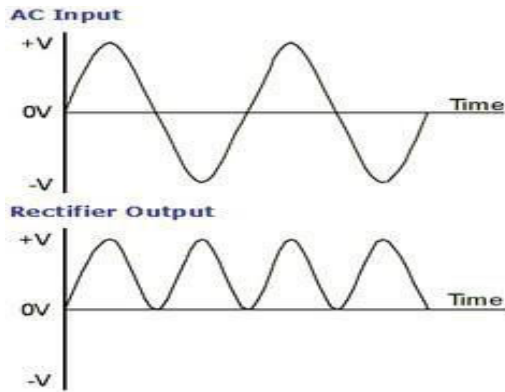

Figure 11 Half-Wave Rectification

While the output of the half-wave rectifier is DC (it is all positive), it would not be suitable as a power supplyfor a circuit. Firstly, the output voltage continually varies between 0V and Vs- 0.7V, and secondly, for half the time there is no output at all.

1. **The Full-wave Rectifier**

Thecircuit in figure 3 addressesthesecond of theseproblemssince at no time is theoutput voltage

0V. This time four diodes are arranged so that both the positive and negative parts of the AC waveform are converted to DC. The resulting waveform is shown in figure 4.


Figure: 12 Full-Wave Rectification

When the AC input is positive, diodes A and B are forward-biased, while diodes C and D are reverse-biased.

WhentheACinputisnegative,theoppositeistrue-diodesCandDare forward- biased, while diodes A and B are reverse-biased.
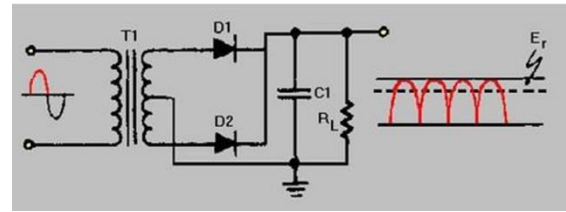
4.4 Capacitor Filter :

The capacitor-input filter, also called "Pi" filter due to its shape that looks like the Greek letter pi, is a type of electronic filter. Filter circuits are used to remove unwanted or undesired frequenciesfromasignal.
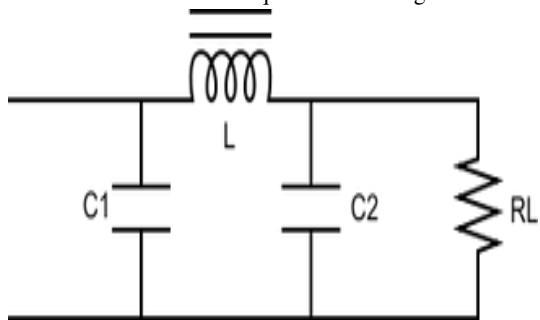
Figure 13 Capacitor Filter

1. The inductor L offers high reactance to the AC component but it offers almost zero reactance to the DC component. As a result the DC component flows through the inductor while the AC component is blocked.

2. The capacitor C2 bypasses the AC component which the inductor had failed to block. As a result only the DC component appears across the load RL.

Figure 14 Centered Tapped Full-Wave Rectifier with Capacitor Filter VoltageRegulator

VOLTAGE REGULATOR

A **voltage regulator** is an electrical regulator designed to automatically maintain a constant voltage level. It may use an electromechanical mechanism, or passive or active electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. There are two types of regulatorare they.

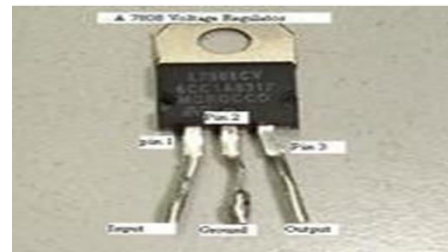Positive   VoltageSeries (78xx) and

Negative VoltageSeries(79xx)

These regulators consists the three pins there are

Pin1: It is used for input pin.

Pin2: This is ground pin for regulator

Pin3: It is used for output pin. Through this pin we get the output

Figure 15 Regulator

4.5 DC MOTOR

Fig 16 Dc Motor

A DC motor rotating at 200 RPM (rotations per minute) refers to a specific speed at which the motor's output shaft is rotating. Here's an explanation of what this means:

1. **DC Motor**: DC stands for direct current, which means the motor operates using electrical current that flows in one direction only. DC motors

consist of a rotor (the rotating part) and a stator (the stationary part). When electrical power is supplied to the motor, it generates a magnetic field that interacts with the magnetic field of the stator, causing the rotor to rotate.

2. **200 RPM**: RPM is a measure of rotational speed, indicating how many complete rotations a motor or any rotating object makes in one minute. So, a DC motor rotating at 200 RPM means its output shaft completes 200 full rotations in one minute. This speed can vary based on factors such as the voltage applied to the motor, the load on the motor shaft, and the motor's design characteristics.

Aluminum T Slot Aluminum Section
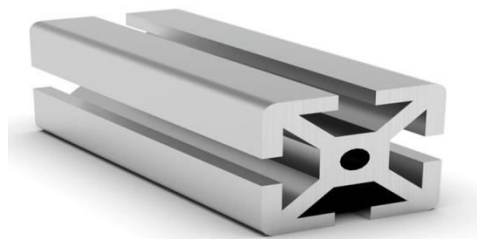
Fig 17 Aluminum T slot Aluminum Section

Aluminum T-slot extrusions, also known as T-slot aluminum profiles or aluminum structural framing systems, are versatile building materials used in various industries for constructing frameworks, enclosures, machine bases, and other structures. Here's a breakdown of what they are and how they're use.

Profile Design: T-slot aluminum sections typically have a cross-sectional shape resembling the letter "T". This design features a central slot running along the length of the extrusion, with T-shaped grooves on one or more of its sides. These slots and grooves allow for the insertion of bolts, nuts, and other fasteners, enabling easy assembly and reconfiguration of the framework without the need for welding.

1. **Material**: These extrusions are made from aluminum, which offers several advantages including lightweight, corrosion resistance, and high strength-to-weight ratio. Aluminum is also easy to machine, making it simple to cut, drill, and modify the profiles according to specific design requirements.

2. **Versatility**: One of the key benefits of T-slot aluminum profiles is their versatility. They come in various sizes, shapes, and configurations, allowing for the construction of structures of different scales and complexities. Additionally, a wide range of accessories such as brackets, connectors, panels, and hinges are available to complement the profiles, enabling the creation of customized solutions for different applications.

3. **Assembly**: Building with T-slot aluminum profiles is straightforward. Users simply connect the profiles together using bolts and nuts inserted into the T-slots. This modular assembly approach facilitates rapid construction and modification, making it ideal for prototyping, manufacturing workstations, ergonomic equipment, display fixtures, and many other applications.

4. **Applications**: T-slot aluminum profiles find applications across diverse industries such as manufacturing, robotics, automation, aerospace, automotive, electronics, and more. They are used to construct machine frames, workbenches, conveyor systems, safety guarding, enclosures, exhibition displays, and even DIY projects.

5. **Benefits**: The use of T-slot aluminum profiles offers several benefits including flexibility, scalability, modularity, and reusability. Structures built with these profiles can be easily modified or expanded as needed, making them adaptable to changing requirements. Additionally, the lightweight nature of aluminum simplifies transportation and installation, while its durability ensures long-lasting performance in various environments

Fig 18 Servo Motor:

Fig 19 Dc Servo Motor

Certainly! A servo motor is a type of motor

commonly used in various applications where precise control of angular position is required. Unlike other types of motors, such as DC motors, servo motors can be controlled to rotate to a specific angle and hold that position with high accuracy.

4.6 SERVO MOTOR

Here's how a servo motor typically works

1. **Internal Mechanism**: Inside a servo motor, there is a DC motor, a set of gears, and a control circuit. The DC motor provides the mechanical power, while the gears amplify the torque and reduce the speed to the desired output.
2. **Feedback System**: Most servo motors include a feedback mechanism, such as a potentiometer or an optical encoder, which provides information about the motor's current position to the control circuit.
3. **Control Signal**: Servo motors are controlled using a control signal, usually a pulse-width modulation (PWM) signal. This signal tells the servo motor the desired position to rotateto.
4. **Position Control**: When the control signal is received, the servo motor's control circuit compares the desired position with the current position feedback. It then adjusts the motor'sspeed and direction to move the output shaft to the desired position.
5. **Hold Position**: Once the servo motor reaches the desired position, the control circuit maintains the otor's power output to hold the shaft in place. This ability to maintain a setposition under load is one of the key features of servo motors.

5.SOFTWARE IMPLEMENTATION

5.1   Arduino Uno on the Arduino Desktop IDE :

If you want to program your Arduino Uno while offline you need to install the Arduino Desktop IDE The Uno is programmed using the Arduino Software (IDE), our Integrated Development Environment common to all our boards. Before you can move on, you must have installed the Arduino Software (IDE) on your PC, as explained in the home page of our Getting Started. Connect your Uno board with an A B USB cable; sometimes this cable is called a USB printer cable.

5.2   Install the board drivers :

If you used the Installer, Windows - from XP up to 10 - will install drivers automatically as soon as you connect your board. If you downloaded and expanded the Zip package or, for somereason, the board wasn't properly recognized, please follow the procedure below.
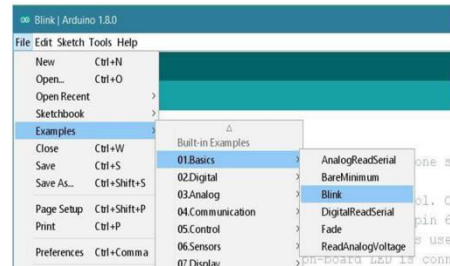

Figure 20 select the board driver

5.3   select your board type and port :

You'll need to select the entry in the Tools > Board menu that corresponds to your Arduino board. Select the serial device of the board from the Tools | Serial Port menu. This is likely to be COM3 or higher (COM1 and COM2 are usually reserved for hardware serial ports).
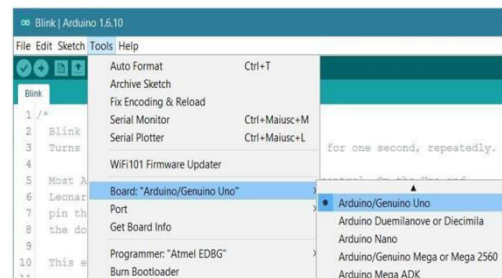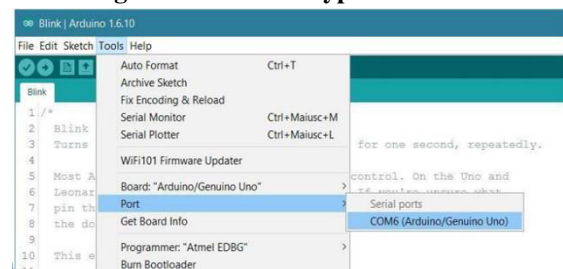

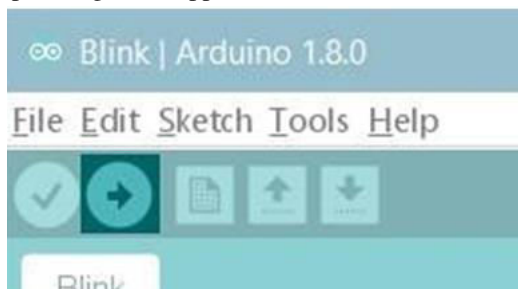**Figure 21 select the type of board**

Figure 22 Select the COM port

5.4   UPLOAD THEPROGRAM

Now, simply click the "Upload" button in the environment. Wait a few seconds - you should see the RX and TX leds on the board flashing. If the upload is successful, the message "Done

uploading." will appear in the status bar.

Figure 23 Sketch the program

A few seconds after the upload finishes, you should see the pin 13 (L) LED on the board start to blink (in orange). If it does, congratulations! You've gotten Arduino up-and-running. Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing. Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments.

5.5 Third-Party Hardware

Support for third-party hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, boot loaders, and programmer definitions. To install, create the hardware directory, then unzip the third-party platform into its own sub-directory. (Don't use "arduino" as the sub-directory name or you'll override the built-in Arduino platform.) To uninstall, simply delete its directory [31]. For details on creating packages for third-party hardware, see the Arduino IDE 1.5 3rd party Hardware specification.

Devices are physical objects like a hardware board that can be contained inside a product (e.g., MKR WiFi 1010). They're the hardware that runs the software, reads sensors, controls actuators and communicates with the Arduino IoT Cloud.

Things represent the inherent properties of the object, with as little reference to the actual hardware used to implement them. Each thing is represented by a collection of properties (e.g., temperature, light). *Properties* are the qualities defining the characteristics of a system. A property can be something like a 'read-only' (RO) setting to indicate the Arduino IoT Cloud can read the data, but cannot change the value of the property.

5.6 3D PRINTING:

3D printing, also known as additive manufacturing, is a revolutionary technology that enables the creation three-dimensional objects layer by layer from digital design files. Here's a breakdown of how it works:
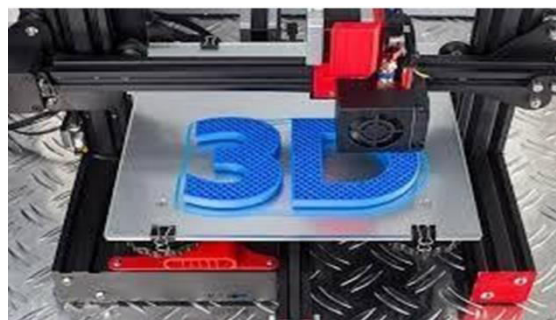
FIGURE 24 3D Printing

6. CONCLUSION

The design and fabrication of the mecanum wheels robot with an arm project has been successfully completed, achieving its intended objectives. Throughout the project, several key aspects were addressed, including mechanical design, electrical system integration, programming, and testing. The following conclusions can be drawn from this project:

Mechanical Design: The design of the mecanum wheels robot chassis and arm mechanism was carefully executed to ensure stability, mobility, and versatility. CAD software aided in visualizing and refining the design before fabrication.

Fabrication: The fabrication process involved precision cutting, drilling, and assembly of components. Attention to detail was crucial to ensure the structural integrity and functionality of the robot.

Electrical System Integration: Integration of the motor drivers, microcontroller, sensors, and actuators was successfully accomplished,

allowing for seamless control and operation of the robot. Wiring and connections were organized to minimize interference and ensure reliability.

Programming: The development of control algorithms and software enabled the robot to perform various tasks autonomously or under user command. Programming languages such as C/C++ were utilized to implement motion control, sensor feedback, and communication protocols.

Testing and Validation: Extensive testing was conducted to validate the performance and functionality of the mecanum wheels robot with an arm. This included testing individual subsystems, as well as integrated testing to evaluate overall performance and compliance with project requirements.

Performance: The robot demonstrated exceptional mobility and manoeuvrability, thanks to the mecanum wheel configuration. The arm mechanism exhibited precise control and manipulation capabilities, allowing the robot to interact with objects effectively.

Overall, the design and fabrication of the mecanum wheels robot with an arm project represent a significant achievement, showcasing the interdisciplinary skills and knowledge required for robotics engineering projects.

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