



RV Educational Institutions®  
RV College of Engineering®

Autonomous  
Institution Affiliated  
to Visvesvaraya  
Technological  
University, Belagavi

Approved by AICTE,  
New Delhi, Accredited  
By NAAC, Bengaluru  
And NBA, New Delhi

*Go, change the world*

## DEPARTMENT OF MECHANICAL ENGINEERING

### **4-DOF Robotic Arm** Experiential Learning Report of **Elements of Industry 4.0 (22EM1C17/27)**

Submitted by

Name	USN	Section	Branch
Khushi Gupta	1RV22CS084	B	CS
K Sriya Choudary	1RV22CS079	A	CS

Under the guidance of  
Dr. Gangadhar Angadi  
Dr. Roopa T S

Assistant professor  
Department of Mechanical Engineering  
RV College of Engineering



2022-23

# RV COLLEGE OF ENGINEERING®, BENGALURU-59

(Autonomous Institution Affiliated to VTU, Belagavi)

## DEPARTMENT OF MECHANICAL ENGINEERING



Topic of the Work:

**4-DOF Robotic Arm**

Marks awarded

Phase I	20	
Phase II	20	
Total marks out of 40		
Signature of examiner		

Name of the students

Sl. No	Name	USN	Signature
1.	<b>Khushi Gupta</b>	<b>1RV22CS084</b>	
2.	<b>K. Sriya Choudary</b>	<b>1RV22CS079</b>	

# CONTENTS

<b>1.0</b>	<b>Introduction</b>	
<b>2.0</b>	<b>Aim of the work</b>	
<b>3.0</b>	<b>Objectives</b>	
<b>4.0</b>	<b>Methodology</b>	
<b>5.0</b>	<b>Components &amp; Industry 4.0 Components</b>	
<b>6.0</b>	<b>Applications</b>	
<b>7.0</b>	<b>Benefits</b>	
<b>8.0</b>	<b>Model</b>	
	<b>Reference</b>	

# 1. INTRODUCTION:

- A 4-DOF robotic arm is a mechanical device designed to replicate the movements and functions of a human arm. The term "4-DOF" refers to the number of independent motions or degrees of freedom the arm possesses. Each degree of freedom corresponds to a specific type of motion the robotic arm can perform, such as rotation or translation along an axis. This particular configuration grants the robotic arm a range of movement resembling the versatility of a human limb
- Transformative Impact: The introduction of the 4-DOF robotic arm has marked a significant turning point in the world of automation and technology. Its integration into industries has led to improved productivity, reduced costs, and increased safety. Additionally, these robotic arms have pushed the boundaries of what is achievable, inspiring innovations that extend beyond their initial applications.
- The advent of the 4-Degree-of-Freedom robotic arm signifies a remarkable achievement in engineering and automation. Its ability to replicate human-like movements with precision and adaptability has revolutionized industries ranging from manufacturing to healthcare. As technology advances, we can expect even more sophisticated iterations of these robotic arms, driving innovation and reshaping the future of various sectors on a global scale.

# 2. AIM OF THE WORK:

The aim of a 4 DOF (Degree of Freedom) robotic arm from an Industry 4.0 perspective is to leverage advanced technologies and principles of the fourth industrial revolution to enhance industrial processes, increase efficiency, and improve overall manufacturing capabilities. In this context, a 4 DOF robotic arm can serve as a versatile and adaptable tool for various automation and smart manufacturing applications. Here's how a 4 DOF robotic arm aligns with Industry 4.0 objectives:

1. **Enhanced Flexibility and Adaptability:** A 4 DOF robotic arm can be programmed and reconfigured easily to perform a wide range of tasks within a manufacturing environment. Its flexibility allows it to adapt to different production needs, making it a valuable asset in agile manufacturing systems.

2. **Integration with IoT (Internet of Things):** In an Industry 4.0 context, the robotic arm can be equipped with sensors and connected to the Internet, enabling real-time data collection and monitoring.
3. **Collaborative Robotics:** A 4 DOF robotic arm can be designed to work safely alongside human operators. Collaborative robots (cobots) are a crucial aspect of Industry 4.0, as they can assist workers in various tasks, improving both productivity and safety.
4. **Remote Monitoring and Control:** Through network connectivity, the robotic arm can be monitored and controlled remotely. This feature enables experts to provide support from anywhere in the world, reducing downtime and enhancing troubleshooting capabilities.
5. **Autonomous Operation:** Leveraging artificial intelligence and machine learning algorithms, the robotic arm can learn from its environment and make autonomous decisions. This can lead to more efficient and adaptive manufacturing processes.
6. **Data Analytics and Decision Support:** The robotic arm generates a wealth of data during its operation. Industry 4.0 principles involve analysing this data to make informed decisions, optimize production, and predict maintenance needs.
7. **Customization and Small-Batch Production:** Industry 4.0 emphasizes the ability to produce customized products and small batches efficiently. A versatile robotic arm can be a key component in achieving this goal.

### 3. OBJECTIVES:

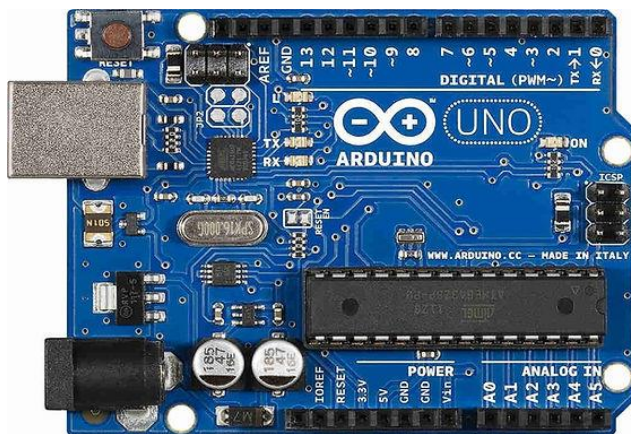
- The objectives for creating a 4-DOF (Degree of Freedom) Robotic Arm are to develop a versatile and efficient automation tool capable of precise and controlled movements. Such a robotic arm aims to enhance productivity by automating repetitive tasks, improving precision in manufacturing processes, and reducing human exposure to hazardous environment
- Flexibility in task execution and adaptability to different applications are key goals, along with the promotion of safety through remote operation. In educational and research contexts, the objective is to provide a hands-on platform for studying robotics principles and advancing control algorithms.
- Overall, a 4-DOF Robotic Arm seeks to offer cost-effective and efficient solutions across a wide range of industries and applications.

## 4. METHODOLOGY:

- Developing a 4-DOF (Degree of Freedom) Robotic Arm follows a systematic methodology. It begins with defining project objectives and requirements, including precision, payload, and workspace. Next, kinematic analysis determines the arm's range of motion and equations for positioning. Component selection involves choosing actuators and sensors.
- Mechanical design creates CAD models for structural integrity. Control system design and software development implement control algorithms and user interfaces. Prototyping and extensive testing validate performance. Integration involves assembling and calibrating the mechanical and electronic components. Documentation and training ensure user readiness. Deployment, monitoring, and maintenance ensure long-term functionality.

## 5. Components:

1. **Arduino Board:** Choose an appropriate Arduino board, such as the Arduino Uno, Arduino Mega, or Arduino Nano, depending on your project's requirements.



2. **Servo Motors:** Servo motors are commonly used for robotic arms due to their precise control and ease of use. You'll need four servo motors, one for each degree of freedom (DOF) in your arm. MG996R or SG90 servos are commonly used for this purpose.



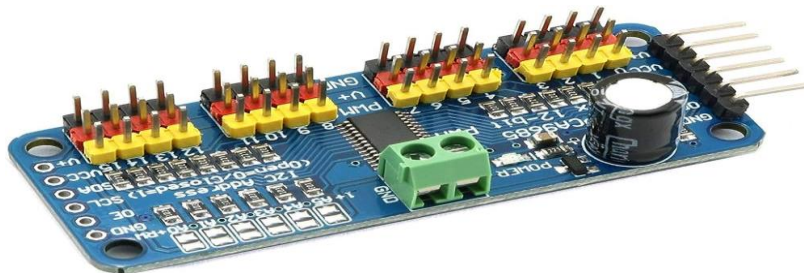
3. **Power Supply:** Servo motors usually require a separate power supply because they draw more current than the Arduino can provide. You'll need a suitable power supply to provide power to the servos. Make sure it matches the voltage and current requirements of your servos.



4. **End Effector:** Depending on your project's purpose, you might need an end effector, such as a gripper, a camera, or a tool for specific tasks. The end effector should be designed to attach to the last joint of your robotic arm.



5. **Motor Drivers:** You may need motor drivers, such as the L298N or L293D, to control the servo motors. These drivers provide the necessary power and control for the motors while reducing the load on the Arduino pins.



6. **Wires and Connectors:** Use appropriate wires and connectors to connect the components together. Ensure that the wires can handle the current required by the servos.



7. **Code:** Write or upload the Arduino code to control the servo motors and any sensors you may have added. The code will define the arm's movements and behaviour.

# Industry 4.0 Components:

## Edge Computing:

- Edge Devices: Deploy edge computing devices close to the robotic arm to perform real-time data processing, reducing latency and enabling quick decision-making.
- Local Control: Edge computing enables local control and automation of the robotic arm, minimizing the need for constant communication with a central server.

## IoT Connectivity:

- Communication Protocols: Utilize industrial communication protocols like MQTT, OPC UA, or Ether CAT to enable seamless data exchange between the robotic arm and other connected devices within the manufacturing environment.
- Connectivity: Robotic arms can be connected to the Industrial Internet of Things (IIoT) network, allowing them to share data with other devices, systems, and the cloud for real-time monitoring, analysis, and optimization.

## Data Analytics and AI:

- Predictive Maintenance: Implement machine learning algorithms to analyse sensor data and predict maintenance needs, helping to prevent unplanned downtime.
- Performance Optimization: Use data analytics to identify patterns and optimize the robotic arm's movements and tasks for improved efficiency.
- Quality Control: AI algorithms can be used to monitor the arm's movements and tasks, ensuring consistent quality in manufacturing processes.

## Cloud Integration:

- Centralized Data Storage: Cloud platforms can store historical data, enabling long-term analysis and trend identification.
- Remote Monitoring and Control: Manufacturers can remotely monitor and control robotic arms through the cloud, allowing for real-time adjustments and troubleshooting.

## Cybersecurity:

- Network Security: Employ robust cybersecurity measures to protect the robotic arm and the entire manufacturing environment from potential cyber threats.



## 6. APPLICATIONS:

A 4-DOF (Degree of Freedom) Robotic Arm has a wide range of applications across various industries due to its versatility and precision. Some notable applications include:

**Manufacturing:** Robotic arms are frequently used in manufacturing processes for tasks like welding, painting, pick-and-place operations, and assembly. They increase efficiency and consistency while reducing production costs.

**Material Handling:** These arms excel in material handling applications, including loading and unloading items on conveyor belts, palletizing, and sorting tasks in warehouses and logistics centres.

**Automated Inspection:** Robotic arms equipped with cameras and sensors can inspect products for defects, ensuring quality control in industries such as automotive, electronics, and food production.

**Medical:** Robotic arms assist in minimally invasive surgery, offering precision and reduced invasiveness. They can be used for tasks like suturing, tissue manipulation, and endoscope positioning.

**Agriculture:** In precision agriculture, robotic arms are employed for tasks like fruit picking, pruning, and sorting, enhancing crop yield and reducing labor costs.

**Research and Education:** Educational institutions and research laboratories use 4-DOF robotic arms for teaching robotics concepts, conducting experiments, and developing new control algorithms and automation techniques.

**Space Exploration:** Robotic arms are essential components of space missions, assisting in tasks like deploying and repairing satellites, collecting samples from other planets, and operating remote instruments.

**Food Industry:** They can be used for food processing tasks, such as cutting, slicing, and packaging, ensuring consistent and hygienic production.

**Construction:** Robotic arms are employed for tasks like bricklaying, concrete spraying, and 3D printing in construction projects, increasing speed and precision.

**Defence and Security:** They can be used in bomb disposal, hazardous material handling, and surveillance, reducing risks to human operators.

**Entertainment and Gaming:** In the entertainment industry, robotic arms are used in theme park rides, virtual reality simulators, and video game controllers, enhancing user experiences.

**Art and Creativity:** Artists and designers utilize robotic arms to create intricate sculptures, paintings, and other forms of art that require precision and repetitive movements.

## 7. BENEFITS:

A 4-DOF (Degree of Freedom) Robotic Arm offers a range of benefits across various applications and industries due to its versatility, precision, and automation capabilities.

Some key advantages include:

**Increased Productivity:** Robotic arms can work continuously without fatigue, leading to higher production rates and reduced cycle times in manufacturing and automation settings.

**Precision and Accuracy:** These arms can perform tasks with incredible precision, ensuring consistent quality and minimizing errors, which is crucial in industries like manufacturing, healthcare, and quality control.

**Enhanced Safety:** By handling dangerous or hazardous materials and performing tasks in risky environments, robotic arms protect human workers from potential harm.

**Cost Reduction:** Robotic automation can lead to cost savings through reduced labour expenses, improved resource utilization, and decreased waste in processes.

**24/7 Operation:** Robotic arms can operate around the clock, increasing overall production capacity and efficiency while reducing downtime.

**Consistency:** Tasks performed by robotic arms are consistent and repeatable, eliminating variations that can occur with human labour.

**Flexibility:** Robotic arms can be reprogrammed or adapted to perform various tasks, making them versatile assets for businesses that require different processes.

**Reduced Labor Intensity:** They can handle physically demanding or repetitive tasks, reducing the need for human workers to engage in monotonous activities.

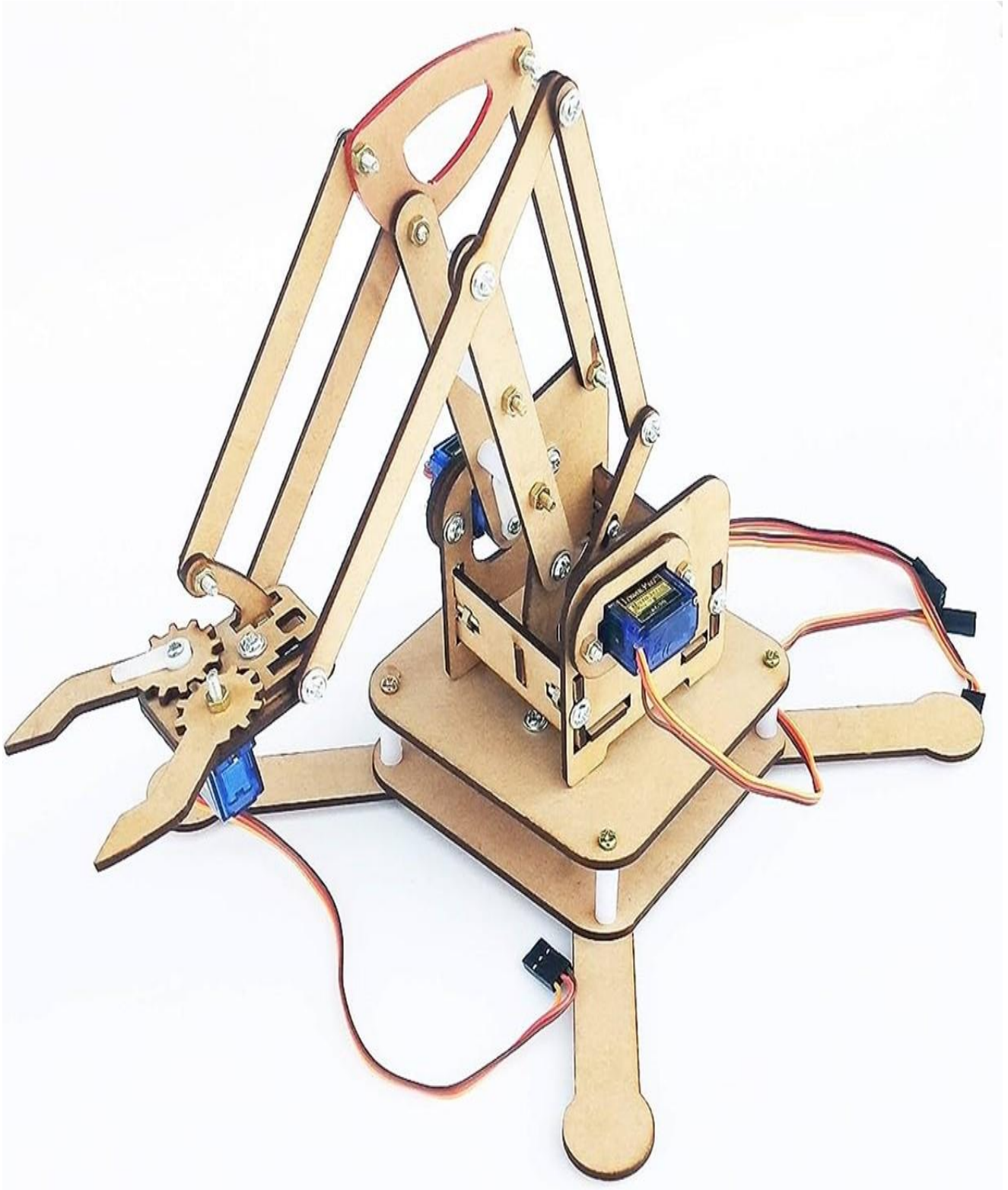
**Space Exploration:** In space missions, robotic arms can extend human capabilities by performing tasks in environments where humans cannot operate directly.

**Medical:** In the medical field, robotic arms aid in minimally invasive surgery, reducing patient trauma, shortening recovery times, and improving surgical precision.

**Environmental Impact:** By optimizing processes and reducing waste, robotic arms contribute to sustainability efforts and can lead to decreased resource consumption.

**Competitive Advantage:** Businesses that adopt robotic automation often gain a competitive edge through improved efficiency, quality, and adaptability.

## 8. MODEL: 4 DOF Robotic Arm



## REFERENCES:

1. Elamvazuthi, N. H. X. Duy, Z. Ali, S. W. Su, M. K. A ; A. Khan, and S. Parasuraman, "Electromyography (EMG) based classification of neuromuscular disorders using a multi-layer perceptron," *Procedia Computer. Sci.*, 76, 2015, pp. 223–228.
2. F. Sadikoglu, C. Kavalcioglu, and B. Dagman, "Electromyogram (EMG) signal detection, classification of EMG signals and diagnosis of neuropathy muscle disease," *Procedia computer. Sci.*, 120, 2017, pp. 422–429.
3. A. Nooranida, H. R. H, M. Hafiz, A. H. I, W. Afezah, and W. A, "Provision of prosthetic services following lower limb amputation in Malaysia," 24(5), 2017, pp. 106–111.
4. L. S. Sudarsan and E. C. Sekaran, "Design and development of EMG controlled prosthetics limb," *Procedia Eng.*, 38, 2012, pp. 3547–3551.
5. M. Jochumsen, A. Waris, and E. N. Kamavuako, "The effect of arm position on classification of hand gestures with intramuscular EMG," *Biomed. Signal Process. Control*, 43, 2018, pp. 1–8.
6. A. Boyali and N. Hashimoto, "Spectral collaborative representation based classification for hand gestures recognition on electromyography signals," *Biomed. Signal Process. Control*, 24, 2016, pp. 11–18

