To: Sir Raheel

PROJECT REPORT

Engineering Mechanics Lab

Project: ROBOTIC ARM

BEME-F-24-B

Group Members:

M. USMAN 241202

ARSEL 241190

M. HAMZA 241238

M. TAYYAB 241235

Table of Contents

List of Figures

Design and Fabrication of a Hydraulic Robotic Arm (Syringe-Based Model)

1. Abstract

This project focuses on the design, fabrication, and testing of a low-cost hydraulic robotic arm using simple materials such as plastic syringes, tubing, and a lightweight structural frame. The robotic arm operates on Pascal's law, where pressure applied to a confined fluid is transmitted equally in all directions. The aim of the project is to demonstrate the basic working principles of hydraulic systems and robotic manipulation without the use of electrical or electronic components. The developed prototype is capable of performing basic movements such as lifting, lowering, and gripping small objects. The project highlights the practical application of fluid mechanics concepts in an educational and cost-effective manner.

2. Introduction

Robotic arms are widely used in industries for material handling, assembly, and automation. Among various actuation methods, hydraulic systems are known for their high force capability and smooth motion. This project presents a simplified hydraulic robotic arm model designed for educational purposes. By using syringes and water as the working fluid, the project demonstrates fundamental principles of hydraulics and mechanical motion in a safe and economical way. The model is suitable for understanding real-world hydraulic systems used in heavy machinery and industrial robots.

3. Literature Review / Background

Hydraulic systems have been used for centuries in machines such as presses, lifts, and excavators. According to Pascal's law, pressure applied to a confined fluid is transmitted equally throughout the fluid. Modern hydraulic robotic arms are commonly used in construction, manufacturing, and aerospace industries due to their ability to handle heavy loads. Previous educational models have used syringes to replicate hydraulic cylinders, allowing students to visualize pressure transmission and mechanical advantage. This project builds upon such models to create a functional multi-degree-of-freedom robotic arm.

4. Problem Statement

To design and fabricate a low-cost, manually operated hydraulic robotic arm that can demonstrate the basic principles of hydraulics, motion control, and force transmission, using easily available materials and without relying on electrical power.

5. Work Distribution Among Group Members

Member Name	Reg ID	Contribution
M. Hamza Khalid	241238	25 %material+report Designing Shoulder + elbow + upper arm (including its syringes)
Arsel Kaleem Abbasi	241190	25 %material+report Rotating mechanism + gripper/hand(design and assembly)
M. Usman Khan	241202	25 %material + report Control panel design + assembly + cad file (parts and assembly)
M. Tayyab	241235	25 %material+report Idea + tube connections + Bases + dimensions + Experimental testing

6. Methodology

The methodology followed in this project includes: 1. Studying the working principle of hydraulic systems 2. Designing a simple robotic arm structure 3. Selecting suitable materials 4. Fabricating mechanical parts 5. Assembling the hydraulic system using syringes and tubes 6. Testing the prototype and recording observations 7. Analyzing failures and performance limitations

7. Materials Used (Bill of Quantities)

Sr. No.	Material	Quantity
1	Plastic Syringes (10–50 ml)	8
2	Plastic Tubes	4
3	Water (Hydraulic Fluid)	40cc
4	Cardboard Base (20*20 cm)	1
5	Popsicle sticks	14
6	Nuts, Bolts, Pins	10
7	Adhesive (Glue)	1
8	Cutter and Tools	—

8. Theoretical Modelling and Calculations

The working principle of the robotic arm is based on Pascal's law:

$$[\ P = F/A\ ]$$

Where:
P = Pressure applied to the fluid
F = Applied force
A = Cross-sectional area of syringe piston

Since pressure is transmitted equally, the output force at the actuator syringe is given by:

$$[\ F_2 = P*A_2\ ]$$

If the input and output syringes have equal areas, the force remains the same, resulting in equal motion. Larger output syringe areas can produce higher forces, demonstrating mechanical advantage.

9. Fabrication Procedure

- The base of the robotic arm was cut from cardboard/wood for stability.
- Arm segments were fabricated using popsicle sticks or plastic strips.
- Joints were created using circular wooden sticks to allow rotation.
- Syringes were attached at joints to act as hydraulic actuators.
- Plastic tubes were connected between control syringes and actuator syringes.
- The system was filled with water carefully to remove air bubbles.

10. Prototype Picture

Figure 1(Robotic Arm)

11. Prototype Development

After assembly, the hydraulic robotic arm was tested for smooth movement. Each syringe controlled one degree of freedom such as base rotation, arm lifting, or gripper movement. The prototype was capable of lifting small lightweight objects like erasers or paper balls.

12. Prototype Experiment Results (Observations and Results)

- **Observations:** Smooth motion observed when air bubbles were removed. Delayed response when air was trapped in tubes. Limited lifting capacity due to lightweight structure.
- **Results:** The robotic arm successfully demonstrated hydraulic motion. Controlled movement achieved using manual syringe input.

13. Cad Design

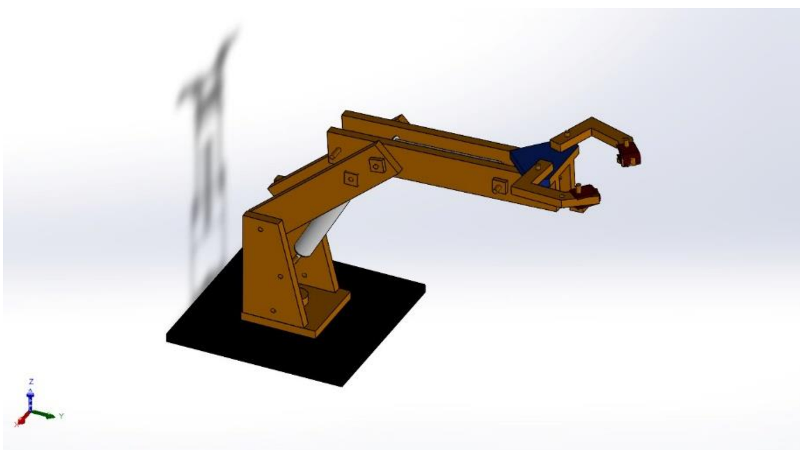

Figure 2 (cad)

14. Failure Analysis

- Leakage at tube-syringe connections reduced efficiency
- Air bubbles caused jerky and delayed motion
- Weak joints limited load-carrying capacity

15. Discussion

The project successfully demonstrated the principles of hydraulics using simple materials. Although the prototype has limitations in strength and precision, it effectively explains how real hydraulic robotic systems function. The absence of electrical components makes the system safe and easy to understand for beginners.

16. Recommendations

- Use stronger materials like acrylic or aluminum for better stability
- Replace water with hydraulic oil to reduce corrosion and leakage
- Incorporate valves for improved control
- Add sensors and motors for automation in future versions

17. Conclusion

The hydraulic robotic arm project achieved its objective of demonstrating hydraulic principles through a functional and low-cost prototype. The project enhanced understanding of fluid mechanics, mechanical design, and teamwork. This model serves as an excellent educational tool for engineering students and can be further improved for advanced applications.

18. References

- Fox, R. W., McDonald, A. T., & Pritchard, P. J., *Introduction to Fluid Mechanics*
- Educational videos and tutorials on hydraulic robotic arms

19. Appendices

- Design sketches
- Experimental photographs
- Cost estimation details

20. Real Time Prototype Development Images

Figure 2

Figure 3

Figure 4

Figure 5