PROJECT ABSTRACT

Hydraulic Arm Trainer using Syringe Actuators

A four-axis hydraulic arm trainer: wooden linkages driven by syringe actuators with water, demonstrating Pascal's law and force multiplication. Delivered built-to-order with the arm, plumbing guide, report, PPT and viva kit.

01. Title

Hydraulic Arm Trainer using Syringe Actuators

02. Introduction / Background

Hydraulics move the world — excavators, lifts, aircraft controls — but to a student Pascal's law is usually just an equation: pressure applied to a confined fluid transmits undiminished. This trainer fills the gap between the equation and the excavator: a four-axis articulated wooden arm where each joint is driven by a syringe actuator. Push the control syringe and fluid pressure moves the working syringe; a small syringe driving a large one multiplies force. Water instead of oil, syringes instead of cylinders — the full fluid-power lesson on a bench.

03. Problem Statement

Fluid power is taught as theory while the hardware — cylinders, valves, bleeding, seal behavior — stays invisible. Students rarely feel Pascal's law or learn why air bubbles ruin hydraulics. This project provides a hands-on trainer where every hydraulic concept is built, plumbed and bled by the student.

04. Objectives

- Build a four-axis articulated arm: shoulder, elbow, wrist, gripper.
- Drive each joint with a syringe actuator pair over transparent tubing.
- Demonstrate Pascal's law and force multiplication by syringe area ratio.
- Provide a documented air-bleed procedure.
- Design wooden linkages converting syringe travel to joint rotation.
- Include a two-finger gripper for pick-and-place demos.
- Deliver a force-ratio measurement guide.
- Deliver the complete student kit: trainer, guides, report, PPT and viva Q&A.

05. Proposed Methodology

Arm links are cut and pivoted; syringes are mounted at each joint and on the control panel; lines are plumbed with transparent tubing and bled of air. The student then runs the force-multiplication measurement (small vs large syringe) and the pick-and-place demonstration task.

06. System Architecture / Working

Pushing a control syringe pressurizes the water column; water barely compresses, so pressure transmits through the tube and extends the working syringe, whose rod pushes the linkage arm into joint rotation. Pulling reverses it — fully manual and proportional. A small control syringe on a large working one multiplies force by the area ratio. Air must be bled because bubbles compress and make motion spongy.

07. Hardware / Software Requirements

- Clear plastic syringes (control + working sets, multiple sizes)
- Transparent flexible tubing and connectors
- Wooden arm links and pivots
- Wooden base and control panel
- Colored water as hydraulic fluid
- Two-finger gripper
- Hand tools: saw, drill, files

08. Expected Outcomes

- A working four-axis hydraulic arm with proportional manual control.
- A student-measured force-multiplication ratio.
- A bled, responsive hydraulic system the student maintains.
- A complete report, PPT and viva Q&A on fluid power and Pascal's law.

09. Applications

- Fluid-mechanics and theory-of-machines teaching laboratories.
- Demonstrating Pascal's law and hydraulic maintenance practice.
- Outreach demonstrations of how excavators work.

10. Future Scope

- Lead-screw motorization of the control syringes.
- Pressure gauges on each line for quantitative study.
- Larger-bore syringe set for heavier demos.
- Joystick-operated master cylinders.