Strengthened Senior High School

DepED
DEPARTMENT OF EDUCATION

Learning Activity Sheets for Mechatronics

TECH-PRO ELECTIVE



Government Property
NOT FOR SALE

Learning Activity Sheets for Mechatronics
Grade 12

This material is intended exclusively for the use of teachers participating in the pilot implementation of the MATATAG K to 10 Curriculum during the school year 2024-2025. It aims to assist in delivering curriculum content, standards, and lesson competencies. Any unauthorized reproduction, distribution, modification, or utilization of this material beyond the designated scope is strictly prohibited and may result in appropriate legal actions and disciplinary measures.

Borrowed content included in this material is owned by their respective copyright holders. Every effort has been made to locate and obtain permission to use these materials from their respective copyright owners. The publisher and development team do not represent nor claim ownership over them.

Development Team

Writer: Mark Andrew L. Yague

Validator: Dr. Erwin R. Callo

Resource Person: Dr. Erwin R. Callo
Philippine Normal University

Learning Area Specialist: John Paul D. Francisco, PhD
Bureau of Learning Delivery
Teaching Learning Division

Bureau of Learning Delivery
Bureau of Curriculum Development
Bureau of Learning Resource

Every care has been taken to ensure the accuracy of the information provided in this material. For inquiries or feedback, please write or call the Office of the Director of the Bureau of Learning Resources via telephone numbers (02) 8634-1072 and 8631-6922 or by email at blr.od@deped.gov.ph.

If you have feedback on the LAS, please complete this form, which may be accessed through the following link: **https://tinyurl.com/sshstechprofeedbackform**

Table of Contents

Lesson Exemplar 1 .....**1**

Lesson Exemplar 2 .....**11**

LEARNING ACTIVITY SHEET

Learning Area:	MECHATRONICS		
Lesson Exemplar:	1	**Date:**	
Lesson Title/Topic:	**Mechatronic Systems Installation** o Electro-Pneumatics Component Integration and System Wiring. **A+, ** A+, A+, A-. (using a 5/2-way solenoid valve)		
Name:		**Grade & Section:**	

I. ACTIVITY NO. 1: Name That Symbol!

II. OBJECTIVES:

At the end of the activity, the learners should be able to:

1. Identify common pneumatic and electrical symbols (5/2-way solenoid valve, spring return, limit switch, double-acting cylinder, DC power supply).
2. Recall the function of each symbol in a control system.
3. Recognize the connection between pneumatic symbols and electrical symbols as a foundation for electro-pneumatics.

III. MATERIALS NEEDED:

- Projector or printed flashcards showing the five symbols
- Whiteboard or chart paper
- Markers or chalk
- Student answer sheets or mini whiteboards (optional)

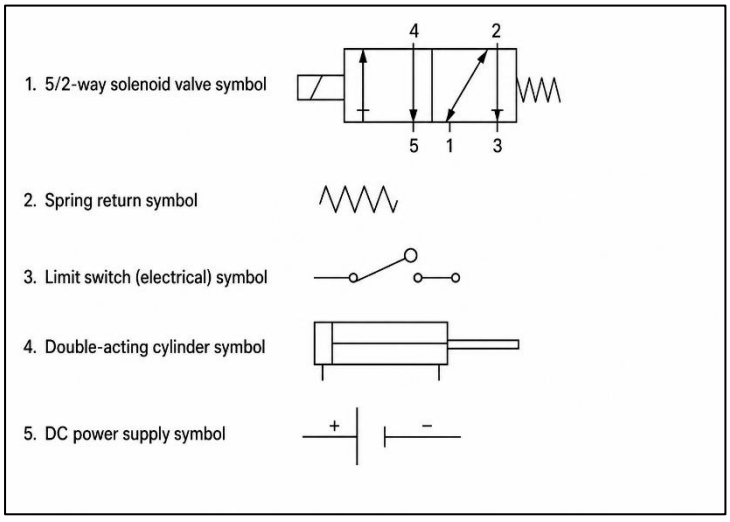
IV. INSTRUCTIONS:

Pedagogy: **4As Approach (Activity, Analysis, Abstraction, Application)**

A. Activity:

The teacher flashes images one by one (or displays all five) of the following symbols:

1. 5/2-way solenoid valve symbol
2. Spring return symbol
3. Limit switch (electrical) symbol
4. Double-acting cylinder symbol
5. DC power supply symbol



Students will individually or in pairs write down the name of each symbol as quickly as possible. After 2–3 minutes, the teacher asks volunteers to share their answers aloud.

B. Analysis:
The teacher facilitates a guided discussion using questions such as:

- Which symbols were easiest to recognize? Why?
- Which symbols were more difficult? What made them confused?
- Among the five symbols, which are purely pneumatic and which are electrical?
- How does a solenoid valve symbol combine both pneumatic and electrical elements?

C. Abstraction:
The teacher explains the key concept: Electro-Pneumatics *is the integration of electrical control signals (e.g., from limit switches, DC power supplies) with pneumatic actuators (e.g., double-acting cylinders) via solenoid-operated valves.*

- The **5/2-way solenoid valve** uses an electrical signal (solenoid) to control air flow.
- The **spring return** brings the valve back to its resting position when the electrical signal stops.
- **Limit switches** send electrical feedback about cylinder position.
- **A DC power supply** provides the necessary voltage for the control circuit.
- The **double-acting cylinder** requires air from the valve to extend and retract.

This activity bridges the gap between previously learned pure pneumatics and the new concept of electro-pneumatic integration.

D. Application:
Students are given a simple scenario: *"A double-acting cylinder must extend when a limit switch is pressed and retract when the switch is released."* Using the five symbols (or their names), students draw or describe a basic electro-pneumatic control sequence, indicating which symbol connects to which.

V. SYNTHESIS / EXTENDED PRACTICE / DIFFERENTIATION
A. Synthesis (Exit Slip): On a small piece of paper, students complete one of these prompts:

- *"One symbol I will never forget from today is _____ because _____."*
- *"Electro-pneumatics is different from pure pneumatics because _____."*

B. Extended Practice (Enrichment):
Students research and draw a complete electro-pneumatic circuit diagram using all five symbols correctly. They must add a push button and explain how pressing the button energizes the solenoid, shifts the 5/2 valve, and moves the double-acting cylinder.

C. Remediation (For students who need more practice):
Students are given a matching worksheet: Column A contains the five symbol images; Column B contains definitions/functions. Students draw lines to match each symbol to its correct function. The teacher reviews answers in a small group session.

I. ACTIVITY NO. 2: Build, Wire, Test

II. OBJECTIVES:

At the end of the activity, the learners should be able to:

1. Differentiate between single-solenoid (mono-stable) and double-solenoid (bi-stable) 5/2-way valves.
2. Follow wiring standards (PEC/IEC) using correct wire colors (red, black, blue, and yellow/green).
3. Properly mount, wire, and test a simple A+ A- electropneumatic circuit based on a layout plan.
4. Demonstrate safety by powering the circuit before wiring and asking the teacher before testing.

III. MATERIALS NEEDED:

Per group (3-4 students):

- 24 VDC power supply
- 5/2-way single solenoid (mono-stable) valve with spring return
- Double-acting cylinder
- Push button (normally open)
- Terminal blocks with common rails
- Cable ducts
- Wires (Red, Black, Blue, Yellow/Green)
- Wire strippers and ferrules (optional but recommended)
- Screwdrivers (flathead and Philips)
- Cable ties
- Layout plan (printed diagram)
- Multimeter (for checking continuity)
- Safety glasses
- Laptop/projector for instructional video access
- Activity sheet with follow questions

IV. INSTRUCTIONS:

Pedagogy: 4As Approach (Activity, Analysis, Abstraction, Application)

A. Activity:

The class is divided into small groups (3–4 students). The teacher first presents an instructional video about the working principle of the 5/2-way valve and double-acting cylinder.

Video link: Directional Control Valve Working Animation | 5/2 Solenoid Valve | Pneumatic Valve Symbols Explained | https://youtu.be/bXXL-0sf8gs?si=K8CIbHpPm_LcJkDU

After watching, each group receives the same set of components and a layout plan. The teacher announces the task: "You *will now build the simple A+ A- circuit you just saw in the video."*

Groups begin by physically mounting components on the panel according to the layout plan.

B. Analysis:
As students work, the teacher circulates and asks guiding questions to promote critical thinking:

- *"Why did you use a blue wire there instead of a red wire?"*
- *"Can you show me where the 0V common is on your terminal block?"*
- *"Is the coil on your valve rated DC? How can you check that?"*
- *"What would happen if you used a red wire for the switched signal?"*
- *"Why does this valve have a spring return? Is it mono-stable or bi-stable?*

Students explain their reasoning aloud, reinforcing correct wiring logic and safety standards.

C. Abstraction:
The teacher discusses new concepts after the analysis:

1. Component Integration – The 5/2-Way Valve

- **Single Solenoid** (Mono-stable): One coil + spring return. Returns to normal position when the coilcoil is de-energized. Requires a single output signal.
- **Double Solenoid (Bi-stable):** Two coils + no spring. Has "memory"—it stays in position after the coil is de-energized. Requires two output signals (A and B).

2. Wiring Standards (PEC/IEC)

- Red: +24VDC (un-switched power)
- **Black:** 0 VDC (common or ground)
- **Blue:** Switched control signals (from push button or sensor to input)
- **Yellow/Green:** Protective earth (for power supply chassis)

Never use a red wire for a switched signal. This ensures safety during troubleshooting.

3. Layout Plan Principles

- Valves mounted on a manifold near cylinders (short air lines)
- Terminal blocks central and accessible
- Cable ducts for neat wire routing (prevents electrical noise, eases troubleshooting)

4. Wiring Procedure Steps

1. Power down – 24V supply OFF and unplugged
2. Layout and mount components
3. Prepare wires – strip 6–8mm, use ferrules for stranded wire
4. Connect ground (green/yellow) to panel ground bus
5. Wire power distribution—Red (+24V) and Black (0V) to terminal block common rails
6. Wire the control circuit (A+ A-):
    - From +24V rail → push button (one side)
    - From push button (other side) → blue wire → A1 (coil +) of solenoid valve
    - From A2 (coil -) → black wire → 0V rail
7. Cable management – use cable ties, route wires through ducts

D. Application:
Each group builds, wires, and tests their A+ A- circuit following the procedures and safety rules.

Key steps to remember:

1. Power off the control circuit while working.
2. Match wire colors to the standard.
3. Use the layout plan for component placement.
4. Ask the teacher before testing the control circuit.

Once the teacher approves, students power on and test the circuit. The push button energizes the solenoid, shifting the 5/2 valve, causing the double-acting cylinder to extend (A+). Releasing the button de-energizes the solenoid, and the spring return shifts the valve back, retracting the cylinder (A-).

The teacher assesses correct wiring, safety compliance, and cylinder movement.

V. SYNTHESIS / EXTENDED PRACTICE / DIFFERENTIATION

A. Synthesis (Exit Slip):
Students complete the following on a small slip of paper before leaving:

1. *One correct wiring color rule I followed today* is _____.
2. *One mistake my group avoided because we asked the teacher first:* _____
3. *I still have a question* about the following: _____

B. Extended Practice (Enrichment):
For students who finish early or want a challenge:

- Modify the circuit by replacing the push button with a limit switch. Wire it so that when the cylinder fully extends, the limit switch automatically de-energizes the solenoid (or triggers retraction).
- Research and draw a wiring diagram for a bi-stable (double solenoid) 5/2 valve controlling a double-acting cylinder. Label all wire colors and terminals (A1, A2, B1, B2).

C. Remediation (For students who need more practice):
For students who struggled with wiring or understanding:

- Provide a pre-wired terminal block and have students trace the path of current from +24V → push button → solenoid coil → 0V, labeling each wire color on a printed diagram.
- Use a color-coded matching activity where students match wire color (red, black, blue, yellow/green) to its correct function and voltage level.
- Conduct a small-group reteaching session where the teacher walks through one complete wiring step using a magnified layout drawing, then the student wires a single connection at a time with immediate feedback.

I. ACTIVITY NO. 3: Test Before You Power!

II. OBJECTIVES:

At the end of the activity, the learners should be able to:

1. Perform three pre-power testing procedures (continuity check, short circuit check, and coil resistance check) on an installed electro-pneumatic circuit using a multimeter.
2. Explain the purpose of each test and why it is performed before applying power.
3. Interpret multimeter readings (continuity beep, resistance values) to determine if the circuit is safe to power.
4. Demonstrate professional safety practices by verifying the circuit before energizing.

III. MATERIALS NEEDED:

Per group (3–4 students):

- Previously wired electro-pneumatic circuit (from Activity 2)
- Digital multimeter with continuity mode (beep symbol) and resistance (Ω) mode
- Testing Procedures Checklist (one per student)
- Pen/pencil for recording readings
- Safety glasses
- Teacher verification stamp or signature pad (optional)

For teacher demonstration:

- One completed circuit (wired correctly)
- One circuit with intentional error (for demo purposes, e.g., short circuit)
- Projector or large multimeter for visibility

IV. INSTRUCTIONS:

Pedagogy: 4As Approach (Activity, Analysis, Abstraction, Application)

A. Activity:

After groups have their circuit wired, the teacher performs a guided pre-power check using a multimeter. The teacher demonstrates each procedure step-by-step on a sample circuit, explaining what to look for and why.

Demonstration sequence:

1. **Continuity Check**—Setting the multimeter to continuity mode, testing from the +24V rail to the solenoid A1 terminal.
2. **Short Circuit Check**—Testing between the +24V rail and 0V rail (ensuring NO beep).
3. **Coil Resistance Check** – Measuring resistance across solenoid terminals A1 and A2.

After the demonstration, each group performs the same three tests on their own installed electro-pneumatic circuit. Students use the Testing Procedures Checklist to document their results and request teacher verification for each step.

B. Analysis:

As students perform the tests, the teacher circulates and asks guiding questions:

- *"What does it mean if the multimeter BEEPS during the continuity check?"*

- "Why is it dangerous if the short circuit check gives a beep between +24V and 0V?"*
- *"Your coil resistance reading is 0 ohms. Is that good or bad? What could that mean?"*
- *"What if your coil resistance is 500 ohms instead of 100 ohms? Would you still power it?"*
- *"Which of these three tests would catch a loose wire? How?*

Students analyze their own readings and compare them to expected values.

Checklist items that prompt analysis:

- Continuity Check: ☐ Pass ☐ Fail
- Short Circuit Check: ☐ Pass ☐ Fail
- Coil Resistance Check: Recorded reading vs. Expected (50–200 Ω)

C. Abstraction:

The teacher facilitates a discussion that leads to generalization after hands on testing.

Key concepts taught:

1. Why Pre-Power Testing Matters

- A professional technician does NOT "turn it on and hope for the best."
- Pre-power testing prevents damage to components (valves, power supply, PLC).
- It prevents electrical hazards (fire, shock, and component explosion).
- It saves troubleshooting time later.

2. The Three Essential Tests

Test	Purpose	Expected Result
Continuity Check	Verify that the control wire from +24V to solenoid coil is unbroken and properly connected.	Multimeter BEEPS (low resistance)
Short Circuit Check	Ensure +24V and 0V are NOT directly connected. Prevents excessive current that could damage the power supply or cause fire.	NO beep (infinite or very high resistance)
Coil Resistance Check	Confirm that the solenoid coil is not open (broken wire) or shortened internally. Also verifies the coil matches the power supply voltage (24V DC coils typically read 50–200 Ω).	50–200 Ω (typical range for 24V DC solenoid)

3. Professional Mindset

"Testing before power is not optional. It is discipline"

The teacher emphasizes that these checks become muscle memory for any qualified technician working with control circuits.

Making Generalization (Pair-Share Activity):

The teacher asks learners to answer the following with a partner:

"In your own words, what is the most important reason we follow a layout plan and strict wiring standards like color coding and pre-power checks?"

After one minute of pair discussion, several pairs share their answers aloud. The teacher synthesizes responses, reinforcing that standards and pre-power checks protect people, equipment, and time.

D. Application:
Each group applies the testing procedures to their own circuit.
Tasks:

1. Complete all three tests in sequence using the multimeter.
2. Record readings and check ☐ Pass or ☐ Fail for each item on the checklist.
3. Call the teacher to verify each test before moving to the next.
4. If any test fails (e.g., short circuit detected or coil resistance out of range), students must troubleshoot and correct the issue before retesting.

Teacher Verification: The teacher observes, asks follow-up questions, and stamps/signs the checklist once all three tests are passed.

Successful completion: Once all checks pass, the teacher gives permission to apply power and test cylinder movement.

V. SYNTHESIS / EXTENDED PRACTICE / DIFFERENTIATION

A. Synthesis (Exit Slip):
Students complete the following on a small slip of paper before leaving:

1. *The three tests I performed today were: _____, _____, and _____.*
2. *If the short circuit check FAILED (multimeter beeped between +24V and 0V), the first thing I would do is _____*
3. *One thing I will ALWAYS do before powering any circuit from now on: _____*

B. Extended Practice (Enrichment):
For students who finish early or want a deeper challenge:

- **Fault finding:** The teacher intentionally introduces a fault into a practice circuit (e.g., loose wire, reversed wire, wrong coil). The student must use the three tests to identify which test fails and diagnose the exact problem.
- **Documentation practice:** Students write a pre-power inspection report as if for a real industrial client, including test results, readings, and a sign-off statement.
- **Research task:** Investigate what happens to a 24V DC solenoid coil if 230V AC is accidentally applied. What safety devices (fuses and circuit breakers) could prevent damage?

C. Remediation (For students who need more practice):
For students who struggle with using the multimeter or interpreting readings:

- **Station rotation with** a guided worksheet: Set up three stations (Continuity, Short Circuit, Coil Resistance). Each station has a pre-wired sample and step-by-step picture instructions. Students rotate and complete each test with teacher or peer assistance.

- **Multimeter simulation** game: Use an online multimeter simulator (or printed images of multimeter displays) where students match the display reading to the correct interpretation (e.g., "0.00 Ω – What does this mean?")
- **Peer tutoring pairing:** Pair a struggling student with a confident student to re-perform all three tests on a simple test board (battery + bulb + switch) before moving to the actual pneumatic circuit.
- **One-test-at-a-time mastery:** Require the student to demonstrate only the continuity check successfully three times before attempting short circuit and resistance checks.

LEARNING ACTIVITY SHEET

Learning Area:	MECHATRONICS		
Lesson Exemplar:	2	**Date:**	
Lesson Title/Topic:	**PLC Programming:** Control Logic Programming and Simulation.		
Name:		**Grade & Section:**	

I. ACTIVITY NO. 1: Think It, Write It

II. OBJECTIVES:

At the end of the activity, the learners should be able to:

1. Identify everyday situations that use "AND" and "OR" logic conditions.
2. Explain the concept of a "permissive" (a condition that must be met before an output turns on) using real-life examples.
3. Translate common-sense scenarios into basic logic statements (e.g., "If A and B are true, then C happens").

III. MATERIALS NEEDED:

- Whiteboard or chart paper with two columns labeled "AND Logic" and "OR Logic"
- Markers or chalk
- Student notebooks or index cards
- Optional: Printed scenario cards (e.g., "Toaster starts," "Car engine runs," "Washing machine fills")

IV. INSTRUCTIONS:

Pedagogy: 4As Approach (Activity, Analysis, Abstraction, Application)

A. Activity:

The teacher writes the following prompt on the board:
"Think of something that starts or happens when you do something. Write it down."
Students are given 2–3 minutes to individually write down one or two everyday examples of a device or machine turning on or performing an action. Examples students might give:

- "The toaster starts when I push the button."
- "The car engine starts when I turn the key."
- "The washing machine fills when I close the lid and press start."

The teacher then asks a few students to share their examples aloud and write simple versions on the board.

B. Analysis:

The teacher facilitates a guided discussion by challenging each example with probing questions to uncover hidden conditions.

Key questioning technique: Circulate and challenge the "AND/OR" logic.

Student Example	Teacher Challenge Question
"The toaster starts when I push the button."	*"What if the toaster isn't plugged in?"*
"The car engine starts when I turn the key."	*"What if the car is in gear?"* or *"What if the battery is dead?"*
"The washing machine fills when I press start."	*"What if the lid is open?"* or *"What if the water supply is off?"*

Follow-up question to introduce permissive concept:
"So, pushing the button alone is NOT enough. What OTHER conditions must be true before the toaster starts?
Students realize that multiple conditions must be satisfied simultaneously. The teacher writes these as logic statements:

- Toaster starts = (Plugged in) AND (Button pushed)
- Car engine starts = (Key turned) AND (Car in Park/Neutral) AND (Battery has charge)

The teacher then asks:
"Can you think of an example where EITHER condition A OR condition B would make something happen?"
Examples of OR logic:

- "The hallway light turns on if I flip the switch at the bottom OR the switch at the top of the stairs."
- "The alarm sounds if the door opens OR the window breaks."

C. Abstraction:
The teacher formally introduces the key concept using the students' own examples.
1. The Idea of a "Permissive"
A permissive is a condition that must be true BEFORE an output is allowed to turn on. It permits action. If the permissive is false, nothing happens—even if you press the button.

Examples from student discussion:

- The toaster being plugged in is permissive for the heating element.
- The lid being closed is permissive for the washing machine spin cycle.
- The emergency stop button NOT being pressed is permissive for almost every industrial machine.

2. AND Logic vs. OR Logic

Logic Type	Meaning	Example
AND	All conditions must be true for the output to happen.	Engine runs IF (key on) AND (fuel has pressure) AND (safety switch closed).
OR	At least one condition must be true for the output to happen.	Light turns on IF (switch A on) OR (switch B on).

3. Why This Matters in Electro-Pneumatics
*"In **electropneumatics,** a cylinder will NOT extend just because you press a button. They are always permissive: Is the emergency stop released? Is the power supply on? Is there any air pressure? The PLC checks ALL conditions before sending a signal."*

The teacher connects back to Activities 2 and 3: the pre-power checks (continuity, short circuit, and coil resistance) are also permissive—they must pass BEFORE you are allowed to apply power.

D. Application:
Students apply the concept to a simple electro-pneumatic scenario.

Scenario:
"A double-acting cylinder must extend when the operator presses the push button. However, the cylinder should NOT extend if either (1) the emergency stop is pressed OR (2) the air supply pressure is below 4 bar."

Task for students (individual or pair):
1. Identify the output (cylinder extends).
2. Identify the permissive (conditions that must be true).
3. Write the logic statement using **AND** / **OR**.

Expected answer:
The cylinder extends IF (the push button is pressed) AND (the emergency stop is released) AND (the air pressure is ≥ 4 bar).

Extension (if time allows):
The teacher gives another simple example:
"A conveyor motor runs if EITHER the 'Start' button is pressed OR the 'Auto' signal from the sensor is ON. BUT the motor stops immediately if the emergency stop is pressed."
Students write logic statements.

Expected answer:
The motor runs IF the start button is pressed OR the auto sensor is ON) AND (the emergency stop is NOT pressed).
The teacher circulates, checks answers, and challenges students with "What if…" questions.

V. SYNTHESIS / EXTENDED PRACTICE / DIFFERENTIATION

A. Synthesis (Exit Slip):
Students complete the following on a small slip of paper:
1. *In your own words, what is "permissive"? Give an example* from *today's discussion.*
2. *Write one real-life example of **AND** logic (not from class).*
3. *Write one real-life example of OR logic (not from class).*

B. Extended Practice (Enrichment):

For students who grasp the concept quickly:

- **Design a safety interlock: Students** draw a simple diagram of a machine (e.g., drill press, paper cutter) with three permissives (e.g., guard closed, emergency stop out, power on). Write the AND logic statement.
- **Truth table creation:** Students create a truth table for a two-input AND gate and a two-input OR gate, then explain how this applies to a solenoid valve with two permissive sensors.
- **Reverse engineering:** Students find a household appliance (microwave, coffee maker) and list all permissive required before it will operate (e.g., door closed, water tank full, power plugged in).

C. Remediation (For students who need more practice):

For students who struggle with AND/OR logic or the permissive concept:

- **Picture sorting activity:** Provide images of everyday scenarios (toaster, car, washing machine, door with two locks, light with two switches). Students sort them into an "AND logic" pile and an "OR logic" pile with a partner.
- **Fill-in-the-blank logic statements:** Give partially completed statements such as "The *vending machine gives a drink IF (money inserted)* _____ *(button pressed)* _____ *(drink* available)." Students fill in "AND" or "OR."
- **Hands-on demo with two switches and a bulb:** Wire a simple circuit with two switches in series (AND logic) and two switches in parallel (OR logic). Students press each combination and observe when the bulb turns on, then label each setup as AND/OR.
- **One-on-one questioning:** The teacher asks the student to explain only the toaster example step-by-step.
- "First, what must be true?"
- "Second, what do you do?"
- "Third, what happens?

  Before moving to a new example.

I. ACTIVITY NO. 2: Watch and Learn

II. OBJECTIVES:

At the end of the activity, the learners should be able to:

1. Define a Programmable Logic Controller (PLC) as the "brain" of an automated machine.
2. Identify basic ladder logic symbols (normally open contact, output coil, rung).
3. Explain the concept of a latching/sealing circuit (start-stop control).
4. Describe how ladder logic is scanned repeatedly by the PLC.
5. Create a simple ladder diagram based on logic conditions.

III. MATERIALS NEEDED:

- Projector or large screen for video playback
- Speakers for audio
- Whiteboard or chart paper with markers
- Student notebooks or printed ladder logic worksheets
- Access to YouTube videos:
-
    - ArduinoPLC | PLC Ladder Simulator Version 2.0 | OVERVIEW
    - SIEMENS | PLC PROGRAMMING TUTORIAL | START-STOP CONTROL
- Optional: PLC Ladder Simulator software (if available for hands-on)

IV. INSTRUCTIONS:

Pedagogy: 4As Approach (Activity, Analysis, Abstraction, Application)

A. Activity:

Before the video: The teacher engages students with a quick warm-up discussion.

- **Question:** *"What devices do you know that work automatically without someone holding a button?"*
- **Expected answers:** traffic lights, vending machine, elevator, automatic door, and washing machine.
- **Teacher introduction:** "All *these machines have a 'brain' that decides when to turn things on and off. That brain is called a* ***Programmable Logic Controller****, or PLC. The language we use to tell the PLC what to do is called* ***ladder logic*** *– it looks like electrical diagrams but works differently."*
-

Pre-viewing instructions given to students:

"Watch for basic symbols – inputs, outputs, and rungs. Pay attention to how a simple start-stop circuit works."

During the video, the teacher plays short video clips (maximum 5 minutes total).

First video: [PLC Ladder Simulator Overview]

- Pause when ladder symbols appear on screen.
- **Quick check question:** *"Is this symbol an input or an output?"*

Second video: [Start-Stop Control Tutorial]

- Play the simulation portion.
- **Prediction question (pause before the button is pressed):** *"What do you predict will happen when this button is pressed?"*

- Resume video to confirm.

After the video, the teacher draws one **simple rung** on the whiteboard:
text
|----[ ]-------------------( )----|
Input (Start) art | Output | put

- **Questions:** *"What are these symbols called? Which one is the input? Which one is the output?*
- **Connection to prior learning:** *"Remember our toaster example from Activity 1? If the toaster is the output, what are the permissives (AND conditions)?"*
- **Clarification:** "Ladder *logic looks like a real electrical circuit, but it is NOT. The PLC scans the rungs repeatedly*—millions *of times per second*—and *updates outputs based on the current inputs."*

Transition statement to application:
"Now that you have seen how ladder logic works, you will create your own ladder diagram based on logic conditions."

B. Analysis:
The teacher facilitates a guided analysis using comparison and contrast questions.

Compare ladder logic to the earlier AND/OR logic (Activity 1):

Question	Purpose
"In our toaster example, was that AND logic or OR logic?"	Recall permissives (plugged in AND button pressed)
"How would you draw that toaster condition as a ladder rung?"	Translate real logic to ladder symbols
"In the start-stop video, what happened when you released the start *button? Did the motor stop?*	Introduce latching concept
"Why didn't it stop? What kept the output on?	Understand sealing contact

Key analytical question:
"What is the difference between a regular electrical circuit and PLC ladder logic?"

Expected student responses after discussion:

- Electrical circuits work instantly and continuously.
- Ladder logic is scanned—inputs are read; logic is solved, and outputs are updated—in repeat cycles.
- A PLC can be reprogrammed without changing wires.

C. Abstraction:
The teacher formally presents the key concepts.
1. What is a PLC?

- **Programmable Logic Controller** – an industrial computer used to control machines and processes.
- It is the "brain" that reads inputs (sensors, buttons) and turns outputs on/off (valves, motors, lights).

2. What is Ladder Logic?

- A graphical programming language that looks like electrical relay diagrams.
- Built on rungs—each rung is a logic statement.
- Basic symbols:

Symbol	Name	Function
--[ ]--	Normally Open Contact	Input – passes power if condition is TRUE
--[\]--	Normally Closed Contact	Input – passes power if condition is FALSE
--( )--	Output Coil	Output – turns on when rung is TRUE

3. The Latching (Sealing) Circuit – Start/Stop Control

text

```
Rung 1:  |----[Start]----[Stop]----(Motor)----|
         |                  |
         |----[Motor]----------|
         | (Seal contact)
```

How it works:

- Press Start → The motor coil energizes.
- Motor coil energizes → Seal contact (motor) closes.
- Release Start → Seal contact keeps the rung TRUE.
- Press Stop (normally closed) → Breaks the path → Motor turns off.

4. Scanning vs. Real Circuit

- A real circuit works instantly and continuously.
- A PLC scans repeatedly: Read inputs → Execute logic → Write outputs → Repeat.
- This is why ladder logic can do things a hardwired circuit cannot (timers, counters, memory).

Connection back to Activity 1:

"The Start button AND the Stop button (not pressed) AND the seal contact are all permissives for the motor output to stay on."

D. Application:

Students create their own ladder diagram based on logic conditions.

Scenario given to students:

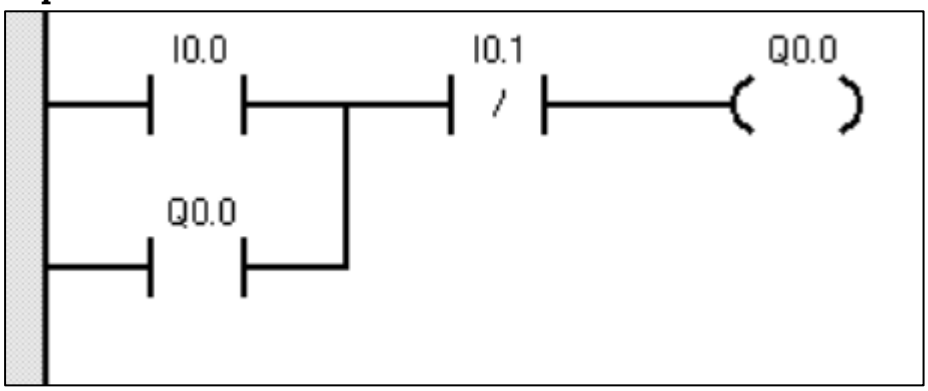
"Design a ladder logic rang for a conveyor belt system. The conveyor motor should run when:

1. *The Start button is pressed (momentary), AND*
2. *The Emergency Stop is NOT pressed, AND*
3. *The motor stays running even after the Start button is released (seal/latch).*
4. *The Stop button turns the motor off."*

Task for students (individual or pair):

1. Draw the ladder with proper symbols.
2. Label all inputs and outputs.
3. Identify the **seal contact**.

Expected answer:



Teacher circulation questions:

- *"What happens if the Emergency Stop is pressed?"*
- *"Which contact is the permissive?"*
- *"After releasing Start, what keeps the motor running?"*

Optional extension (if time allows): Students simulate their rung using a free online PLC simulator (or on paper by tracing the path).

V. SYNTHESIS / EXTENDED PRACTICE / DIFFERENTIATION

A. Synthesis (Exit Slip):

Students complete the following on a small slip of paper:

1. *A PLC is the "___" of an automated machine.*
2. *The ladder logic symbol --[ ]-- is called a _____ contact.*
3. *In a start-stop latch circuit, the _____ contact keeps the output on after the Start button is released.*
4. *One thing I still wonder about PLCs or ladder logic is _____*

B. Extended Practice (Enrichment):

For students who finish early or want a deeper challenge:

- **Add a second condition:** Modify the conveyor ladder diagram so the motor only runs if BOTH a Start button is pressed AND a sensor detects a box present. Draw the new rung.
- **Compare mono-stable vs. bi-stable in** a ladder: Explain how a start-stop latch circuit is like a bi-stable (double solenoid) valve from Activity 2—both have "memory."
- **Research task:** Find out what the letters in "PLC" stand for and name three real-world brands of PLCs (e.g., Siemens, Allen-Bradley, Mitsubishi).
- **Simulation challenge:** Using a free online PLC simulator (if available), build and test the start-stop circuit virtually.

C. Remediation (For students who need more practice):

For students who struggle with ladder logic symbols or the latching concept:

- **Symbol flashcard** drill: The teacher shows printed symbols (normally open contact, normally closed contact, and output coil). Students say the name and whether it's an input or output.

- **Physical tracing activity:** Print a large start-stop ladder rung. Students physically trace the path with a finger, saying "Start pressed → path closes → coil energizes → seal closes" step by step.
- **Color-coded worksheet:** Provide a ladder rung where the teacher has pre-drawn it. Students color the seal contact yellow, the start button green, the stop button red, and the output coil blue.
- **One-on-one re-teaching:** The teacher uses a simple two-switch-and-bulb circuit to mimic a latch (push button + toggle switch in parallel) before introducing the ladder symbol version.
- **Peer buddy** system: Pair a struggling student with a stronger student to draw ONE rung together—only the start-stop latching circuit—before attempting the conveyor scenario.

I. ACTIVITY NO. 3: Logic Challenge

II. OBJECTIVES:

At the end of the activity, the learners should be able to:

1. Identify the physical inputs and outputs required for a basic electro-pneumatic sequencing task.
2. Design a ladder logic diagram that controls a single pneumatic cylinder with automatic retraction.
3. Implement a latching (seal-in) circuit for continuous operation.
4. Include a safety stop button that halts the process at any point.
5. Use standard ladder logic symbols and proper documentation.

III. MATERIALS NEEDED:

- Whiteboard or chart paper with markers
- Student notebooks or printed ladder logic worksheets
- Projector for presenting examples (videos)
- Access to YouTube videos:
    - ArduinoPLC | PLC Ladder Simulator Version 2.0 | OVERVIEW
    - SIEMENS | PLC PROGRAMMING TUTORIAL | START-STOP CONTROL
- Copy of the rubric for each student (optional for self-assessment)
- Pencils and erasers
- Optional: PLC simulation software (e.g., PLC Ladder Simulator) for testing

IV. INSTRUCTIONS:

Pedagogy: 4As Approach (Activity, Analysis, Abstraction, Application)

A. Activity:

1. Presenting Examples (Review from Activity 2)

The teacher reviews the instructional videos from Activity 2 to refresh students' understanding of PLC ladder logic and start-stop control.

Videos:

- ArduinoPLC | PLC Ladder Simulator Version 2.0 | OVERVIEW
- SIEMENS | PLC PROGRAMMING TUTORIAL | START-STOP CONTROL

Quick review questions:

- *"What does normal open contact look like? What does it do?*
- *"What is* a seal-in *contact? Why is it important?*
- *"How does a Stop button work in ladder logic?"*

2. Introducing the Logic Challenge

The teacher reads the logic condition aloud to the class:

"Design a ladder logic diagram for a system that controls a single pneumatic cylinder based on the following logic condition:
When a 'Start' button is pressed, the cylinder extends. When it reaches the fully extended position (detected by a limit switch), it automatically retracts. A 'Stop' button should halt the process at any point."

Pre-activity question to the class:
"How many inputs and outputs are needed for this system?"
Students think individually, then share answers.

Expected answer:

- **Inputs:** Start button (NO), Stop button (NC), Limit switch (NO)
- **Outputs:** Solenoid valve (cylinder extend)

B. Analysis:
The teacher facilitates analysis by breaking down the logic condition.

Guided questioning:

Question	Purpose
"What happens first? What triggers the cylinder to extend?"	Identify Start button as initial trigger
"After extending, how does the PLC know when to retract?"	Identify limit switch as feedback
"Does the cylinder retract immediately after extending, or after reaching the end?"	Clarify sequence timing
"Should the cylinder keep extending even after I release the Start button?"	Introduce need for latching
"Where should the Stop button be placed in the rung?"	Understand NC contact in series
"What happens if the Stop button is pressed while the cylinder is extending?"	Confirm safety requirement
"After retracting, what should the system do? Extend again automatically?	Clarify single-cycle behavior

Important note for the teacher to emphasize:
"The cylinder retracts automatically only AFTER the limit switch is activated, NOT immediately after extending."

Input/Output summary written on board:

Type	Device	Symbol Type	Address (example)
Input	Start Button	Normally Open	I0.0
Input	Stop Button	Normally Closed	I0.1
Input	Limit Switch (Extended position)	Normally Open (ACTUAL)	I0.2
Input	Limit Switch (Extended position)	Normally Open (ACTUAL)	I0.3
Output	Solenoid Valve (Extend)	Output Coil	O0.0

C. Abstraction:
The teacher presents new concepts related to PLC programming.
1. PLC Programming Quick Guide

Software Setup:
Before coding, match your digital environment to physical hardware:

- **Pick Your Platform:** TIA Portal (Siemens), GX Works (Mitsubishi), or CCW (Rockwell)
- **Configure Hardware:** Define CPU model and I/O modules, so software knows where physical wires are connected.
- **Establish** Comm-Link: Set up IP address or USB driver to "talk" to the PLC.

Basic Control (The Start/Stop)

- **Seal-In Logic:** Place a contact from the motor output in parallel with the start button.
- Result: Once started, the output "holds itself on" until the stop button breaks the circuit.

Timers & Counters (for future reference)

- **TON (On-Delay):** Waits X seconds before starting (e.g., warning siren before belt moves)
- **TOF (Off-Delay):** Keeps device running for X seconds after signal stops (e.g., cooling fan)
- **CTU** (Count Up): **Up):** Counts parts on a belt
- **CTD (Count Down):** Tracks remaining items in a hopper

Program Download

- Transfer logic from PC to PLC via Ethernet or USB.
- PLC is placed in STOP or PROGRAM mode during transfer, then switched to RUN.

Online Monitoring

- Go online to watch Logic live.
- Visual feedback: Energized contacts change color (green/blue).

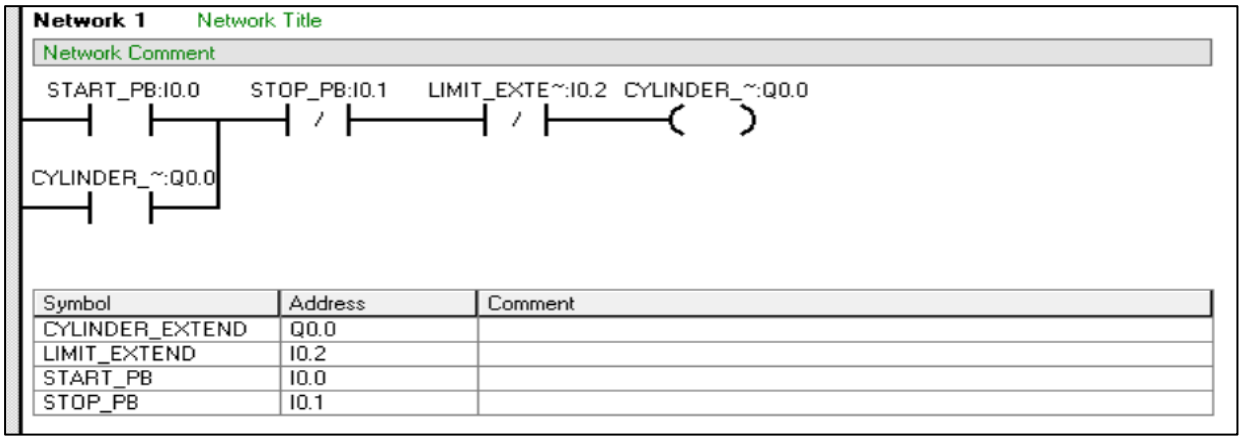
Testing & Debugging

- **I/O Checkout:** Manually trigger the sensor to ensure the correct input light turns on.
- **Forcing Bits:** Temporarily "force" an output to test wiring.
- **Troubleshooting:** Identify "bugs" (logical errors) or wiring faults.

2. Ladder Logic Structure for This Challenge
The teacher explains the required rungs:

Rung 1: Start/Stop with Seal-In (Controls the extend command)
text

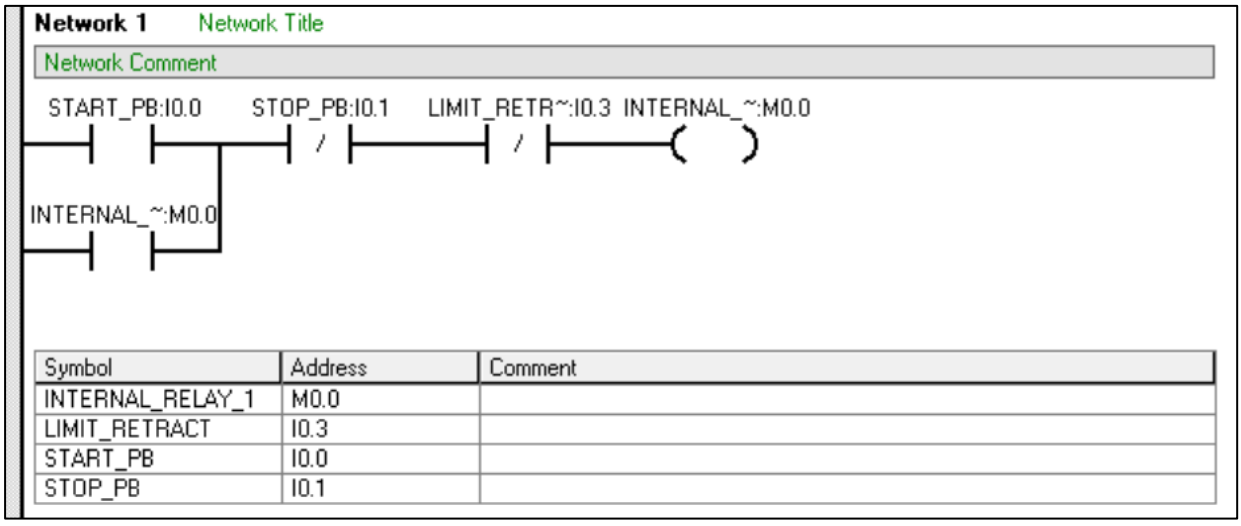
```
|----[Start]----[Stop]----[Limit_Switch_NC?]  ----(Extend Output) ----|
|                  |                                  |
|----[Extend Output] --|                                |
|   \(Seal contact)
```



Symbol	Address	Comment
CYLINDER_EXTEND	Q0.0	
LIMIT_EXTEND	I0.2	
START_PB	I0.0	
STOP_PB	I0.1	

Important clarification: The limit switch should NOT prevent extension from starting. It should ONLY trigger retraction. Therefore, the limit switch is NOT placed in series with the extend output. Instead, a second rung handles retraction.

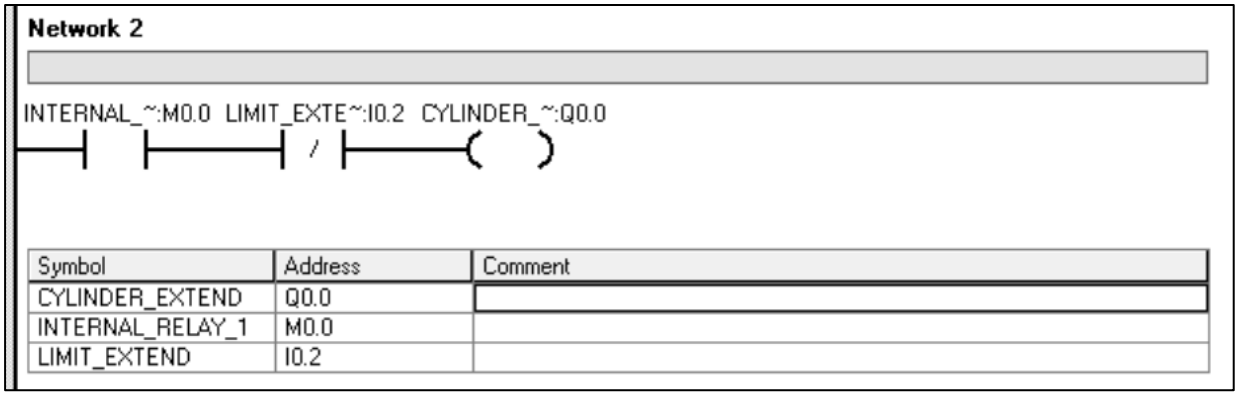
Alternative correct approach (more common):
Rung 1: Extend Control with Latch
text
|----[Start]----[Stop]--------------------(Extend_Latch)----|
| | |
|----[Extend Latch]---|



Symbol	Address	Comment
INTERNAL_RELAY_1	M0.0	
LIMIT_RETRACT	I0.3	
START_PB	I0.0	
STOP_PB	I0.1	

|

Rung 2: Extend Output (with limit switch to break)
text
|----[Extend Latch]----[Limit_Switch_NC]----(Solenoid Extend)----|

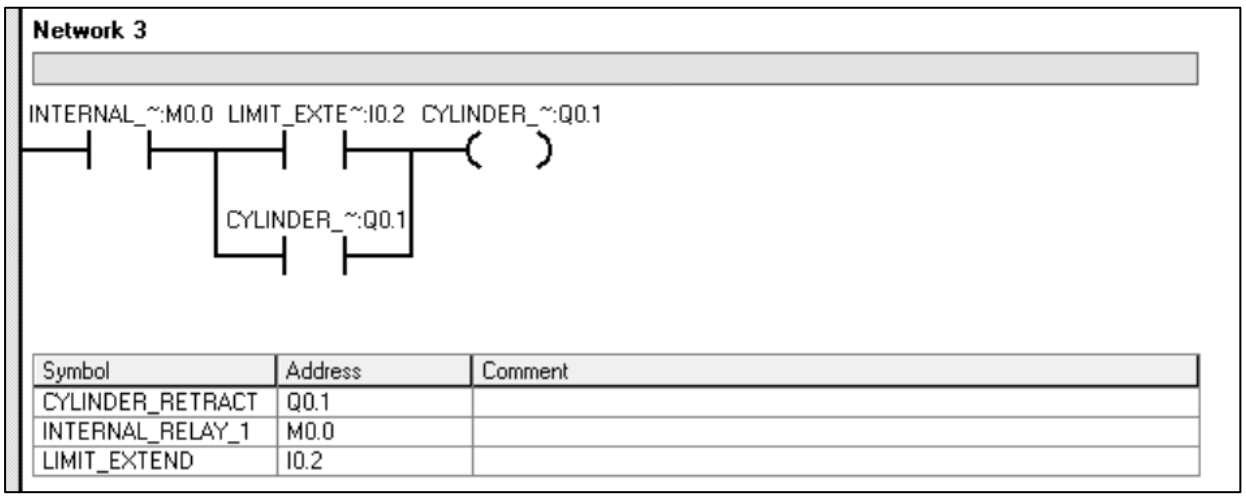


Symbol	Address	Comment
CYLINDER_EXTEND	Q0.0	
INTERNAL_RELAY_1	M0.0	
LIMIT_EXTEND	I0.2	

Rung 3: Reset Extend Latch when limit switch is made

text

```
|----[Limit_Switch_NO]--------------------(Reset_Extend_Latch)----|
|                    (or use a second rung to break the seal)
```



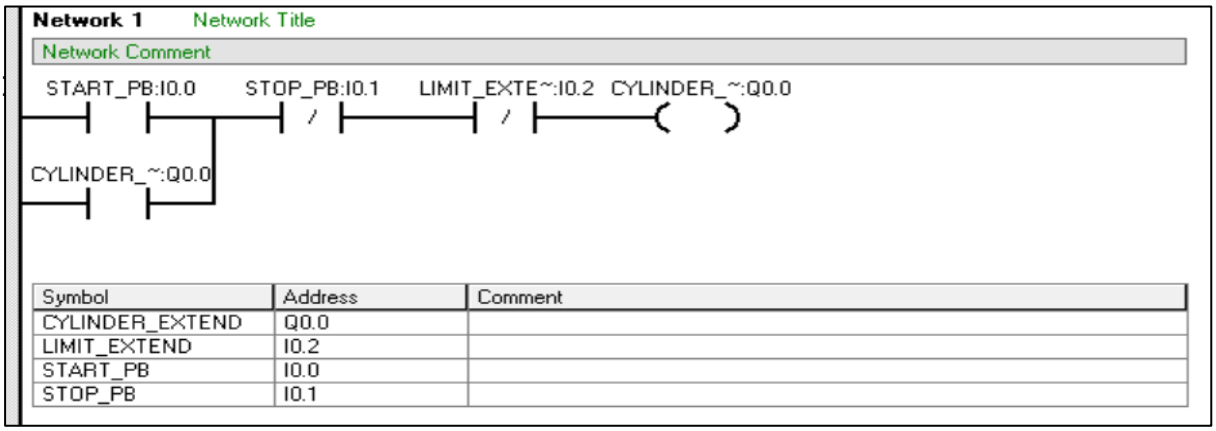
Symbol	Address	Comment
CYLINDER_RETRACT	Q0.1	
INTERNAL_RELAY_1	M0.0	
LIMIT_EXTEND	I0.2	

Simplest correct solution (for student level):

Rung 1:

text

```
|----[Start]----[Stop]----[Limit_Switch_NC]----(Extend  Output)----|
|                    |                                  |
|----[Extend  Output]--|
```



Symbol	Address	Comment
CYLINDER_EXTEND	Q0.0	
LIMIT_EXTEND	I0.2	
START_PB	I0.0	
STOP_PB	I0.1	

D. Application:
Task: Students design a ladder logic diagram for the described system.

Instructions given to students:

1. First, list the physical inputs and outputs required.
2. Second, draw the ladder logic diagram for this control sequence.
3. Use standard ladder logic symbols.
4. Label all contacts and outputs clearly.

Before activity checklist for teacher:

- Read the logic condition to the class.
- Ask: "How *many inputs and outputs are needed?"*
- Remind students: Start (NO), Stop (NC), Limit Switch (NO), and Cylinder Output.

During activity:

- Tell students to list inputs and outputs first.
- Remind them to use proper symbols.
- Walk around and check their work.
- Ask guiding questions: *"Where does the seal contact go?" "What happens when the limit switch is activated?"*

After activity:

- Call one student to draw their answer on the board.
- Show the correct diagram and explain it briefly.
- Correct any mistakes.

Rubric for Assessment:

Criteria	Exemplary (4)	Proficient (3)	Developing (2)	Beginning (1)
I/O Identification	All physical inputs (Start, Stop, Limit Switch) and outputs (Solenoid) correctly identified	Most inputs/outputs identified, minor errors	Only basic inputs (Start/Stop); missing limit switch or solenoid	Failed to list or incorrectly identified I/O components
Logic & Sequencing	Ladder logic perfectly executes: Start → Extend → Limit Switch → Retract	Functional but minor logic gaps	Starts and extends but fails to retract correctly	Does not initiate cylinder or follow sequence
Safety & Control (Stop Function)	Stop button halts process	Stop button works but only	Stop button in diagram but	No Stop button or

	instantly at any point	at specific stages	incorrectly wired	safety interlock
Circuit Integrity (Latching)	Uses professional latching (seal-in) or SET/RESET logic	Latching used but may require multiple presses	Attempted latching but button must be held	No latching logic used
Documentation & Symbols	Standard LD symbols; neatly organized with labels	Standard symbols; legible but lacks some labels	Non-standard symbols; cluttered	Disorganized, missing rungs, incorrect notation

V. SYNTHESIS / EXTENDED PRACTICE / DIFFERENTIATION

A. Synthesis (Exit Slip):

Students complete the following on a small slip of paper:

1. *The three inputs I used in my ladder diagram were: _____, _____, and _____.*
2. *The limit switch in this system serves what purpose? (Answer: It detects full extension and triggers retraction.*
3. *If the cylinder extended but never retracted, the most likely problem is _____*
4. *One thing I want to clarify about ladder logic is _____*

B. Extended Practice (Enrichment):

For students who complete the task successfully and want a deeper challenge:

- **Add a timer:** Modify the ladder diagram so that after the cylinder extends and hits the limit switch, it waits 3 seconds (TON timer) before retracting.
- **Add a counter:** Modify the system to extend and retract 5 times automatically after one Start press, then stop. (Use a CTU counter.
- **Add indicator lights:** Design additional rungs for a green "Running" light (on while extending) and a red "Idle" light (on when retracted or stopped).
- **Simulate the program:** If PLC simulation software is available, students enter their ladder logic and test it virtually before the teacher shows the correct answer.

C. Remediation (For students who need more practice):

For students who struggle with I/O identification or ladder logic design:

- **Step-by-step guided worksheet:** Provide a partially completed ladder diagram with the Start button and Stop button already drawn. Students add only the seal contact and limit switch.
- **Card sorting activity:** Print separate cards for each component (Start, Stop, Limit Switch NC, Limit Switch NO, Output, Seal contact). Students arrange them on a table to form a correct ladder rung.
- **Color-coded template:** Provide a printed rung where
    - Start button = Green box
    - Stop button = Red box
    - Seal contact = Yellow box

    - Limit switch = Blue box
    - Output = Orange box
    - Students trace the path and explain what each box does.
- **One-on-one re-teaching:** The teacher works with a small group to draw ONE rung together—only the start-stop seal circuit—then adds the limit switch and then discusses how the cylinder retracts.
- **Peer explanation:** Pair a struggling student with a proficient student. The proficient student explains their diagram step by step using these sentence starters: *"First, when Start is pressed... Next, the seal contact... Finally, the limit switch..."*