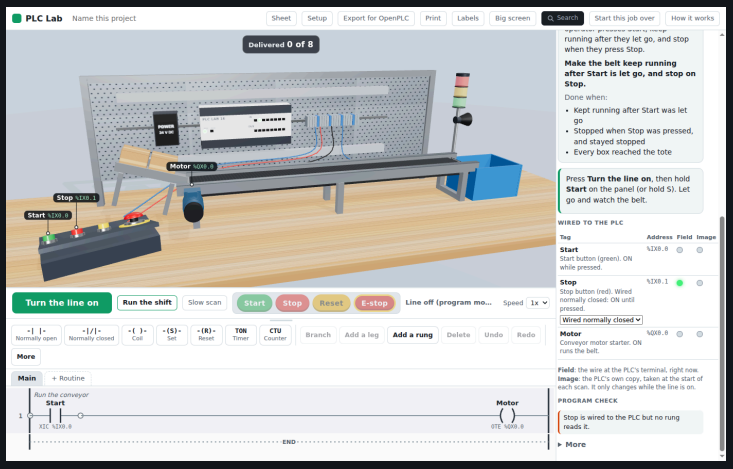
mytekDev

PLC Lab: Start, Stop and the Seal-In, a First Ladder Logic Program

Grades 10-12 · 45 minutes

Career and technical education · Engineering · Manufacturing technology



Slides, rubric and answer key | **Print and go** | **No student accounts** | **Chromebook friendly**

What's included

- A one-page overview: objectives, essential question, vocabulary, standards and assessment
- A 45-minute lesson sequence: warm-up, direct instruction, guided practice, independent practice, closure
- Slides for the board: a PowerPoint file that also opens in Google Slides
- A student worksheet with a QR code and a box to draw the finished rung
- A 3-question exit ticket, two to a page, with an answer key
- A rubric: 3 criteria, 4 levels, scored out of 12
- Differentiation for English learners, students with IEPs or 504 plans, and students who need more support or more challenge
- Cross-curricular extensions, and notes for teaching it in grade 9 and in a second-year PLC course
- Standards: Texas PLC courses, Massachusetts 2025, PMMI, SACA and CSTA 2017

PLC Lab: Start, Stop and the Seal-In, a First Ladder Logic Program

Grades 10-12 · 45 minutes · Career and technical education, Engineering, Manufacturing technology

Job 1 in PLC Lab is a conveyor with a green Start and a red Stop. The program it opens with runs the belt only while Start is held. Students build the seal-in, the branch that lets Motor hold itself on, and put Stop in series to break it. Stop is wired normally closed, so its lamp is lit before anyone touches it, and a student who matches the contact to the button gets a belt that never starts. A crew runs a shift on each program and counts every box. The class ends on Fix the line: a program that ran fine yesterday, with one contact changed.

At a glance

ESSENTIAL QUESTION

Why does a normally closed stop button get a normally open contact in the program?

OBJECTIVES

Students will be able to:

- read a wiring list and tell which inputs are wired normally open and which normally closed
- build a start/stop seal-in from contacts in series and in parallel
- explain what a normally open and a normally closed contact ask about a bit
- describe the scan: inputs in, rungs top to bottom, outputs out
- find a changed contact from what the line does and what the lamps show

VOCABULARY

PLC, Rung, Normally open contact, Normally closed contact, Seal-in, Scan

STANDARDS

(3)(F), (5)(C), (6)(A), (6)(B), (6)(C), Recommended activity, Standard 9, PLC 1 competency, PLC 1 competency, C-207 key skills, 3A-AP-16

TIME AND MATERIALS

45 minutes, grades 10-12.

- One computer or Chromebook per student
- A projector
- The worksheet and exit ticket, one copy each per student
- The rubric, one copy per student if you grade the work

PREP

Make copies of the worksheet and exit ticket. Before class, open mytekdev.com/try/plclab?lesson=start-stop-and-the-seal-in&ref=tpt-plclab-1 once on a student computer: it opens on Job 1, Build it, and checks that your school's filter allows the app. Follow the short guide yourself, Fix the line included, about ten minutes. Nothing in the app drives real hardware, so there is nothing to clear with IT.

ASSESSMENT

- Formative: the questions under What to look for, asked while students work, and the exit ticket (answer key included).
- Summative: the worksheet, scored with the rubric.

TECHNOLOGY AND PRIVACY

Runs in any browser, Chromebooks included, with nothing to install. Students need no account and no email: the link works signed out, and nothing they do is stored on our server unless they choose to save. Nothing in the app drives real hardware. If a computer cannot draw the 3D station, the program still runs, and the lamps in the wiring list show what it does.

Lesson sequence

MINUTES	STAGE	WHAT YOU DO	WHAT STUDENTS DO
0 to 5	**Warm-up** Hook	Show the title, essential question and Today I can slides (about 1 minute). Then the warm-up: should a stop button's circuit be open or closed at rest, and what happens if its wire breaks? Leave both answers on the board.	Answer the warm-up on the worksheet.
5 to 13	**Direct instruction (I do)** Model it	Project Job 1. Read the wiring list aloud: Start at %IX0.0 wired normally open, Stop at %IX0.1 wired normally closed, Motor at %QX0.0. Point at Stop's lit Field lamp. Explain that a normally open contact asks "is this bit ON?" and a normally closed one asks "is it OFF?". Press Slow scan, then Turn the line on, and hold Start: the scan reads the inputs, works the rung, writes Motor. Let go: the belt stops. Do not build the fix. **It's working when:** Say "the contact asks about the bit" every time, not "the contact is the button". That one sentence is the lesson.	Watch, and fill in the vocabulary and the Wiring box on the worksheet.
13 to 25	**Guided practice (We do)** Build the seal-in	Students open the link or scan the QR code. A short guide walks them through: turn the line on, hold Start and let go, add a branch around Start with a normally open Motor contact, put Stop in series, and run the shift. Walk the room and look at each Stop contact. **Watch for:** Students who put a normally closed contact on Stop because the button is normally closed. The belt never moves. Ask them to read Stop's lamp first, then what a normally closed contact asks. **Watch for:** Students who seal in with no Stop in the rung. The shift result says Stop did not stop the belt.	Follow the guide. Draw your finished rung on the worksheet before you press Run the shift.
25 to 37	**Independent practice (You do)** Three shifts and a cut wire	A job passes on three different shifts: the crew presses Stop at a different moment each time. Students who pass turn the line on, start the belt, and tick Cut the Stop button's wire under Line settings. The belt stops, as if Stop were pressed. They answer the broken-wire questions on the worksheet. Walk the room with the What to look for questions. **If they ask:** "If Stop were wired normally open and its wire broke, could anyone stop this belt?" The broken wire	Pass three shifts, try the cut wire, and fill in the rest of the worksheet.

MINUTES	STAGE	WHAT YOU DO	WHAT STUDENTS DO
37 to 45	**Closure** Fix the line and exit ticket	Show Fix the line: it will not start. Everyone opens the Fix the line tab, runs the shift, and finds the contact. The first student who can explain it from the lamps, not from the program, says it aloud. Back to the warm-up answers on the board. Hand out the exit ticket.	Fix Job 1's Fix the line, then answer the exit ticket.

Before you teach: a ten-minute walkthrough

Open mytekdev.com/try/plclab?lesson=start-stop-and-the-seal-in&ref=tpt-plclab-1. A short guide opens over Job 1, Start and Stop, on the Build it tab. The top half is the station: a conveyor on a bench, its operator panel, and the PLC. Under it is the run bar and the ladder; on the right are the jobs, the job card, a hint box, the wiring list and the program check.

1. **The wiring list.** Start at %IX0.0, wired normally open. Stop at %IX0.1, wired normally closed: ON until pressed, and its Field lamp is lit at rest. Motor at %QX0.0. Labels switches the addresses to Allen-Bradley (I:0/0), Siemens or CLICK, and the instruction names under each contact (XIC, XIO, OTE by default).
2. **The starting program.** One rung: a normally open Start contact to the Motor coil. Turn the line on (or the space bar) and hold Start (or the S key): the belt runs only while Start is held.
3. **The seal-in.** Click the Start contact, press Branch, then Normally open and pick Motor. Then click the wire after the branch, press Normally open and pick Stop. The guide card on the right gives the same moves.
4. **The shift.** Run the shift: a crew presses Start, lets go, presses Stop about 10 to 14 seconds in, and starts it again, with 8 boxes. The result lists the checks: kept running, stopped and stayed stopped, every box to the tote. A Build it job passes on three different shifts.
5. **Fix the line.** The second tab holds the finished program with Stop changed to a normally closed contact. The belt never moves. On this tab the result names only the symptoms: Delivered 0 of 8, and the checks that failed. One clean shift passes it.
6. **Ways back.** Start this job over puts the starting program back for the job and tab that is open. Undo works one change at a time.

> In the wiring list, Field is the wire at the PLC's terminal right now, and Image is the PLC's own copy, taken at the start of each scan. Image only changes while the line is on. Under More on the right, Cut the Stop button's wire turns Stop's input OFF while the line is on, the same as pressing it.

Background for the teacher

Tony Kuphaldt, whose free textbook many PLC teachers use, calls this "the main problem students have comprehending PLC Ladder Diagram programs": they expect the contact in the program to match the physical switch, so a normally closed stop button gets a normally closed contact, and the motor never runs. PMMI's PLC 1 competency list names the same idea: "Describe how input device logic affects input instruction logic."

The way out is to separate the field from the program. The button is wired one way, and that decides whether its input bit is ON or OFF at rest. The contact in the program is a question about that bit. A stop button is wired normally closed so that a broken wire looks the same as a press, and the line stops. Wired normally open, a broken wire would leave a line nobody can stop.

The scan explains why the seal-in works. The PLC copies the inputs, works the rungs from top to bottom, and writes the outputs. On the scan after Start is let go, the Motor contact on the branch still reads the Motor bit from the scan before, which is ON, so Motor stays on until Stop breaks the rung. Most small PLCs scan this way; some larger ones update inputs and outputs on their own schedule.

> The E-stop on the panel is not part of Job 1's program. On a real machine it cuts power through a safety relay, outside the PLC. Job 6 shows the program side of it.

What to look for

Ask these while students work. A student who has understood the lesson can answer them without help:

- Which input is ON while nobody touches anything? How do you know?
- What does a normally open contact on Stop ask about the Stop bit?
- Why does the belt keep running after you let go of Start?
- What would happen if the wire to Stop broke?
- In what order does the PLC read the inputs, run the rung and write Motor?

> The second question is the one that matters. A student who says "normally open, because it is ON until pressed" has it. A student who says "it just works that way" will put a normally closed contact on the next normally closed device too.

Cross-curricular extensions

- Math: write the seal-in as a Boolean expression, Motor = (Start OR Motor) AND Stop, and fill in its truth table.
- Science: look up how a relay coil and its contacts work. A seal-in was built from relays long before PLCs.
- Writing: write the rung comment a technician would want to read at 3 a.m., in twelve words or fewer.
- Careers: look up what an industrial maintenance technician or a controls technician does on a normal day.

Vocabulary

PLC	Programmable logic controller: the computer that runs a factory machine. It reads inputs (buttons, sensors) and turns outputs on (motors, valves).
Rung	One line of a ladder program, between the two rails. Contacts on the left, a coil on the right.
Normally open contact	Asks "is this bit ON?" and passes power when it is. Allen-Bradley calls it XIC.

Normally closed contact	Asks "is this bit OFF?" and passes power when it is. Allen-Bradley calls it XIO.
Seal-in	A branch around Start with the output's own contact on it, so the output keeps itself on after the button is let go.
Scan	The PLC's loop: copy every input into memory, work through the rungs from top to bottom, then write every output at once.

Differentiation

ENGLISH LEARNERS

- Keep the vocabulary slide up, and point at the lamp in the wiring list or the instruction on the ladder as you say each word: the picture carries the meaning.
- Give the contact rule as a sentence frame on a card: A normally _____ contact passes power when the bit is _____.
- Use the Labels button to show XIC and XIO next to the words normally open and normally closed, and keep both on the board.

STUDENTS WITH IEPS OR 504 PLANS

- Pair students, one at the keyboard and one reading the lamps aloud.
- Turn on Big screen for a larger station; the ladder stays below it.
- Where the IEP allows a modified assignment, score the first two rubric rows and skip the cut-wire questions.

STUDENTS WHO NEED MORE SUPPORT

- Build the seal-in together on the board one click at a time, then let students build it themselves.
- The guide card on the right gives the exact clicks for Job 1.
- Give the finished rung on a card: Start or Motor, then Stop, to the Motor coil.

STUDENTS READY FOR MORE

- In the wiring list, set Stop to Wired normally open, then fix the program so it still works. What does a broken wire do now?
- Set the scan time to 100 ms under Line settings. Does the belt still start and stop? What could a press shorter than one scan do on a real PLC?
- Open Job 2, Stop at the Eye. A seal-in like yours is already rung 1, on a bit called Running: what does each rung do now?

Adapting for other grades

Younger students: In grade 9, build the seal-in together on the board and stop after the first clean shift. Skip the scan and the cut wire. Score the first two rubric rows, total 8, and 6 meets the objectives.

Older students: In a second-year PLC course, have students write the same circuit for a CLICK or Allen-Bradley trainer from the Labels view, and compare it with the Export for OpenPLC text, rung for rung.

Student worksheet

Name: _____ Date: _____

Open the app: scan the QR code, or go to mytekdev.com/try/plclab?lesson=start-stop-and-the-seal-in

Essential question: Why does a normally closed stop button get a normally open contact in the program?

Warm-up: Should a stop button's circuit be open or closed while nobody touches it? Why?

_____

1. **Vocabulary.** PLC, rung, normally open contact, normally closed contact, seal-in, scan: write each in your own words.

2. **Wiring.** Start is wired normally _____. Stop is wired normally _____. With nobody touching anything, the lit Field lamp is _____.
3. **My rung.** Draw your finished rung: each contact, its tag, and the coil.

4. **The shift.** Shifts passed (circle): 1 2 3. The first time a shift failed, the result said: _____
5. **Cut the wire.** With the belt running, I cut Stop's wire. The belt _____.
6. **Fix the line.** Symptom: _____ The contact that changed: _____

1. Stop is wired normally closed. Why does the program use a normally open contact for it?

2. If Stop were wired normally open and its wire broke, what would happen? Why is that worse?

Exit ticket

Name: _____

1. Stop is wired normally closed. While nobody presses it, its input bit is: (A) ON (B) OFF (C) it changes every scan

2. Which rung keeps the belt running after Start is let go? (A) Start to Motor (B) Start, or Motor, then Stop, to Motor (C) Stop, then Start, to Motor

3. A program has a normally closed contact on a normally closed Stop. What does the belt do, and why?

PLC Lab: Start, Stop and the Seal-In, a First Ladder Logic Program

Exit ticket

Name: _____

1. Stop is wired normally closed. While nobody presses it, its input bit is: (A) ON (B) OFF (C) it changes every scan

2. Which rung keeps the belt running after Start is let go? (A) Start to Motor (B) Start, or Motor, then Stop, to Motor (C) Stop, then Start, to Motor

3. A program has a normally closed contact on a normally closed Stop. What does the belt do, and why?

Answer key: exit ticket

QUESTION	ANSWER	WHY
1	A	A normally closed button passes current until it is pressed, so the input is ON at rest. The Field lamp in the wiring list is lit.
2	B	The Motor contact on the branch keeps the rung true after Start is let go; Stop in series breaks it.
3	Open answer	It never starts. The Stop bit is ON at rest, and a normally closed contact passes power only when its bit is OFF, so no power reaches Motor.

Worksheet: what students should find

BLANK	WHAT THE APP SHOWS
Wiring	Start: normally open. Stop: normally closed. The lit Field lamp at rest is Stop's.
My rung	A branch of normally open Start and normally open Motor, then a normally open Stop, to the Motor coil. Other correct shapes pass too: the shifts are the test.
The shift	With the starting program: The belt ran only while Start was held. With a normally closed Stop: The belt never moved. With no Stop: Stop did not stop the belt.
Cut the wire	The belt stops, the same as pressing Stop.
Fix the line	Symptom: the belt never starts, Delivered 0 of 8. The Stop contact was changed to normally closed.
Question 2	Wired normally open, a broken wire leaves the Stop input OFF, the same as nobody pressing it, so nothing could stop the belt.

> The crew's Stop press moves a little from shift to shift (about 10 to 14 seconds in), so a program tuned to one shift can fail the next. That is why a Build it job needs three.

Rubric

Score each row from 1 to 4.

Name: _____

CRITERIA	4 EXCEEDS	3 MEETS	2 APPROACHING	1 BEGINNING
Reading the wiring	Says which inputs are normally open and normally closed, and explains why Stop is wired closed using the broken wire.	Says which inputs are normally open and normally closed, from the wiring list and the lamps.	Names one correctly, or reads the device but not its lamp.	Cannot say how Stop is wired.
The seal-in	Passes three shifts and explains in words how the branch and the Stop contact work together.	Passes three shifts with a seal-in and a Stop contact.	Builds a seal-in that does not pass: no Stop, or Stop the wrong way round.	The belt runs only while Start is held.
Contacts and the scan	Explains the Fix the line fault from the lamps and what a normally closed contact asks, and describes the scan in order.	Fixes Fix the line and says which contact changed.	Fixes it by trying contacts until one works, without saying why.	Does not fix it.

Total: ____ / 12. A score of 9 or more meets the objectives.

Standards

The lesson addresses the relay logic and field device lines of Texas's Programmable Logic Controller I course, and the matching lines in Massachusetts's Standard 9, PMMI's PLC 1 list and SACA C-207. It is practice for these skills on a simulated station, not a replacement for time on a real trainer.

FRAMEWORK	CODE	GRADES	STANDARD	HOW THE LESSON MEETS IT
Texas Programmable Logic Controller I (innovative course N1303689)	**(3)(F)**	10-12	identify normally open (NO) and normally closed (NC) states for common field input devices;	Students read Start (normally open) and Stop (normally closed) from the wiring list and the lit Field lamp, and explain why Stop is wired closed.
Texas Programmable Logic Controller I (innovative course N1303689)	**(5)(C)**	10-12	explain how relay logic can be represented as bits of information in the PLC memory;	The Image column is the PLC's copy of each input bit; students explain the seal-in in terms of the Motor bit from the scan before.
Texas Programmable Logic Controller I (innovative course N1303689)	**(6)(A)**	10-12	describe the ladder logic program structure including rungs, branches, and instructions;	Students build a rung with a branch, contacts and a coil, and draw it on the worksheet.
Texas Programmable Logic Controller I (innovative course N1303689)	**(6)(B)**	10-12	display, explain, and justify the use of relay logic instructions, including Examine if Closed (XIC), Examine if Open (XIO), Output Energized (OTE), Output Latched (OTL), and Unlatched (OUT) within a ladder logic program;	Students explain and justify XIC on a normally closed Stop, and see the cost of XIO there. Latch and unlatch come in Count It, Sort It.
Texas Programmable Logic Controller I (innovative course N1303689)	**(6)(C)**	10-12	apply input information using logical conditions such as Logic OR and Logic AND functions to control actuators;	The seal-in is an OR (Start or Motor), in series with Stop, an AND, controlling the conveyor motor.

FRAMEWORK	CODE	GRADES	STANDARD	HOW THE LESSON MEETS IT
Texas Programmable Logic Controller II (innovative course N1303690)	**Recommended activity**	11-12	Write a ladder logic program that uses momentary start, latching start, and latching start with interrupts.	The starting program is a momentary start; students turn it into a latching start with Stop as the interrupt.
Massachusetts Robotics and Automation Engineering Technology, July 2025	**Standard 9**	9-12	Explain the role of electromagnetic relays and NO/NC contacts in PLC programming and wiring diagrams.	Students explain normally open and normally closed contacts against the way each button is wired, and see a normally closed field device need a normally open contact.
PMMI Mechatronics: Programmable Logic Controllers 1	**PLC 1 competency**	Entry-level technicians	Describe how input device logic affects input instruction logic	The whole lesson turns on this: the normally closed Stop button decides which contact the program needs.
PMMI Mechatronics: Programmable Logic Controllers 1	**PLC 1 competency**	Entry-level technicians	Describe the function and operation of PLC seal-in and latch logic	Students build the seal-in and explain why it holds. Latch logic is in Count It, Sort It.
SACA C-207 Programmable Controller Systems 1	**C-207 key skills**	Industry credential	Interpreting basic and intermediate level PLC ladder logic programs (with contacts, coils, timers, counters, math, comparison instructions); interpreting common PLC program logic applications using electro-pneumatic actuators and on/off motor control systems.	Students interpret and write on/off motor control logic for a conveyor motor: contacts and a coil.
CSTA 2017	**3A-AP-16**	9-10	Design and iteratively develop computational artifacts for practical intent, personal expression, or to address a societal issue by using events to initiate instructions.	The operator's Start and Stop presses are events that start and stop the program's output, and students revise the rung over three shifts.

Checked November 2026 against: Texas Education Agency: Programmable Logic Controller I, innovative course (2020-2021), Texas Education Agency: Programmable Logic Controller II, innovative course (2021-2022), Massachusetts DESE: Robotics and Automation Engineering Technology Standards and Skills (July 2025), PMMI: Programmable Logic

Controllers (PLCs) 1 certification test, Polk State College: PMMI PLC 1 competency list, O*NET: SACA C-207 Programmable Controller Systems 1, CSTA K-12 Computer Science Standards, Revised 2017.

Optional: save student work in a free class

The whole lesson runs at the link on the worksheet, with no accounts and no sign-up.

To keep students' work, and see it all in one place, make a free class. It takes about ten minutes, once, and covers every lesson in this series: mytekdev.com/tools/class-setup

Students in a class open mytekdev.com/tools/plc-lab/lessons/start-stop-and-the-seal-in/start instead of the worksheet link. Each one gets their own copy of the starter, and the same link reopens it next time.

Terms of use

Thank you for downloading this lesson. The plan, the handouts and the art were made by mytekDev.

You may:

- print and copy it for your students
- change it for your own classes
- post it on your class website or learning management system
- share this file with other teachers, whole and unchanged, with this page included

You may not:

- sell it, or put it in a product you sell
- share a changed copy
- claim it as your own

The app this lesson uses is free and runs in the browser. Students need no account. It is at mytekdev.com.

Questions, or found a mistake? Ask on the Teachers Pay Teachers Q&A for this resource, or write to us at mytekdev.com/contact.

© 2026 mytekDev. All rights reserved.