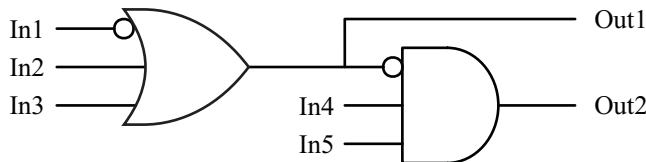


## CHAPTER 2 SOLVED PROBLEMS

**SP2-1.** Implement the digital logic diagram in Figure SP2.1 in PLC ladder logic. Out1 and Out2 are the only physical outputs. Do not use any internal coils.

In words, Out1 is **on** when In1 is **off** or In2 is **on** or In3 is **on**

Out2 is **on** when Out1 is **off** and In4 is **on** and In5 is **on**

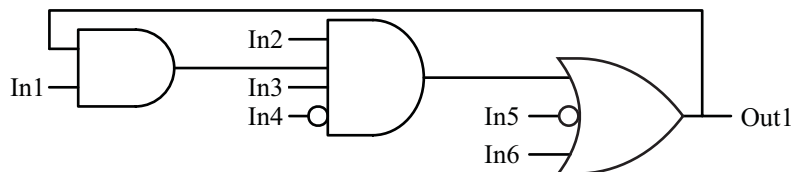


**Figure SP2.1.** Digital logic for exercise SP2-1.

**SP2-2.** Implement the digital logic gate circuit in Figure SP2.2 in PLC ladder logic. Out1 is the only physical output. You may use a maximum of one internal coil.

In words, Out1 is **on** when In5 is **off** or In6 is **on** or:

In2 is **on** and In3 is **on** and In4 is **off** and Out1 is **on** and In1 is **on**



**Figure SP2.2.** Digital logic for exercise SP2-2.

**SP2-3.** Use ladder logic to implement a simple *high level indicator and alarm* for a tank.

A panel implements a simple interface showing the tank level. The panel has three lamps: green, yellow, and red. The panel also has an alarm horn and an alarm acknowledge button that turns off the alarm horn. No more than one light is **on** at any time:

Green lamp **on** when  $5 \text{ inches} \leq \text{tank level} < 50 \text{ inches}$

Yellow lamp **on** when  $50 \text{ inches} \leq \text{tank level} < 60 \text{ inches}$

Red lamp **on** when  $60 \text{ inches} \leq \text{tank level}$

In addition, when the level is greater than or equal to 60 inches, the alarm horn is turned **on**, and remains **on** until the level becomes less than 60 inches and the alarm acknowledge (ALM\_ACK\_PB) button is pressed. If the level is greater than or equal to 60 inches, pressing the alarm acknowledge button should not silence the alarm horn, even momentarily.

There are 3 level sensors, each corresponding to one of the “boundary” levels:

## 2 Basic Ladder Logic Programming

LS\_1 is **on** when the tank level  $\geq 5$  inches  
LS\_2 is **on** when the tank level  $\geq 50$  inches  
LS\_3 is **on** when the tank level  $\geq 60$  inches

Assume the following physical inputs and outputs. Only symbols are used to avoid any PLC-specific addressing. **DO NOT assign any more inputs!!**

Physical Inputs:

<u>Symbol (Tag)</u>	<u>Description</u>
ALM_ACK_PB	Alarm acknowledge pushbutton switch, N. O., <b>on</b> when acknowledging (resetting) alarm horn
LS_1	<b>On</b> when the tank level $\geq 5$ inches
LS_2	<b>On</b> when the tank level $\geq 50$ inches
LS_3	<b>On</b> when the tank level $\geq 60$ inches

Physical Outputs:

<u>Symbol (Tag)</u>	<u>Description</u>
GRN_LA	<b>On</b> to light green indicator lamp
YEL_LA	<b>On</b> to light yellow indicator lamp
RED_LA	<b>On</b> to light red indicator lamp
ALARM	<b>On</b> to sound alarm horn

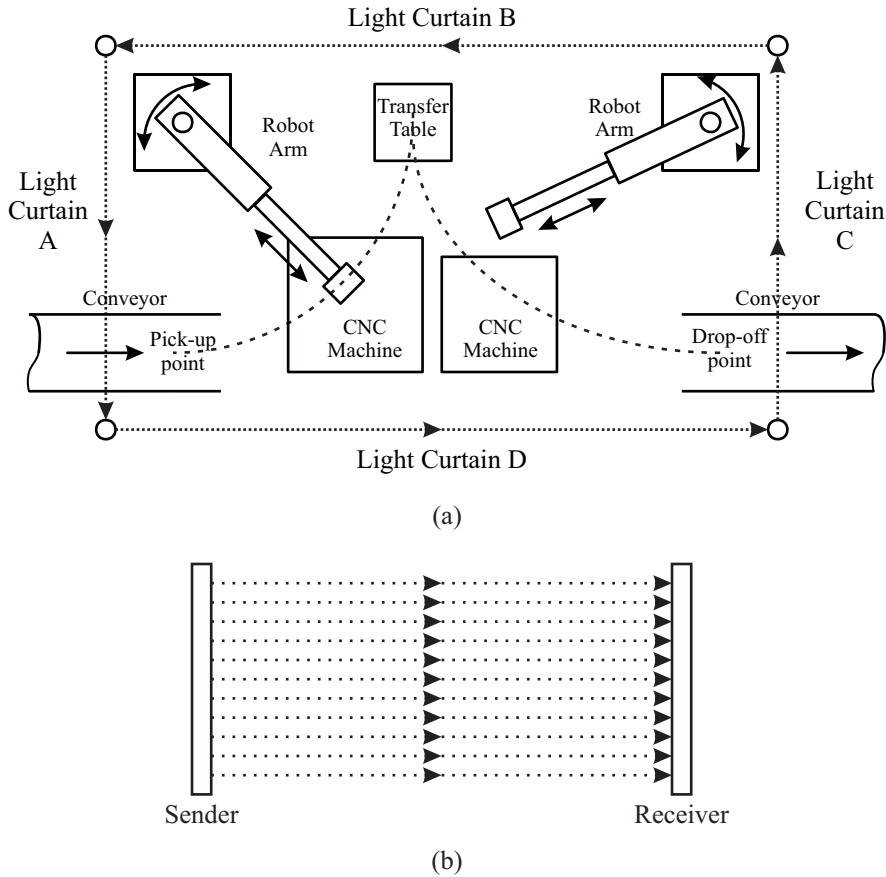
**SP2-4.** Design a ladder logic program to provide the intrusion interlock for a machine work cell shown in Figure SP2.4a.

The work cell is bounded by an array of four light curtains to detect the presence of people or objects entering the work area. When any light curtain sensor is tripped, the motion of all machines in the work cell must stop and an alarm must be sounded. This action ensures that no injury or damage to the “intruder” occurs. To allow the process to continue all sensors must signal “no intrusion” and a reset button must be pressed.

A light curtain sensor detects the presence of an intruder by using a series of light beams (Figure SP2.4b) where any broken beam = intrusion. The sensors are self-diagnosing and detect when they are not functioning properly. Therefore, the process must be halted whenever any light curtain malfunctions or when any light curtain senses an intrusion. Design the PLC control program so that the machines will be halted if any light curtain malfunctions or senses an “intrusion”.

The machine start and stop push buttons are used to start and stop the work cell operation. If an intrusion or curtain malfunction occurs, the machine is stopped and cannot be restarted until the reset button is pressed. The start button does need to be pressed for the machine to restart after an intrusion alarm has been reset. The reset button should have no effect if the intrusion or curtain is still occurring.

Assume the following physical I/O and internal coils. Only symbols are used to avoid any PLC-specific addressing. **DO NOT assign any more inputs!!**



**Figure SP2.4.** Work cell: (a) boundaries; (b) light curtain.

Physical Inputs:

<u>Symbol (Tag)</u>	<u>Description</u>
START_PB	Start NO pushbutton, <b>on</b> when starting
STOP_PB	Stop NC pushbutton, <b>off</b> when stopping
ALM_RST_PB	Alarm reset pushbutton switch, N. O., <b>on</b> when resetting alarm horn
CUR_OK_A	<b>On</b> when light curtain A is functioning properly
CUR_INT_A	<b>Off</b> when light curtain A senses intrusion
CUR_OK_B	<b>On</b> when light curtain B is functioning properly
CUR_INT_B	<b>Off</b> when light curtain B senses intrusion
CUR_OK_C	<b>On</b> when light curtain C is functioning properly
CUR_INT_C	<b>Off</b> when light curtain C senses intrusion
CUR_OK_D	<b>On</b> when light curtain D is functioning properly
CUR_INT_D	<b>Off</b> when light curtain D senses intrusion

## 4 Basic Ladder Logic Programming

Physical Outputs:

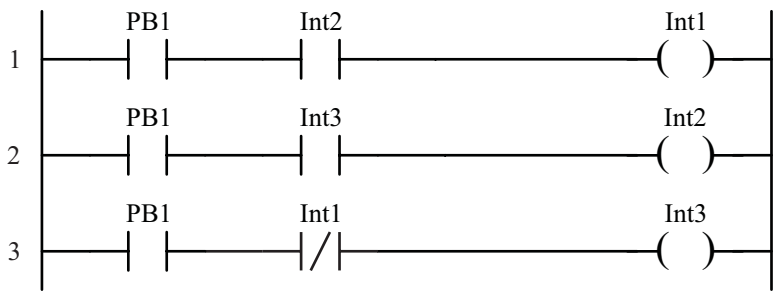
<u>Symbol (Tag)</u>	<u>Description</u>
ALARM	<b>On</b> to sound alarm when any curtain fails or any curtain detects intrusion

PLC Internal Coils:

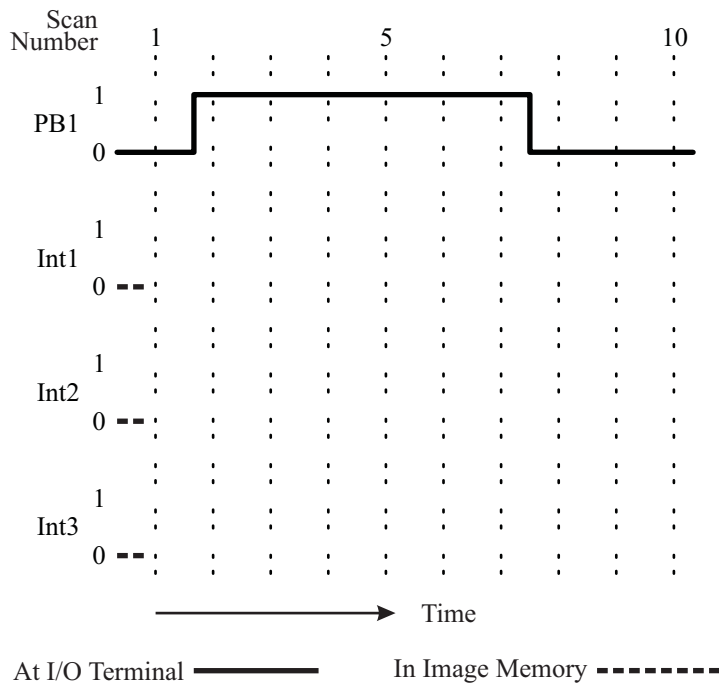
<u>Symbol (Tag)</u>	<u>Description</u>
MACHINE_EN	Internal coil that is <b>on</b> when machines can operate. This coil is to be controlled by your ladder logic. It is used by other parts of the ladder logic.

**SP2-5.** Draw the timing diagram for the ladder logic diagram in Figure SP2.5a. A chart is provided in Figure SP2.5b. Assume the external input is read at the beginning of a scan and any change in the external input has no effect until the start of the next scan. The only external input is PB1, a normally open pushbutton switch. Int1, Int2, and Int3 are internal coils. The timing of PB1 is shown in Figure SP2.5b.

On the chart, the widely spaced dashed vertical lines indicate the start of the processor scans. The solid line indicates the state of the physical input or output at the module terminal. Use dashed lines to indicate the state of the PLC image or internal memory. Assume everything starts **off** (a value of 0). The **on** state is indicated by a value of 1.



(a)



(b)

**Figure SP2.5.** Ladder logic and timing diagram for exercise SP2-5: (a) ladder logic; (b) timing diagram.