Closed book, closed notes portion of test. Total of 30 out of 100 points for questions #1 to #5.

1. [10] Fully identify the following pneumatic and electrical schematic symbols:

   ![Pneumatic Symbols](image1)

   ![Electrical Symbols](image2)

   ![Additional Symbols](image3)

   Answer the following questions in the space provided below the question.

2. [2] Sketch two different ways that you could use photoelectric proximity sensors to detect the presence of parts moving along an assembly line conveyor belt.

4. [2] Describe one advantage and one disadvantage that inductive proximity sensors have with respect to mechanical limit switches.

5. [14] A double-acting, single-ended cylinder is positioned by an appropriate solenoid-operated, directional control valve. Meter-out speed control (in both directions) is used for the cylinder. A N.O. pushbutton is used to start an operation cycle. When the start pushbutton is pressed, the cylinder should cycle (fully extend, fully retract) exactly 3 times.

Sketch a complete pneumatic system, PLC wiring diagram, and PLC ladder logic diagram.
7. [15] A fluid power system and its ladder logic controls are shown below. The circuit works as intended. Describe the operation of the system. Use the rung labels and be complete and thorough in your description.
8. [20] A fluid power system and its ladder logic controls are shown below. The circuit does not work as intended, but it is supposed to do the following:

- cycle the cylinder (out, then back = 1 cycle) three times when C43 is pressed. 
- cycle the cylinder two times when C45 is pressed.

a) Describe the operation of the system given below if the C43 button is pressed. Be complete and thorough in your description.

b) Describe the operation of the system given below if the C45 button is pressed. Be complete and thorough in your description.

c) Modify the ladder logic diagram such that the system works "correctly." Note that NO NEW LIMIT SWITCHES, PUSHBUTTONS, OR SOLENOIDS can be used!
9. A local manufacturer has a need for a pneumatic system controlled by a PLC. The system employs four double acting, single ended cylinders controlled by 2 position solenoid actuated, spring return, directional control valves as shown in the figure below. The desired task is:

- N.O. limit switch “Detect” determines that a part is ready to be processed
- Cylinder A extends and pushes the part into the clamp fixture (not shown), then immediately retracts
- Cylinder B clamps the part once cylinder A is fully extended
- Cylinder C then extends, waits 1 second (while “drilling” the part the first time), then retracts
- Cylinder D then extends, rotates the part (and clamp fixture) 90 degrees, then retracts
- After Cylinder D is fully retracted, Cylinder C then extends again, waits 2 seconds (while “drilling” the part the 2nd time), then retracts
- Cylinder B then retracts, the part is unclamped, the part falls out of the clamp fixture
- System is returned to the start-up configuration.

Your problem:

a) Draw a PLC wiring diagram for the limit switches and solenoids.

b) Design a PLC type ladder logic diagram to control the system. Be sure to provide a brief description beside each rung of the ladder to describe what you are trying to accomplish.