Answer all of the following 6 questions in the space provided below the question.

1. [5] Sketch the NFPA schematic symbol for an adjustable pressure relief valve and the symbol for a pressure regulator. How are the operational characteristics of these two valves different?

2. [5] Sketch the three common photoelectric proximity sensor configurations: through-beam, reflective, and cross-beam. Clearly mark the emitter and detector in each.

3. [5] What are both the primary advantage and the primary disadvantage of pneumatic actuators when compared to electric actuators for industrial automation?

4. [5] In ladder logic, what is a “hold” circuit and what is it used for? What are the important considerations in designing a “hold” circuit?

5. [5] List at least 5 of the eight PLC programming rules for ME 360.

6. [5] What are the three broad classifications of fluid power (pneumatic or hydraulic) valves? Give the NFPA schematic symbol for one of each type of valve.

7. [15] A hydraulic system is shown in the figure below.
   - Identify each of the components labeled in the figure (#1 to #7)
   - Describe the operation of the system. Use the component labels and be complete and thorough in your description.
8. [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.
9. A local manufacturer has a need for a pneumatic system controlled by a PLC. The system employs three double acting, single ended cylinders controlled by 2 position, 4 port, solenoid actuated, spring return, directional control valves as shown in the figure below. The desired task is:

- A momentary contact pushbutton (wired NO, connected to X0) is pressed when a part is ready to be processed
- Cylinder A extends and pushes a part into the clamp fixture (not shown), and remains extended
- Once Cylinder A is fully extended, Cylinder B then extends and “drills” the part the first time, then fully retracts.
- Cylinder C then extends, remains extended for 3.5 seconds, then fully retracts.
- Cylinder B then extends and “drills” the part the second time, then fully retracts.
- After Cylinder B retracts the second time, the part is unclamped by retracting Cylinder A, and the part is removed from the clamp fixture by another automation system.
- Your system returns to the original start-up configuration when Cylinder A is fully retracted.

Your problem:

a) Draw a PLC wiring diagram for the limit switches and solenoids. All limit switches and pushbuttons should be wired normally open except X6 which is wired normally closed.

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.