Closed book, closed notes portion of test. Total of 35 out of 100 points for questions #1 to #6.

1. [3] What are three primary differences between hydraulic and pneumatic systems?

2. [2] One of the three common photoelectric proximity sensor configurations is called retro-reflective, what are the other two? Name or sketch.

4. [3] One of the four common center conditions/types for hydraulic 3-position directional control valves is the float center. The other three types are the ________________ center, the ________________ center, and the ________________ center.


7. [3] What are the three major categories or classifications of fluid power valves?
8. [13] Identify all ten of the fluid power components shown in the figure below:

9. [6] Identify the illegal elements or PLC rule violations in the Direct Logic ladder logic system below. Note that these do not depend on the exact application for this system.
Closed book, but one page of hand-written notes allowed for this section of the test.

10. [10] a) A hydraulic tube has a diameter of 0.25 inches with a flow rate of 3.2 GPM. What is the average fluid velocity in the tube?

b) A hydraulic pump delivers 5.6 GPM of flow at a $\Delta P$ of 2000 psi. What size motor is required to operate the pump?

11. [10] a) Estimate the pressures $P_1$ and $P_2$ while the load is moving to the right slowly.

$P_1 =$

$P_2 =$

b) Estimate the pressures $P_1$ and $P_2$ when the load stops at the barrier.

$P_1 =$

$P_2 =$

c) Estimate the pressures $P_1$ and $P_2$ while the load is moving left.

$P_1 =$

$P_2 =$

d) Estimate the pressures $P_1$ and $P_2$ while the load is accelerating to the right at 6.0 ft/s$^2$.

$P_1 =$

$P_2 =$
12. [15] A complete pneumatic and ladder logic system is shown below. Fully describe the operation of this system both in terms of ladder logic components (C1, Y2, X10, etc.) and in terms of the actions of the two cylinders.
A local manufacturer has a need for a pneumatic system controlled by a PLC. The system employs three cylinders controlled by directional control valves as shown in the figure below. The desired task is:

- Two momentary contact pushbuttons (wired NO, connected to X11 & X12) are 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.
- Immediately after Cylinder A is fully extended, Cylinder B executes this pattern 3 times:
  - B fully extends,
  - B pauses for 1.5 seconds, then
  - B retracts.
- Once Cylinder B is fully retracted after the 3rd extension, cylinder C then extends and immediately retracts 2 times.
- After Cylinder C fully retracts the 2nd time, the part is unclamped by retracting Cylinder A, and the part is removed from the clamp fixture by another automation system.

Your problem:

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

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.