Closed book, closed notes portion of test. Total of 40 out of 100 points for questions #1 to #8.

1. [15] Fully identify all of the fluid power schematic symbols marked by dotted line arrows:

![Fluid Power Schematic Diagram]

2. [4] One of the four different types of center positions on hydraulic valves is shown in the upper left-hand corner of the figure above. Name and sketch two of the remaining three types.

3. [3] You have seen the component referred to as NPN, i.e. “not pointing in” in several applications in ME 360. Sketch the NPN component, tell what it does and describe or sketch one application.
5. [6] Mark the following ME 360 PLC programming rules as either True or False:

   ____ a. Each rung of the ladder has one (and only one) output.
   ____ b. An individual input device can appear on the ladder diagram only once.
   ____ c. Control relay coils (outputs) appear on the ladder diagram only once.
   ____ d. Control relay contacts are inputs and may be used as many times as necessary on the ladder diagram in both N.O. and N.C. configurations.
   ____ e. Any rung of the ladder diagram may be "OR"ed with a following rung at more than one location.
   ____ f. An individual physical input device (limit switch, push-button, pressure switch, etc.) may be used as many times as necessary on the ladder diagram in either the N.O. or N.C. configurations, but not both.

6. [4] Sketch meter-out flow controls for the cylinder:

![Diagram]

7. [8] Five different types of proximity and mechanical switches and are available as listed below. Select the best proximity sensor type for each application and briefly justify your selection.

- through-beam photoelectric
- reflective photoelectric
- cross-beam photoelectric
- inductive
- mechanical limit switch (i.e., “microswitch”)

   a. detecting a brass insert in a plastic car part

   b. detecting if a washing machine door is open

   c. detecting if boxes are present on a conveyor belt

   d. detecting the presence of an unknown object near the tips of a robot’s “fingers”
8. [10] a) Estimate the pressures $P_1$ and $P_2$ while the load is moving slowly to the left.
   b) Estimate the pressures $P_1$ and $P_2$ when the piston reaches the right end of the cylinder.
   c) If the pump flowrate is 5.2 GPM, how fast does the cylinder move to the right in \( \text{ft/sec} \)?
   d) If the pump flowrate is 5.2 GPM, how fast does the cylinder move to the left in \( \text{ft/sec} \)?

![Diagram of hydraulic system with labeled dimensions and pressures.](image-url)
9. A factory automation system is shown below. Fully describe the operation of the PLC ladder-logic on a rung-by-rung basis and describe what the cylinders do.

Rung#1: X0 X3 C2
Rung#2: X2 T5 Y2
Rung#3: X4 X1 C1
Rung#4: X1 X2 C1 T5
Rung#5: Y1
Rung#6: X2
Rung#7: CNT CT4 K4
Rung#8: X0
Rung#9: X4
Rung#10: TMR T5 K78
10. [40] 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:

- One of two momentary contact pushbuttons (wired NO, connected to X11 and X12) is pressed when a part is ready to be processed.
- Cylinder C extends and pushes a part into the clamp fixture (not shown), and remains extended to keep the part clamped.
- Cylinder A then extends, waits 1.5 seconds, then retracts.
- After Cylinder A has fully retracted, Cylinder B then
  - extends and retracts 1 time if X11 was pressed, or
  - extends and retracts 2 times if X12 was pressed.
- The part is then unclamped by retracting Cylinder C.
- Your system returns to the original start-up configuration when Cylinder C is fully retracted.

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.