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

1. [12] Fully identify all of the following schematic symbols:

2. [3] One of the four common center conditions/types for hydraulic 3-position directional control valves is the open center. The other three types are the ____________________ center, the ____________________ center, and the ____________________ center.


5. In Lab #9 (Proximity Sensors and PLC Intro) there were three different types of proximity sensors. Identify the three proximity sensor types and give a primary advantage of each.

6. Estimate the pressures $P_1$, $P_2$, and $P_3$ while the load in the figure below is moving up the incline.

$P_1 =$

$P_2 =$

$P_3 =$

7. Draw the schematic symbols for the following fluid power or electrical system components:

- diode
- NO momentary contact pushbutton
- hydraulic motor
- check valve
- NC limit switch
- ram cylinder
- accumulator
Closed book, but **one page of hand-written notes allowed for this section of the test.**

9. [20] 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.
10. What minimum size electric motor would be required to drive a hydraulic pump that generates a flowrate of 6.7 GPM with a ΔP across the pump of 1900 psi?

- What is the inside diameter of the tubing / pipe / hose required to keep the average fluid velocity below 5 ft/sec?

11. 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:

- A momentary contact pushbutton (wired NO, connected to X0) is pressed when a part is ready to be processed
- Cylinder 1 extends and remains extended for the entire operation.
- 1.5 seconds after Cylinder 1 is fully extended, Cylinder 2 fully extends and remains extended
- After Cylinder 2 is fully extended, Cylinder 3 “works” the part by executing this cycle 3 times:
  - fully extend,
  - pause for 2 seconds, then
  - fully retract,
- After Cylinder 3 fully retracts the 3rd time, the part is first unclamped by retracting Cylinder 2.
- After Cylinder 2 fully retracts, the part is fully unclamped by retracting Cylinder 1.

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.