1. [3] One of the four common center conditions/types for hydraulic 3-position directional control valves is the tandem center. The other three types are the ________________ center, the ________________ center, and the ________________ center.

2. [3] Sketch the NFPA schematic symbol for a hydraulic motor, a pneumatic compressor/pump, and a pilot-operated check valve.

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

4. [3] Sketch the three common photoelectric proximity sensor configurations. Clearly mark the emitter and detector in each.

5. [3] Name three different kinds or types of positive displacement hydraulic pumps / motors:
6. [10] Identify all ten of the fluid power components shown in the figure below:
Closed book, but one page of hand-written notes allowed for this section of the test.

7. [5] A hydraulic hose has a cross-sectional area of 0.32 square inches with an average fluid velocity of 12 feet/second. What is the volumetric flow rate in in³/sec and GPM?

8. [5] A hydraulic pump delivers 5 GPM at a ΔP of 2400 psi. What pump horsepower is required?

9. [6] a) Estimate the pressures P1 and P2 while the load is moving up.

   \[ P1 = \]

   \[ P2 = \]

b) Estimate the pressures P1 and P2 when the load stops at the maximum height.

   \[ P1 = \]

   \[ P2 = \]

c) Estimate the pressures P1 and P2 while the load is moving down.

   \[ P1 = \]

   \[ P2 = \]
10. 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.
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 A extends and pushes a part into the clamp fixture (not shown), and remains extended.
- Once Cylinder A is fully extended, Cylinder B then fully extends and retracts 3 times.
- Once Cylinder B is fully retracted the 3rd time, cylinder C then extends, remains extended for 2.2 seconds, then fully retracts.
- After Cylinder C fully retracts, 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.