Yıldız Technical University, Department of Mechatronics Engineering
MKT 3162 - Hydraulic & Pneumatic Systems – GR2 Final Exam May 31, 2018

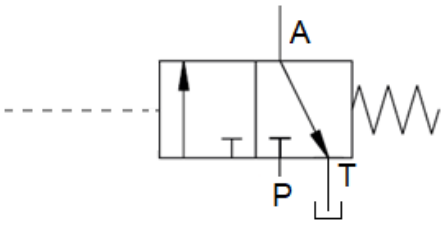
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Question 1) [9 points] What are the 3 advantages of a 5/2 pneumatic valve vs 4/2 one?
Answer 1)

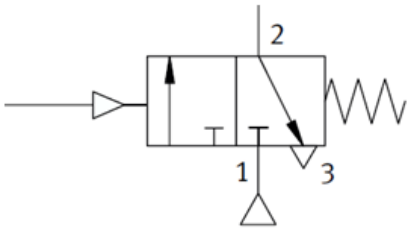
a) Easier construction,
b) Allowing the exhaust of both extension and retraction air to be separately controlled.
c) In a 4/2 pneumatic valve, an extremely high air flow causes icing in the single exhaust port. In a 5/2 pneumatic valve, this icing can be reduced 50% in 2 exhaust ports.

Question 2) [16 points] List 4 major differences between hydraulic and pneumatic circuits with their standard symbols and short explanations. Please do not mention "air and liquid, more expensive, more powerful or so". Talk about the circuit differences.
Answer 2)

a) Pilot pressures are indicated as dashed lines in hydraulic circuits, while they are indicated as dashed or straight line with a triangle. See the figures below.
b) Ports in the hydraulic valves are labeled with alphanumeric symbols such as A, P, T, while the numerical symbols are used in pneumatic valves.



A hydraulic valve



A pneumatic valve

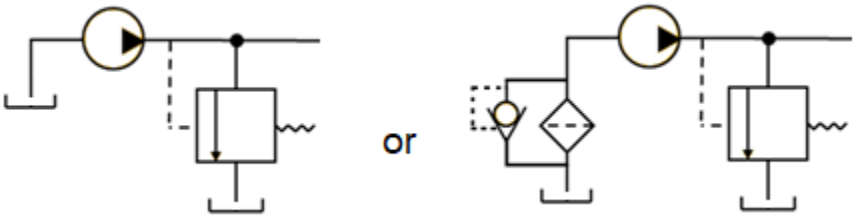
c) The return to the reservoir tank in hydraulic circuit:



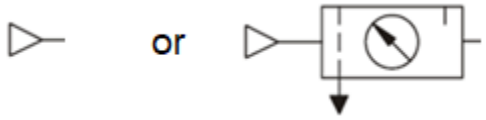
Exhaust to the atmosphere in pneumatic circuit:



d) In hydraulic circuits, pressurized fluid is shown as



In pneumatic circuits, conditioned pressurized air is shown as a triangular symbol only or with additional pressure relief valve symbol as below:



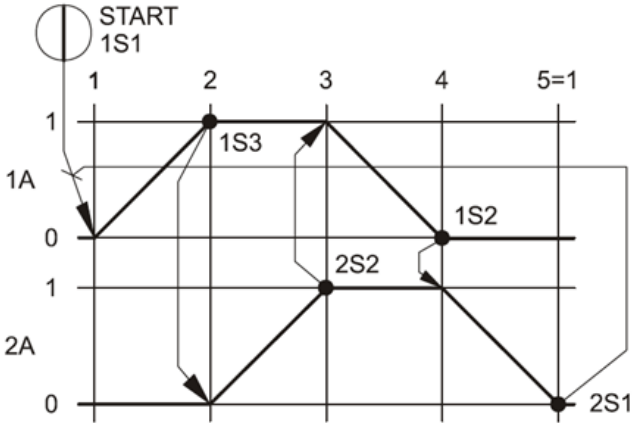
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Question 3) The processes for 2 identical pneumatic cylinders are following:

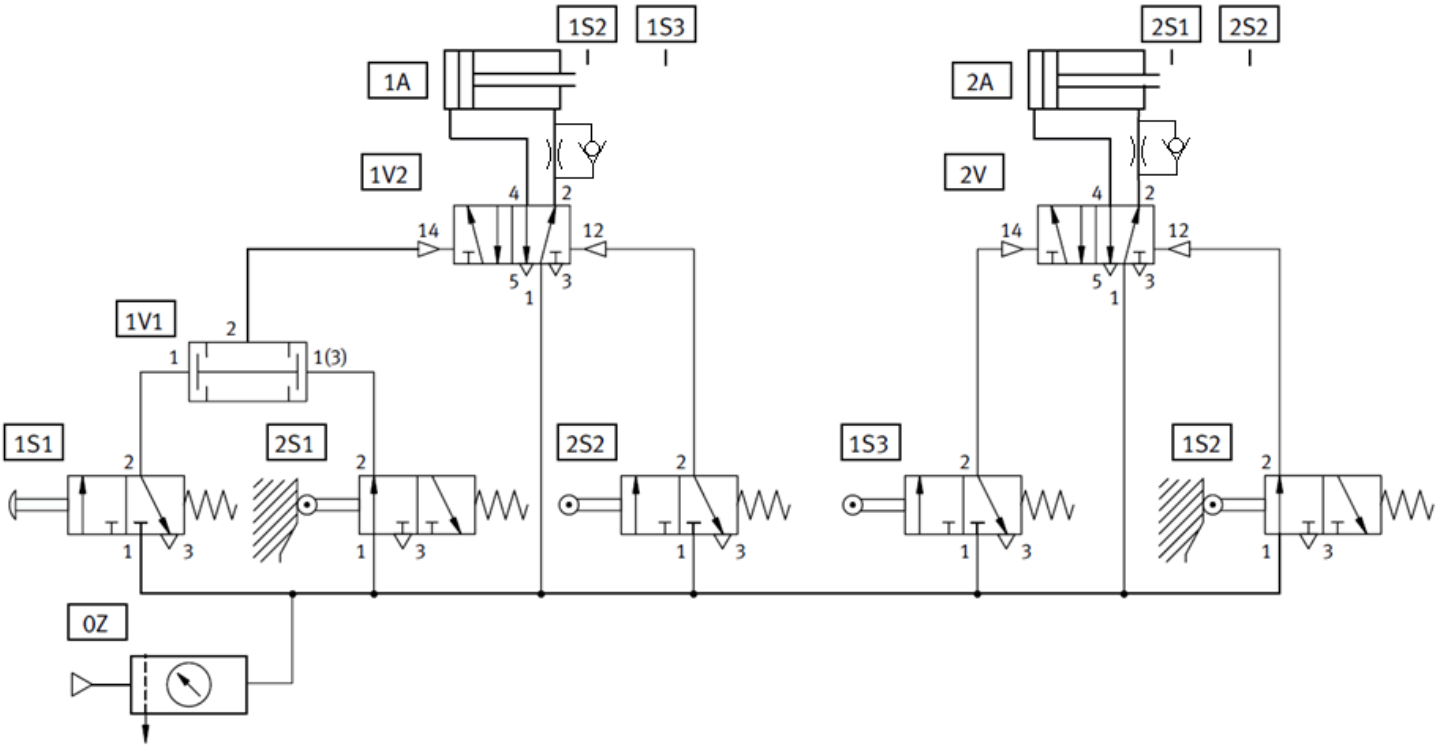
Step 1- Initially both of the cylinders are at their back (retracted) position.
Step 2- The operator presses the pneumatic valve button (3/2 push button valve) to start.
Step 3- The 1st cylinder fully extends with adjustable speed,
Step 4- then the 2nd cylinder fully extends with adjustable speed,
Step 5- then the 1st cylinder fully retracts with full speed,
Step 6- then the 2nd cylinder fully retracts with full speed,
As long as the manual button is pushed, the cylinders keep working as indicated above. So,

a) [10 points] Draw the displacement step diagram with sensor interactions, and
b) [15 points] complete the pneumatic circuit below for this process, showing all necessary units from the pressure source to the actuators with the standard symbols. Hint: 5/2 pilot operated valves for cylinder control.

Answer 3) a)



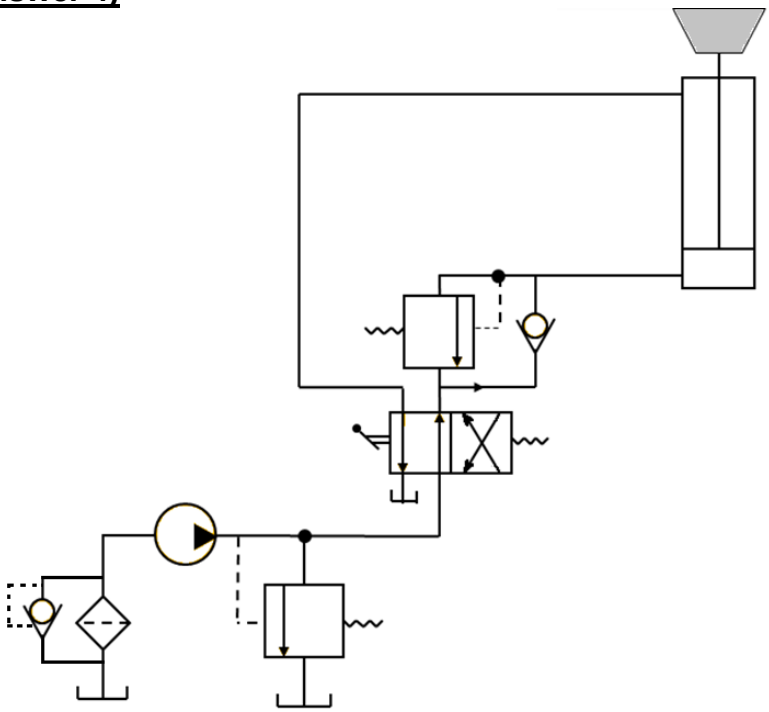
b)



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Question 4) [15 points] A vertical hydraulic cylinder holds a heavy load. You want to manually rise and lower the load. In case of a malfunctioning hydraulic pump, the load should not go down, unless the operator manually lowers it. So, complete the hydraulic circuit below for this safety purpose.

Answer 4)



Question 5) [15 points] A hydraulic cylinder needs to be designed to provide 4 kN force with 0 to 45 cm displacement range. The maximum pressure the pump can supply is 1.5 MPa. Assuming the efficiency is 95%, the elasticity modulus of the cylinder material E=100 GPa and maximum allowable normal stress $\sigma_{all} = 60\ MPa$, determine the all major dimensions of the cylinder. Note: $F_{cr} = \frac{\pi^2 \cdot E \cdot I}{(0.7\ L)^2}$

Answer 5)

The stroke of the cylinder is ***L=50 cm***.

$$F = \frac{\pi^2 \cdot E \cdot I}{(0.7\ L)^2} = \frac{\pi^2 \cdot E \cdot \frac{1}{4} \cdot \pi \cdot r^4}{(0.7\ L)^2} = \frac{\pi^3 \cdot E \cdot \frac{1}{4} \cdot r^4}{(0.7\ L)^2} \quad \rightarrow \quad r = \sqrt[4]{\frac{4\ F\ (0.7\ L)^2}{\pi^3 \cdot E}} = \sqrt[4]{\frac{4 \cdot 4000 \cdot (0.7 \cdot 0.45)^2}{\pi^3 \cdot 100 \cdot 10^9}}$$

The minimum rod radius is r=0.0048 m. Let ***r=5 mm***.

Now, let's check for maximum normal stress: $\sigma = \frac{F}{\pi \cdot r^2} = \frac{4000}{\pi \cdot 0.005^2} = 50929581\ Pa \cong 51\ MPa < \sigma_{all}\ \ OK.$

For the inner radius of the cylinder: $P \cdot 0.95 = \frac{F}{\pi \cdot R^2} \rightarrow R = \sqrt{\frac{F}{\pi \cdot 0.95 \cdot P}} = \sqrt{\frac{4000}{\pi \cdot 0.95 \cdot 1.5 \cdot 10^6}}$

$$\rightarrow \boldsymbol{R = 0.03\ m = 30\ mm}$$

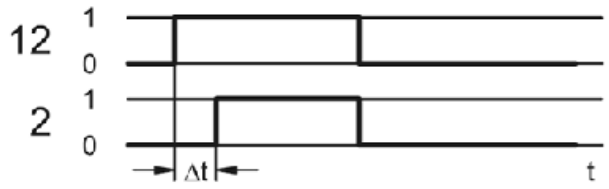
For the cylinder wall thickness: $\sigma_{all} \geq \frac{P \cdot 0.95 \cdot R_i}{t} \rightarrow t \geq \frac{P \cdot 0.95 \cdot R_i}{\sigma_{all}} \rightarrow t \geq \frac{1.5 \cdot 10^6 \cdot 0.95 \cdot 0.03}{60 \cdot 10^6} \rightarrow t \geq 0.00071\ m$

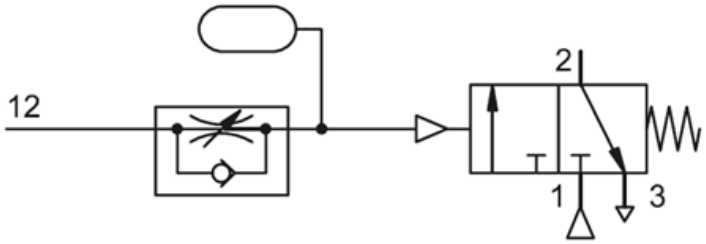
Let ***t=1 mm***.

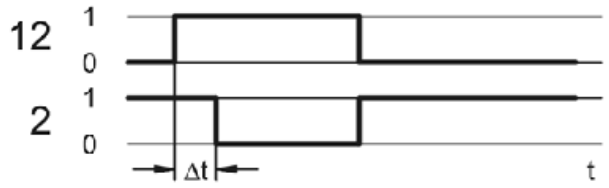
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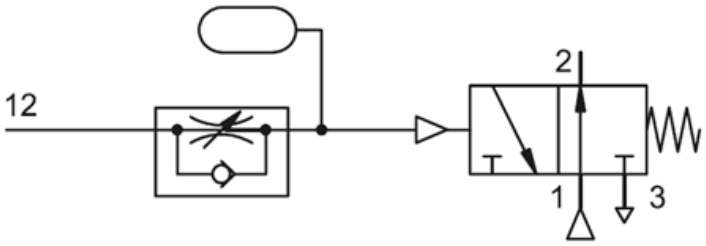
Question 6) [20 points] Assume you have two different 3/2 pneumatic pilot operated control valves. To obtain the indicated delays shown in the signal charts below (time response with delay on and off), draw proper circuits consisting of proper delay elements and valves (from pressure through valve). Do not use timer or something for delay. Use pneumatic elements.

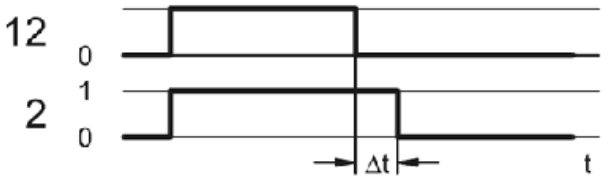
Answer 6)

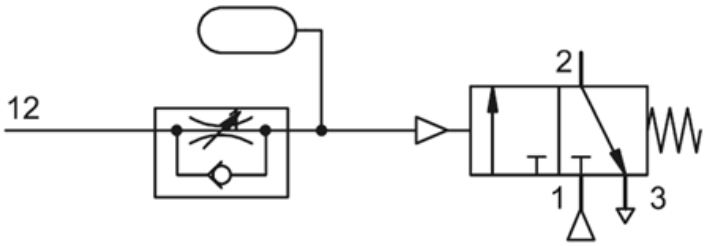




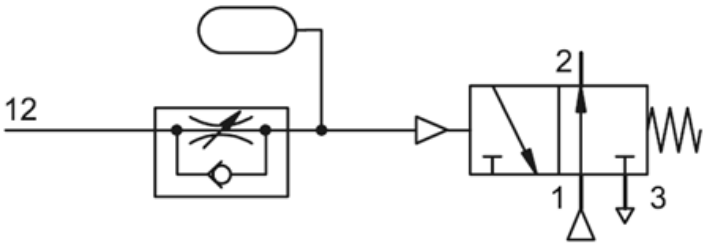












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