Kafrelsheikh University
Faculty of Engineering
Dept. Mech. Engineering
Year: Fourth Year
Subject: Pneumatic Power Systems

Semester: 1st Semester
Final Examination
Date: Jan. 26th, 2016
Time allowed: 3 hours
Full Mark: 70

1. No. of pages: 4
2. No. of questions: 8
3. This is a closed book exam.
4. Clear systematic answers and solutions are required.

Question 1(24 Marks):

1. Name three reasons for considering the use of pneumatics instead of hydraulics.
2. How do a pneumatic actuators differ from hydraulic actuators?
3. Name the required steps to size an air compressor.
4. Define the term "flow capacity constant" when dealing with valve flow rates.
5. Name the four important considerations that must be taken into account when analysing or designing a pneumatic circuit.
6. What effect do air leaks into the atmosphere from a pneumatic system have on the operation of the compressor?
7. Name two applications of pneumatic vacuum systems.
8. What is the difference between an aftercooler and a chiller air dryer?
9. Why would a lubricator be used in a pneumatic system?
10. Describe the function of an air pressure regulator.
11. Name one disadvantage of using a vacuum lift system.
12. What benefit is achieved in using an accumulator as an auxiliary power source?

Question 2 (4 Marks):

A compressor delivers 180 scfm of air through a 1-in schedule 40 pipe at a receiver pressure of 125 psig. Find the pressure loss for a 150-ft of length.

Question 3 (8 Marks):

A 70% efficient compressor delivers air to a pneumatic system at 100 psig and 120 scfm. The efficiency of the electric motor driving the compressor is 90%, and the compressor operates 4000 hours per year. If the cost of the electricity is $0.10/kW.h

a) Determine the cost of the electricity per year.
b) If the compressor is required to provide air at 112 psig to offset a 12-psi pressure loss in the pipelines due to friction. In addition, compressor is required to provide an additional 50 scfm of air to compensate for air leakage from the pneumatic system to the atmosphere. What is the additional cost of electricity per year due these two types of energy losses?

Question 4 (6 Marks):

Air at 100 °F passes through a 1/2 –in diameter orifice having a flow capacity constant of 7. If the upstream pressure is 125-psig, what is the maximum flow rate in units of scfm of air?

Question 5 (6 Marks):

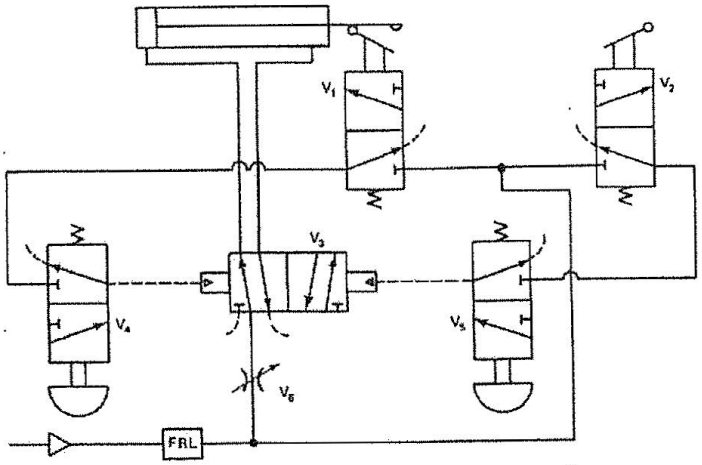
A pneumatic vacuum lift system has a total volume of 5 ft^3 inside the cup and associated pipeline leading to the vacuum pump. The vacuum pump produces a flow rate of 3 scfm when turned on. The desired suction pressure is 5 psia and atmospheric pressure is 30 in Hg abs. Determine the time required to achieve the desired suction pressure.

Question 6 (6 Marks):

What compressor discharge pressure is required for 85% of the moisture to be removed by an aftercooler? The compressor receives saturated air at 90 °F and the aftercooler returns the compressed air temperature back to 90 °F.

Question 7 (6 Marks):

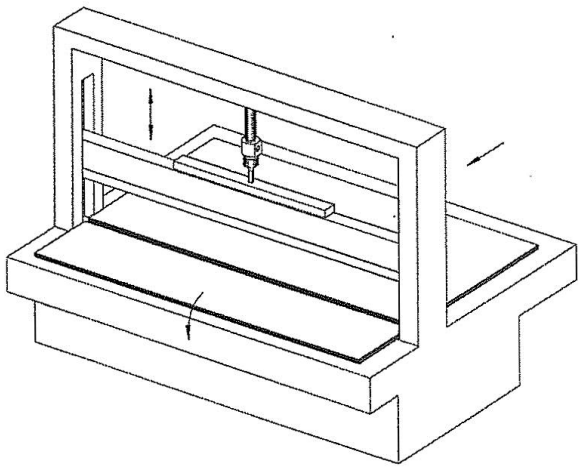
a) What happens to the cylinder when V4 is depressed?
b) What happens to the cylinder when V5 is depressed?



Question 8 (10 Marks):

Design an Electro-pneumatic systems that is used in a cutting device in a factory. The cutting device is used to cut sheets of paper to size. The cutting device operates as follows: By pressing two pushbutton switches the cutting blade is advanced and the sheet of paper is cut. After releasing one pushbutton switch the cutting blade is returned to its start position.

a) State the components used (electrical and pneumatic).
b) Show a schematic of the pneumatic circuit.
c) Show the control circuit diagram.



End of Questions
Best wishes.
Dr. Roshdy Abo-Shanab

Useful relations

$$V_r(\text{ft}^3) = \frac{14.7 \times\ t(\text{min}) \times (Q_r - Q_c)\ \text{scfm}}{(p_{\text{max}} - p_{\text{min}})\text{psi}}$$

$$V_r(\text{m}^3) = \frac{101 \times\ t(\text{min}) \times (Q_r - Q_c)\ \text{std m}^3}{(p_{\text{max}} - p_{\text{min}})\ \text{kPa}}$$

$Q\ = 22.7 C_v \sqrt{\frac{(p_1 - p_2) \times p_2}{T_1}}$ (units: psi, scfm, °R)

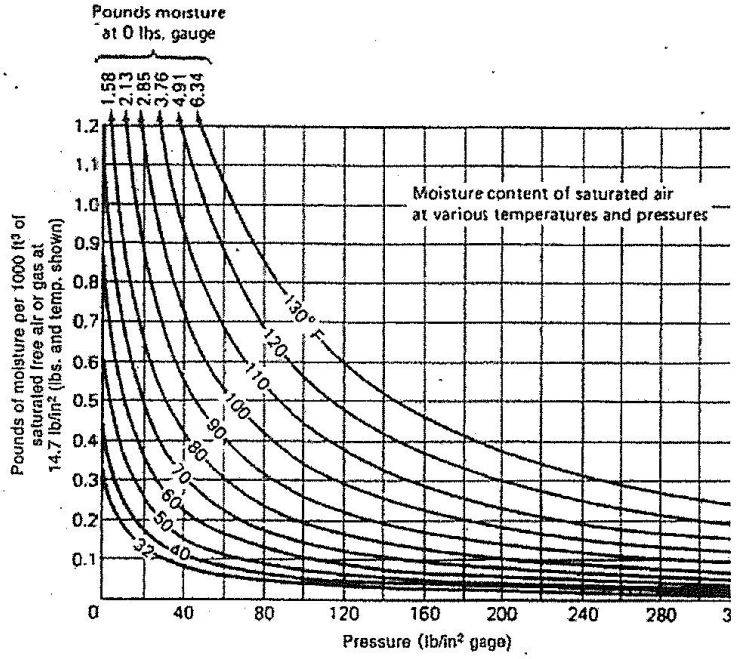
$Q\ = 0.0698 C_v \sqrt{\frac{(p_1 - p_2) \times p_2}{T_1}}$ (units: kPa, std m^3/min, °K)

Theoretical HP$= \frac{p_{\text{in}} Q}{65.4}\left[\left(\frac{p_{\text{out}}}{p_{\text{in}}}\right)^{0.286} - 1\right]$ (units: psi, scfm)

Theoretical kW $= \frac{p_{\text{in}} Q}{17.1}\left[\left(\frac{p_{\text{out}}}{p_{\text{in}}}\right)^{0.286} - 1\right]$ (units: kPa, std m^3/min)

$$p_f = \frac{0.1025\ L(\text{ft}) \times Q^2(\text{scfm})}{3600\ CR\ \times d^{5.31}(\text{in})}$$

$$t(\text{min}) = \frac{\text{V}(\text{ft}^3)}{\text{Q}(\text{scfm})} \ln \frac{\text{p}_{\text{atm}}(\text{psia})}{\text{p}_{\text{vacuum}}(\text{psia})}$$



Nominal Pipe Size		Inside Diameter (d)	$d^{6.31}$	Nominal Pipe Size		Inside Diameter (d)	$d^{6.31}$
$\frac{3}{8}$	3/8	0.493	0.0234	$1\frac{1}{4}$	1-1/2	1.610	12.538
$\frac{1}{2}$	1/2	0.622	0.0804	2	2	2.067	47.256
$\frac{3}{4}$	3/4	0.824	0.3577	$2\frac{1}{2}$	2-1/2	2.469	121.419
1	1	1.049	1.2892	3	3	3.068	384.771
$1\frac{1}{4}$	1-1/4	1.380	5.5304	$3\frac{1}{2}$	3-1/2	3.548	832.550

Tabulated values of d for schedule 40 common pipe size.