Lastname **Name** **Student code**

Section 1. QUIZ

1. The **membrane valve** got this name just because has a **ceramic membrane** in contact with the flowing fluid

   true ☐ false ☐

2. The **Coriolis Flowmeter** is a transducer of volumetric flowrate

   true ☐ false ☐

3. The **sonar level sensors** always provide the contemporary measurement of the temperature

   true ☐ false ☐

4. **Closed liquid column manometers** (closed "U" tube manometers) containing mercury are used for measuring pressure in a vacuum

   true ☐ false ☐

5. **Flow restriction sensors** measure the fluid flow based on the pressure variation generated by the constriction effect.

   true ☐ false ☐

Section 2. MULTIPLE CHOICE QUESTIONS

1. When the percentage of flow through a valve equals the percentage of plug movement, a valve has
   a. ☐ Linear flow characteristic
   b. ☐ Equal percentage flow characteristic
   c. ☐ Quick opening flow characteristic
   d. ☐ Curved flow characteristic

2. Which of the following parts of a globe valve serves the same purpose as the disk in a butterfly valve?
   a. ☐ Seat
   b. ☐ Plug
   c. ☐ Packing rings
   d. ☐ Packing flange

3. What is roughly a **gauge pressure** of 195 psi when converted in absolute psi ?
   a. ☐ 151
   b. ☐ 164
   c. ☐ 178
   d. ☐ 210

4. In the processing industry, the most common control valve body style is
   a. ☐ Saunders
   b. ☐ Three-Way
   c. ☐ Globe
   d. ☐ Bourdon

5. A magnetic flow meter determines the flow by measuring the following property of the fluid:
   a. ☐ velocity
   b. ☐ density
   c. ☐ temperature
   d. ☐ volume

Section 3: SENSORS AND INSTRUMENTATION EQUIPMENT FOR PROCESS MEASUREMENTS

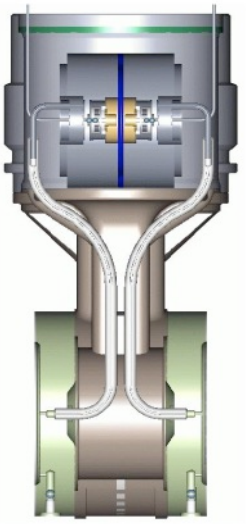
3.1. Temperature measurement with termocouple

A thermocouple of type N is used to measure the temperature of a fluid in a tank. When the reading of the voltmeter is 8.99 mV and the cold junction is at a temperature of 283.16 K, determine the temperature of the fluid with the approximation ±1 K = ±1 °C

a. 150 °C
b. 300°C
c. 352 K
d. 363 K

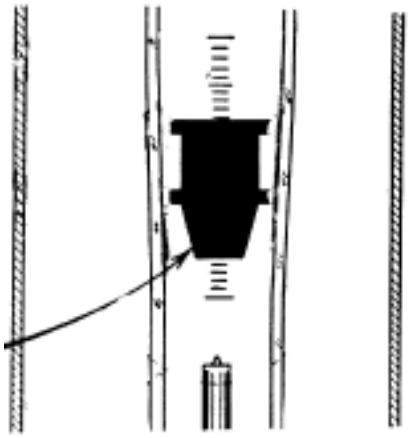
3.2. The inductive pressure transducer

a) Recognize the most important parts and match them directly on the image
b) Is it measuring the **absolute pressure, relative or differential**?
c) Directly on the image, indicate exactly where the fluid actually is for pressure measurement

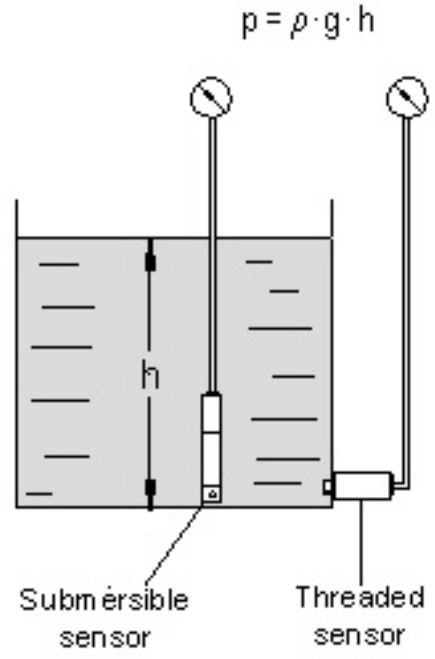


3.3. Level meters

a) Is the one sketched in figure a type of level sensor (YES/NO) ?



c) Is the next one sketched in figure a type of level sensor (YES/NO) ?



d) If the answer is YES, which type is it? Which is its working principle?

3.4. Accuracy and precision

a) Discuss briefly the difference between **accuracy** and **precision**

b) Using a graph, try to show how **accuracy** and **precision** affect measurements, for example as a function of time

3.5. Positive-displacement flow meter

a. Please provide an explanation how it works (in 3 text lines)

3.6. The rotary vane flow meter

a. Provide a schematic drawing of how it works

3.7. Throttle flow meters

a) Obtain the flow rate equation in the **ideal case**
b) Calculate the flow rate measured for water with the following data: P_1=90 kPa, P_2=60 kPa, d_1=55 mm, d_2=25 mm
c) Extend the flow rate equation to **non-ideal cases**
d) Extend the flow rate equation to the case of **non-constant density**

Section 4: VALVES

4.1. Diaphragm valve with pneumatic actuator

Draw a simple sketch representing the pneumatic servomotor membrane mounted on a globe valve in both of the following cases:

a) "direct action"

b) "reverse action"

4.2. Problem

A globe valve is to be sized that can work for flow control of the following fluid:

liquid: hexane
density $\rho = 654.8$ kg/m^3

under the following additional conditions:

nominal diameter of the line:	DN = 4 in
pressure upstream of the valve:	P_1= 32.5÷36.5 psi
pressure downstream of the valve:	P_2= 27.5 psi
nominal flow rate:	$\dot{V}$ = 10 L/s
vapor pressure:	P_v = 0.29 psi

ratio coefficient of the critical pressure for liquids: $F_F = 0.956$

1. Calculate **the flow coefficient C_v**

A **Riggs** globe valve is available with the following manufacturer's table:

DN inches	Valve Opening Percent of Total Travel (h, %)									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	C_v [gpm psi$^{-0.5}$]									
1”	0.79	1.25	1.80	2.53	3.63	5.28	7.59	10.7	12.7	13.2
1.5”	0.80	1.23	1.91	2.95	4.30	6.46	9.84	16.4	22.2	28.1
2”	1.65	2.61	4.30	6.62	11.1	20.7	32.8	44.7	50	53.8
3”	3.11	5.77	9.12	13.7	21.7	36	60.4	86.4	104	114
4”	4.90	8.19	13.5	20.1	31.2	52.6	96.7	140	170	190

2. Draw the intrinsic characteristic and suggest which type it appears to be
3. Size the valve, choosing the one with the right DN
4. Calculate the relevant points characterizing the **flow characteristic**, put them in a graph and determine if the valve operates under **normal flow** conditions
5. Calculate the "theoretical" value of the **recovery coefficient** which would determine cavitation in the chosen valve

Next, you are prompted to enter the sized valve in a circuit, taking $\Delta P_n = (P_1 - P_2)$, i.e., equal to the original value, and considering a user’s equipment pressure drop:

$$\Delta P_u = 2\Delta P_n$$

6. How much is the V authority?
7. Discuss if the calculated value for the authority V is consistent or not with the inherent characteristic under the point 2)
8. Calculate the value of the nominal flow $\dot{V}_n$ that passes through the valve in the circuit
9. How much is the flow rate $\dot{V}_1(h)$ which passes the valve for $h_1 = 0.4$?
10. How much is the actual pressure drop across the valve ΔP_{v1} for $h_1 = 0.4$?
11. How much will the relative stroke h_2 be for which a flow rate $\dot{V}_2(h) = 28.5$ gpm will transit into the valve inserted in the circuit?