Surname **Name** **Student's code:**

Section 1. QUIZ

1. The RTD is characterized by a negative temperature coefficient

   True ☐ false ☐

2. A fail-safe valve with an electric motor actuator, in the absence of power, always comes into the opening position

   True ☐ false ☐

3. The pyrometer measures the temperature by means of a radiation measurement

   True ☐ False ☐

4. Fluid shifting direction is greater in a free-flow (*Y-body)* valve than in a guided-flow (*Z-body)* one.

   True ☐ False ☐

Section 2. QUIZ

1. What happens if the temperature of the hot coupling in a thermocouple is lower than the reference jumper temperature?

a. ☐ No output voltage is not generated
b. ☐ The polarity of the output voltage is inverted
c. ☐ The polarity does not change and the output voltage increases
d. ☐ The output voltage remains the same when the temperature changes

2. This property of the sensors depends on the full scale

   NB: Only mark the wrong answer!

a. ☐ Accuracy
b. ☐ Precision
c. ☐ R*angeability*
d. ☐ Measuring Range

3. Which of the following components does not exist in a temperature industrial sensor?

a. ☐ Protective tube
b. ☐ Threaded or flanged joint for piping attachment
c. ☐ Ceramic membrane
d. ☐ Electric terminal

Section 3: SENSORS AND MEASURING INSTRUMENTS PROCESS

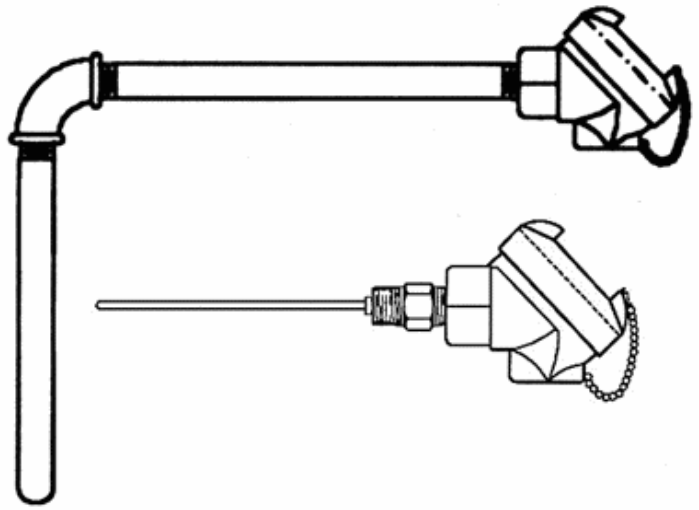
3.1 The thermocouple

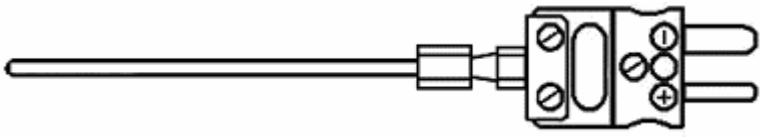
For each thermocouple in figures:

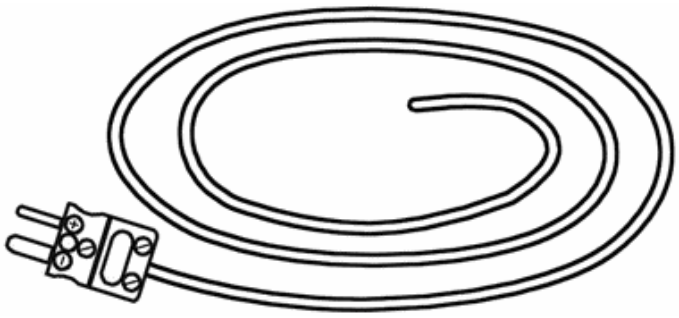
a. Recognize the type of application

b. Comment on the main parts you see in the figures.

NOTE: It's possible to indicate parts directly on the figure







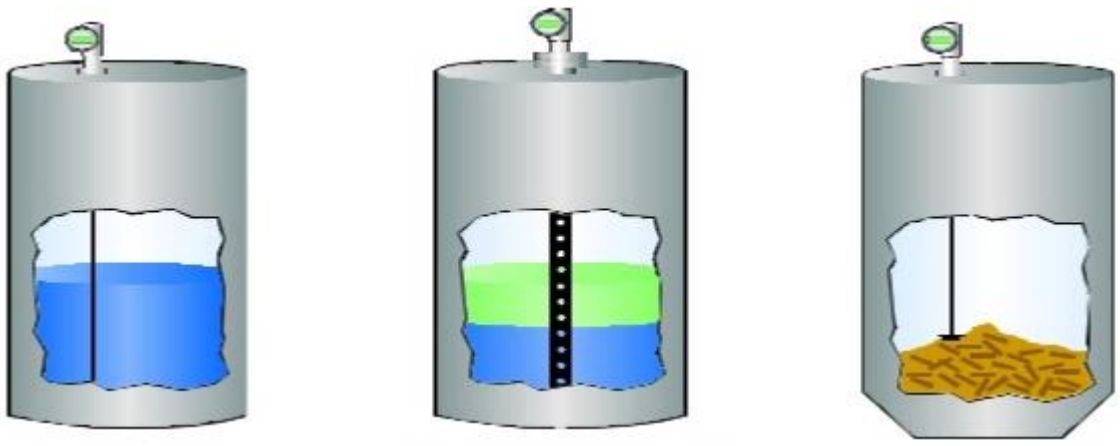
c. Recognize the type of **hot junction** for these thermocouples

3.2 Capacitive pressure sensor

a. Provide a schematic diagram of its operation

3.3 Level meters

a. What is the difference among the three tanks in the type of measurement performed for level?



3.4 The rotameter

a. Draw a **simple scheme** useful for explaining its working principle
b. Derive the equation of the flow rate in the ideal case
c. Extend the equation of the flow rate to the case of non-constant density
d. Prepare a summary table about rotameter, stating in its columns **advantages, disadvantages, other features** deemed interesting.

Note: A short and well-articulated discussion will be evaluated more than a long and confused text!

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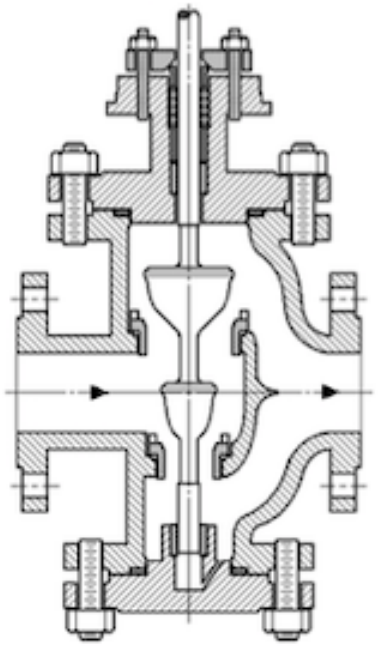
Section 4: VALVES

4.1 Valve technology

a. Recognize the **type of valve** in the figure



b. Is it a **linear** or **rotary** valve?
c. What is its **application purpose**?
d. Recognize the main **component parts** of valve in the figure

NOTE: It's possible to indicate parts directly on the figure

e. Is this type of valve subject to possible **cavitation**?

4.2 Control valves

Demonstrate how from the original eq. of the intrinsic **=% characteristic**

$$\Phi = \Phi_0 \, e^{\beta h}$$

you can mathematically obtain the corresponding parametric expression in rangeability:

$$\Phi = r^{h-1}$$

4.3 Sizing Problem

You are requested to make the optimal choice of valve under the following working conditions:

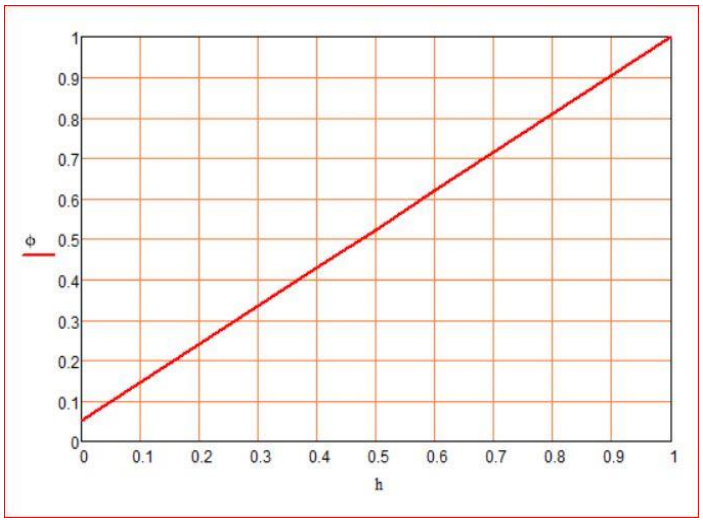
fluid: water
density: $\rho_f = 1000$ kg/m^3
nominal flow rate: $\dot{m} = 50$ kg/s
nominal diameter of the line: DN = 8”
pressure upstream of the valve: $P_1 = 18$ psi
pressure downstream of the valve: $P_2 = 16$ psi
vapor pressure: $P_v = 1.5$ psi
coefficient of the ratio of the critical pressure for liquids: $F_F = 0.956$

1. Calculate **the flow coefficient C_v** for the above conditions

You have available from manufacturers three different valves, each one being equipped with just one **intrinsic characteristic** in a graphical shape and with its **table of C_{vn}.** They are:

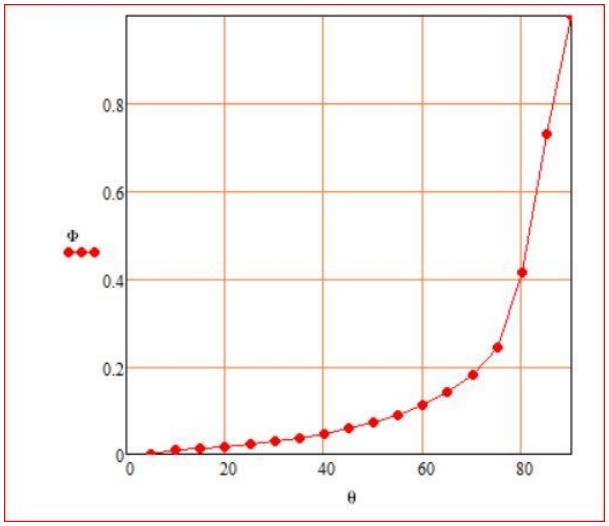
a) a **Saunders diaphragm** valve

Valve Size, in	C_{vn} gpm psi$^{-1/2}$
6	484
8	1040
10	1584
12	2044



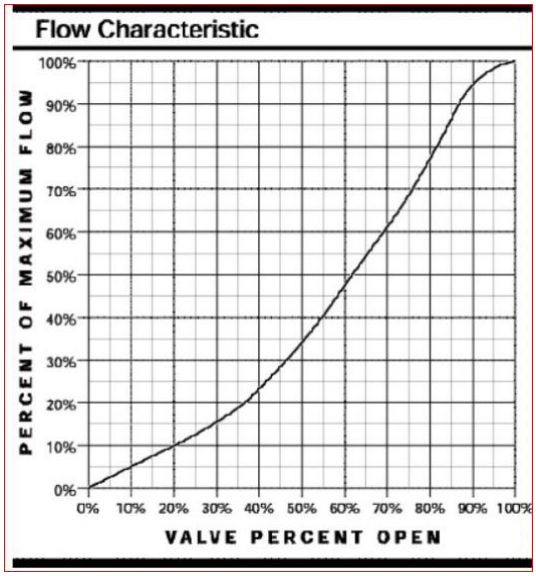
b) a **Pratt modulating sphere** valve

Valve Size, in	C_{vn} gpm psi$^{-1/2}$
6	5250
8	9330
10	14600
12	21000



c) a **De Zurick butterfly** valve

Valve size, in	Cvn, gpm $psi^{-1/2}$
5	860
6	1360
8	2260
10	3350



where **valve percent open = (θ/90°)·100** in this particular case

2. Size the valve for DN and choose the most appropriate one among the three different available types
3. Verify cavitation according to the IEC norm.

Next, you are prompted to enter the selected valve in a circuit, taking ΔP_n equal to the original value (P_1 - P_2) and considering an user's equipment pressure drop:

$$\Delta P_u = 1.9 \text{ atm}$$

4. What is the definition of the installed characteristic
5. Calculate the nominal flow rate $\dot{V}_n$ that will pass through the valve in the circuit
6. What is the flow rate $\dot{V}_1$ that will pass through the valve for an opening of 35% ?
7. What is the actual pressure drop across the valve ΔP_{v1} for an opening of 35% ?
8. What is the opening required for the valve in order to have a flow rate $\dot{V}_2 = 60$ gpm passing through the valve inserted in the circuit?

Finally, we want to consider the use of the same valve in the event that the **pressure upstream of the valve** increases by 20% compared to the initial datum.

2bis Is the valve selected in step 2 still okay? Why?