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?

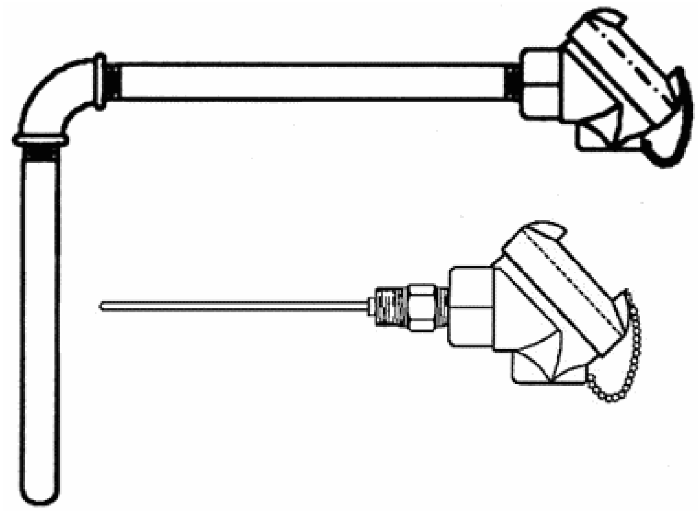
a. ☐ Protective tube
b. ☐ Threaded or flanged joint for piping attachment
c. ☐ Ceramic membrane
d. ☐ Electric terminal

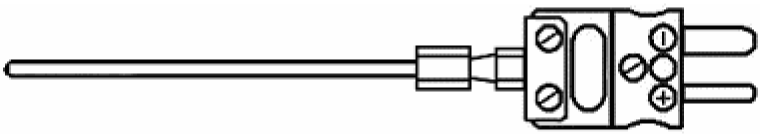
Section 3: SENSORS AND MEASURING INSTRUMENTS PROCESS

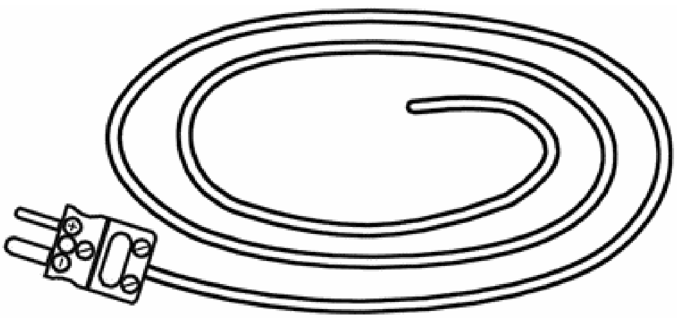
3.1 The thermocouple

For the thermocouples in figures:

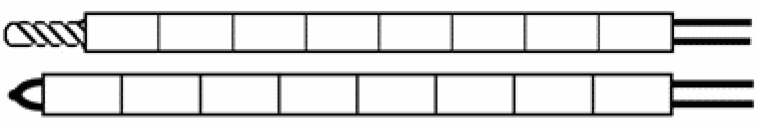
a. Recognize the type of application
b. Comment on the main parts you see in the figures.







c. Recognize the type of hot junction for this thermocouple

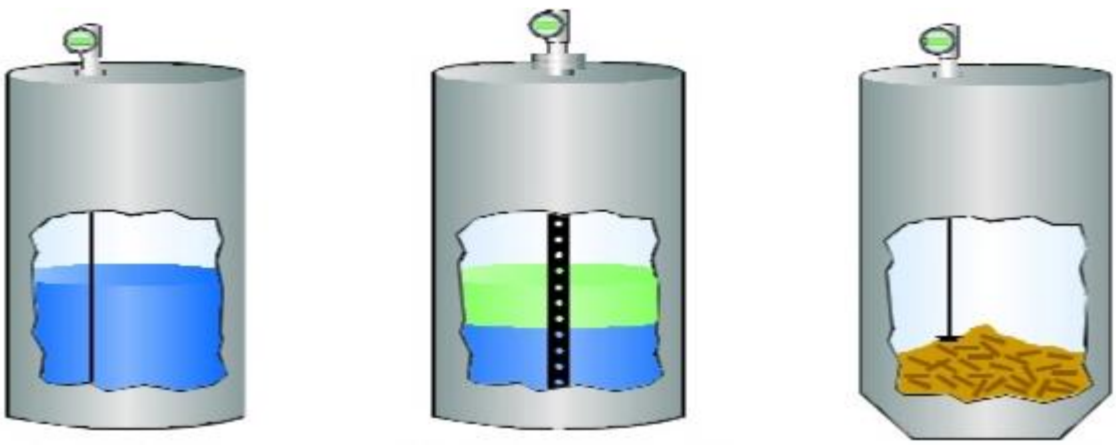


3.2 Capacitive pressure sensor

a. Provide a schematic diagram of its operation

3.3 The sonar level meter

a. Recognize the type of level measured in the three tanks



3.4 The rotameter

a. Draw a **simple scheme** useful for 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.

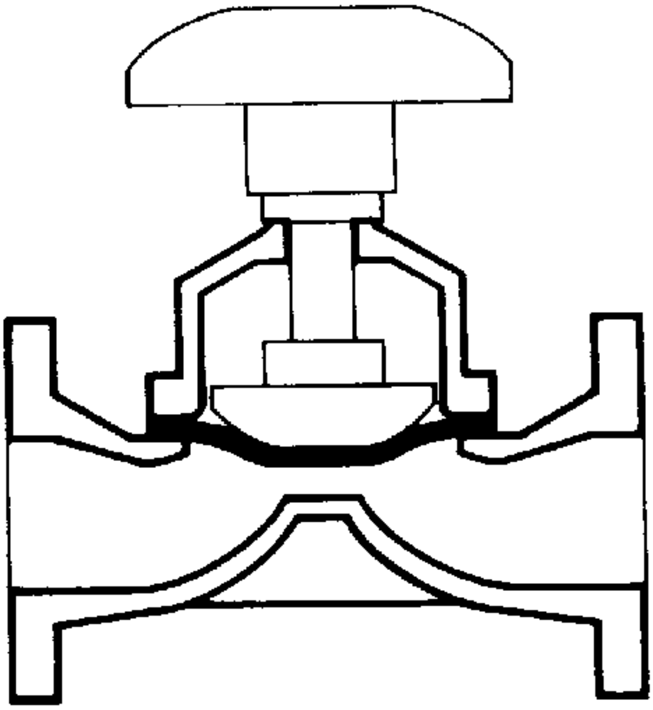
Note: A short and well-articulated discussion will be evaluated more than a long and confused text!

.

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

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

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

4.2 Control valves

Demonstrate how from 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 required to perform the sizing of a valve for the following conditions:

nominal diameter of the line: DN = 4”
fluid: acetic acid,
density: ρ_f = 65.487 lb/ft^3
pressure upstream of the valve: $P_1 = 2.1 \cdot 10^5$ Pa
pressure downstream of the valve: $P_2 = 1.65 \cdot 10^5$ Pa
nominal flow rate: $\dot{m}$ = 28.5 kg/s
vapor pressure: P_v = 65 torr
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 only have a **butterfly valve** model available with the following table of **C_{vn}** values

DN, in	2.5	3	4	5	6	7	8
C_{vn}, gpm psi$^{-0.5}$	224.629	323.465	575.050	898.515	1293.862	1761.090	2300.199

and the following **intrinsic characteristic** giving the **relative flow coefficient** ϕ as a function of the **opening angle θ:**

$$\phi = exp\left[-\left(\frac{\frac{\theta}{90°} - 1}{c}\right)^2\right]$$

where the parameter is: c = 0.4154

2. What is the valve nominal size?
3. Plot the **intrinsic characteristic** in a diagram
4. Check **cavitation** according to the IEC norm

Next, the valve chosen above is to be installed in a plant circuit that has ΔP_n equal to the original value ($P_1 - P_2$).

5. Calculate the **authority V** in the following 3 cases for the user circuit **pressure drop**:
   a. $P_2 - P_3 = \Delta P_u = \Delta P_n$
   b. $\Delta P_u = \Delta P_n/2$
   c. $\Delta P_u = 2\Delta P_n$

For the condition in which: $\Delta P_u = \Delta P_n/2$

6. What is the **flow rate** $\dot{V}_\theta$ that will pass through the valve for $\theta = 45°$?
7. What is the value θ_s of the angle that will allow the passage of a small flow in the valve, equal to $\dot{V}$ = 46.7 gal/min ?

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 and the nominal flow doubles with respect to the initial datum.

8. Is the valve selected in step 2 still okay? Why?