Last Name **Name** **Student's code**

Section 1. TRUE/FALSE QUESTIONS

1. The sensor **span** is the amplitude of the measuring range:
   true ☐ false ☐
2. The **membrane valve** got this name just because has a **ceramic membrane** in contact with the flowing fluid
   true ☐ false ☐
3. In a **"air-to-open" valve** the air operates on the actuator in order to move away the closure member from the seat
   true ☐ false ☐
4. The **Bourdon pressure gauge** is based on the balance force principle
   true ☐ false ☐

Section 2. MULTIPLE CHOICE QUESTIONS

1. Which one of the following working principles is <u>not</u> used to measure **flow rate**?
   a. ☐ electrical resistance variation
   b. ☐ ultrasound
   c. ☐ heat conductivity
   d. ☐ magnetic field

2. The **Coriolis effect** is associated with the:
   a. ☐ Level meter
   b. ☐ Mass flowmeter
   c. ☐ Volumetric flowmeter
   d. ☐ Pressure meter

3. When the percentage variation of flow through a **valve** equals the percentage variation of plug movement, a valve has a
   a. ☐ Linear flow characteristic
   b. ☐ Equal percentage flow characteristic
   c. ☐ Quick opening flow characteristic
   d. ☐ Parabolic flow characteristic

4. Which of the following types of valve actuators responds to a **pneumatic signal?**
   A. Solenoid
   B. Motor
   C. Diaphragm
   D. Electromagnetic valve

Section 3: SENSORS AND INSTRUMENTATION FOR PROCESS MEASURING

3.1. Temperature measurement with thermocouple

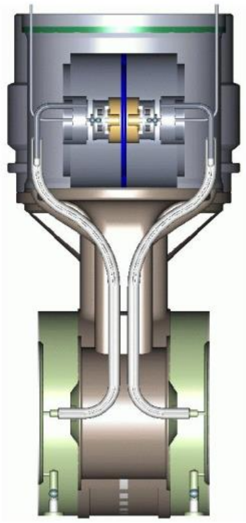
A **J-type thermocouple** is used to measure the temperature of superheated steam.

The **cold junction** of the measuring circuit is at a temperature T_{gf} = 291 K, that is different from the reference temperature of 0°C.
The voltmeter connected to the cold junction provides a measure of the electromotive force V = 23.32 mV.

a. determine the temperature of steam T_{gc} in °C with an accuracy ± 1°C

3.2. Inductive Pressure Transducer

a) Recognize the constituent parts and indicate them just with ref. to the drawing.
b) Where is exactly the fluid the pressure of which has to be measured ?



3.3. Radioisotope Level Sensor

a. Draw a **simple scheme** showing its working principle

3.4 Sensors' properties

a) Draw <u>a suitable diagram</u> just to show the difference between **accuracy and precision** for a process variable that is measured during time

b) Provide the definition and one example of static characteristic.

3.5. 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, reporting in 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. Divert Valve

a. What is it ? Please answer with the aid of a schematic drawing

4.2. Pneumatic membrane servomotor

a. Briefly explain working principle and operation, with the aid of a schematic drawing

4.3. Valve sizing problem

It is required the sizing of a **globe valve** for the following conditions:

nominal diameter of the line: DN = 65 mm
fluid: olive oil, with a density $\rho = 920\ kg/m^3$
upstream pressure of the valve: $P_1 = 4.5$ atm
downstream pressure of the circuit in which the valve is inserted: $P_3 = 1.6$ atm
downstream pressure of the valve P_2 as given from the formula $\Delta P = (P_1 - P_2) = 45\%(P_1 - P_3)$
nominal flow rate in the range: $\dot{V} = 4.5 \div 6.5$ L/s
vapor pressure: $P_v = 0.003$ atm
liquid critical pressure ratio factor: $F_F = 0.956$

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

The manufacturer provided the following Table for a Burkert 2013 valve, which is available as:
a VA1 valve with **equal percentage** intrinsic characteristic,
a VA2 valve with **linear** intrinsic characteristic
and a VA3 valve with **quadratic** intrinsic characteristic.
The *rangeability* is always r = 30.

DN (mm)	K_{vn} $(m^3(H_2O) / h\ bar^{1/2})$
10	2.7
15	4.0
20	7.1
25	12.0
32	18.0
40	34.0
50	48.0
65	64.0

$\mathbf{C_{vn}=1.16\ K_{vn}}$

2. **Size the valve** for the problem, choosing the one with the most appropriate DN and intrinsic characteristic.

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

$$\Delta P_0 = 2.9 \text{ atm}$$

3. How much is the V authority?
4. Discuss if the calculated value for the authority V is consistent or not with the inherent characteristic previously chosen under the point 2)
5. Calculate $\dot{V}_n$
6. How much is the flow rate $\dot{V}_1(h)$ which passes the valve for $h_1 = 0.4$?
7. How much is the actual pressure drop across the valve ΔP_{v1} for $h_1 = 0.4$?
8. What is the **relative stroke** h_2 that allows a flow rate $\dot{V}_2 = 155$ gal/min trough the valve
9. Check **cavitation** according to IEC norm