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

Section 1. QUIZ

1. **Immersion** level measurement can also be done for **solids**
   true ☐ false ☐
2. The **primary sensitive element** never transforms the measured variable into an electrical or pneumatic signal
   true ☐ false ☐
3. In the **gate valves** the shutter always moves parallel to the sealing seats
   true ☐ false ☐
4. **The Seebeck effect** generates a f.e.m. which is a linear function of temperature
   true ☐ false ☐

Section 2. MULTIPLE CHOICE QUESTIONS

1. A magnetic flow meter determines the flow by measuring the following property of the fluid:

a. ☐ velocity
b. ☐ density
c. ☐ Temperature
d. ☐ Volume

2. Which meter does not introduce an obstruction?

a. ☐ Head meter
b. ☐ Magnetic flowmeter
c. ☐ Time-of-travel ultrasonic meter
d. ☐ Turbine meter

3. 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

4. What is roughly a **gauge pressure** of 195 psi when converted in absolute psi ?

a. ☐ 151
b. ☐ 164
c. ☐ 178
d. ☐ 210

Section 3: SENSORS AND INSTRUMENTATION FOR PROCESS MEASUREMENTS

3.1. The thermocouple

a. make a **schematic drawing** of an **industrial thermocouple**
b. appropriately highlight the hot junction and the connection terminals in such a **schematic drawing**

3.2. Pressure sensors

Make a **schematic drawing** of the Bourdon tube

3.3 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**

3.4. "Sonar" level meter

Make a **schematic drawing**

3.5. General properties of sensors

Draws and comments on the block diagram which includes the essential elements for the measurement and therefore allows the schematization of the **"measurement chain"**

3.6. Accuracy and precision

Draw a graph of a measurement over time showing the difference between **accuracy and precision** for a sensor, and discuss its meaning shortly

Section 4: VALVES

4.1 The control valves

Prove how mathematically from the Eq. of the intrinsic equal percentage characteristic

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

the corresponding expression is obtained for a control valve with rangeability *r*:

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

4.2. Sizing problem

The sizing of a valve is required under the following conditions:

liquid: sea water
density: ρ=1025 kg/m^3
nominal flow rate: $\dot{m}$ =15÷20 kg/s
nominal diameter of the line: DN = 2 in
absolute pressure upstream of the valve in the range: P_1= 19.5÷24.5 bar
absolute pressure downstream of the valve: P_2= 16.5 bar
vapor pressure P_v = 0.02 bar
coefficient of the critical pressure ratio for liquids: F_F = 0.956

1. Calculate the valve **flow coefficient C_v**

A **diaphragm valve** type "**Saunders**" is available with:

- a single **intrinsic linear characteristic** with ***rangeability*** r=20
- **recovery coefficient** F_L=0.7
- the following C_{vn} table:

DN (in)	C_{vn} [gpm psi$^{-0.5}$]
1/2 ″	9
1″	38
1 ½″	75
2″	128

2. Make a **schematic drawing** of this valve
3. Choose the most appropriate **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

Subsequently, you must insert this valve in a circuit whose user pressure drop is:

a. $\Delta P_u = \Delta P_n/2$
b. $\Delta P_u = 2\Delta P_n$

assuming that $\Delta P_n = P_1 - P_2$ from the data previously used for sizing.

5. How much is the authority V value in the two cases a) and b)?

Moreover, in condition a) in which: $\Delta P_u = \Delta P_n/2$

6. What is the volumetric flow rate $\dot{V}_h$ that will pass through the valve being h = 0.25 ?
7. What is the pressure drop ΔP_{v_h} through the valve inserted in the circuit being h = 0.25 ?
8. How much will the relative stroke h_r be for which a flow rate $\dot{V}_r$ = 340 gal(US)/min will transit into the valve inserted in the circuit?
9. Can you let gasoline (ρ = 740 kg m^{-3}) pass through the same valve, under the above flow and pressure conditions? What is going to change? How much will the new C_v value be?