Surname **First Name**

Section 1.TRUE/FALSE QUESTIONS

1. A **fail-safe valve** with an electric motor as actuator moves always to the open position when electricity shuts down
   true ☐ false ☐
2. The **needle valve** is commonly used for low flow rates and when a more accurate flow rate is required
   true ☐ false ☐
3. A **capacitive pressure transducer** cannot measure a differential pressure
   true ☐ false ☐
4. The **Bourdon pressure gauge** is based on the balance force principle
   true ☐ false ☐

Section 2. MULTIPLE CHOICE QUESTIONS

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

2. What is <u>not</u> used to measure **flow rate** from the following working principle?
   a. ☐ electrical resistance variation
   b. ☐ ultrasound
   c. ☐ heat conductivity
   d. ☐ magnetic field

3. Which one is <u>not</u> a **contraction-based flow meter**?
   a. ☐ orifice plate
   b. ☐ vortex-shedding flow meter
   c. ☐ Venturi meter
   d. ☐ flow nozzle

4. 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

5. What occurs if the temperature of the **thermocouple** measuring junction is lower than the reference junction?
   a. ☐ There is not e_{mf} output
   b. ☐ The output voltage polarity is reversed
   c. ☐ The polarity stays the same but voltage increases
   d. ☐ The e_{mf} remains the same when temperature changes

Section 3: SENSORS AND INSTRUMENTATION FOR PROCESS MEASUREMENTS

3.1 Temperature measurement with thermocouple

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. 200 °C
b. 300°C
c. 350 K
d. 323 K

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3.2 The Resistance Temperature Detector (RTD)

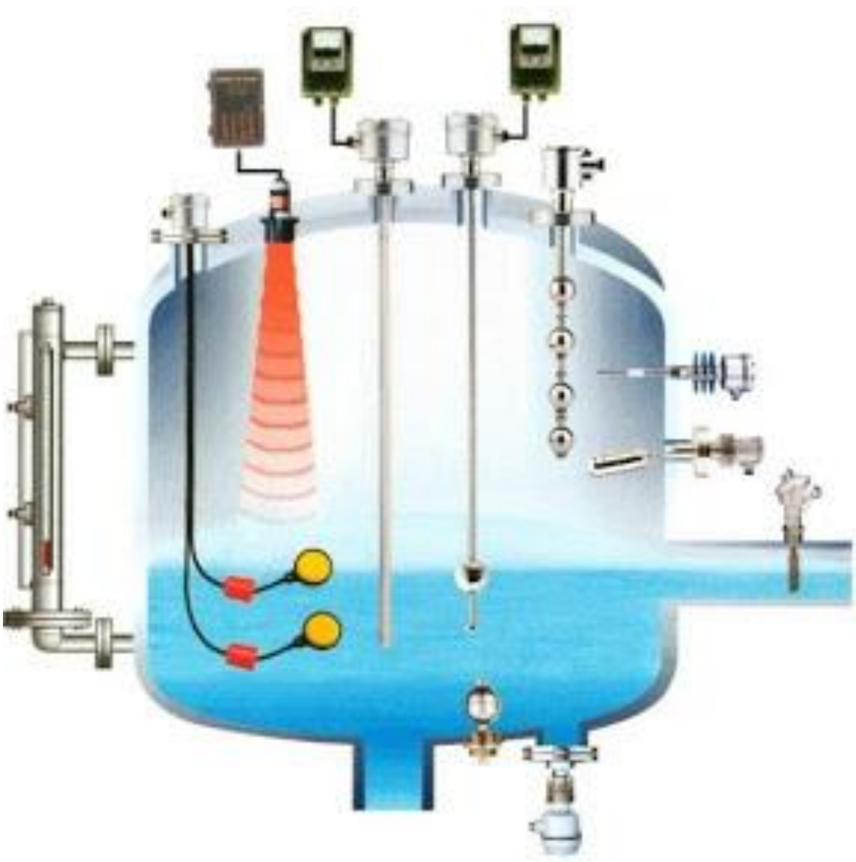
a. Describe in 3 rows its **working principle**

3.3 Inductive Differential Pressure transducer

a. Describe in 3 rows its **working principle**

3.4 Level Sensors

a. Recognize as many as possible Level Sensors directly on the Figure



3.5 The general properties of Sensors

a. Describe in 3 rows definition and meaning of **repeatability**

Section 4: VALVES

4.1 Valve Classifications

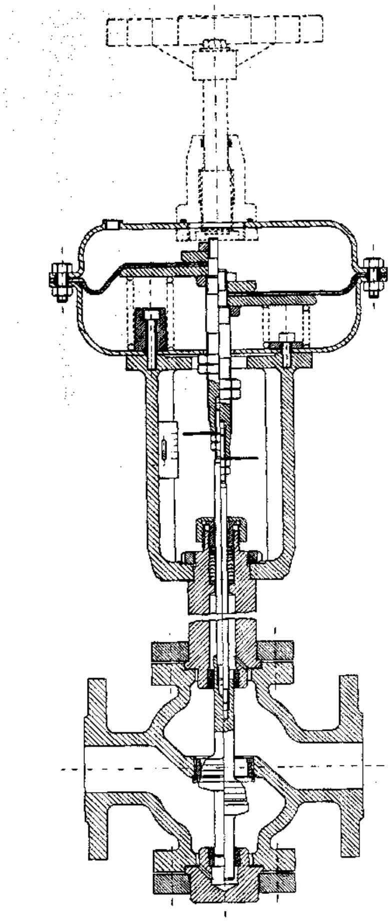
a. Report in a schematic way and discuss all the general **valve classifications**

NOTE: A well organized and short paragraph will be assessed more than a long and confused text!

4.2 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. Is it equipped with a **servomotor**?
e. Is it equipped with a **positioner**?
f. Recognize the main **component parts** of valve in the figure
g. Is this type of valve subject to possible **cavitation**?

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



4.3 Valve Sizing Problem

A **control valve** has to be chosen and sized at the following conditions:

nominal pipe size: NPS = 125 mm
fluid: sea water; density ρ_f = 1.025 kg/L
upstream pressure: P_1= 1900 torr
downstream pressure: P_2= 1290 torr
nominal flow rate: $\dot{m}$ = 70 kg/s
vapor pressure: P_v = 4000 Pa
liquid critical pressure ratio factor: F_F = 0.956

1. With respect to the above conditions, calculate the **flow coefficient C_v**

A GHIBSON **butterfly valve** is available with the following table of $\mathbf{C_v}$ (gal min^{-1} psi$^{-½}$) as a function of the **opening angle** θ (for each nominal valve diameter reported in column):

	Nominal Diameter, mm						
θ, deg	**50**	**65**	**80**	**100**	**125**	**150**	**200**
5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
15	0.2	0.6	1.8	2.4	4.2	5.6	14
20	0.9	2.5	5.2	9.5	15	83	110
25	3	6.1	12	22	38	61	125
30	6.1	11	21	39	69	112	211
35	9.9	18	33	60	105	166	303
40	15	27	49	88	148	228	405
45	21	38	68	121	199	303	528
50	29	51	91	159	262	394	679
55	39	68	119	207	338	505	863
60	53	90	156	269	434	641	1085
65	72	121	209	357	565	820	1364
70	92	161	283	487	768	1097	1788
75	109	209	381	662	1059	1507	2425
80	115	240	457	815	1303	1861	3043
85	115	253	502	906	1457	2008	3642
90	116	257	508	925	1492	2168	3838

2. **Size the valve** selecting the proper nominal diameter.
3. Plot the **inherent characteristic** of the chosen valve.
4. What kind of **inherent characteristic** is?
5. Plot the **flow curve** of the selected valve and verify the flow condition with respect to **cavitation**.

Let us now consider the valve installed in a circuit plant assuming ΔP_n equal to the provided value ($P_1 - P_2$) for the 3 following cases of the **user pressure drop**:

a. $P_2 - P_3 = \Delta P_u = \Delta P_n$
b. $\Delta P_u = \Delta P_n/2$
c. $\Delta P_u = 2\Delta P_n$

6. What is the **valve authority** V for the 3 cases?

For the case for which: $\Delta P_u = 2\Delta P_n$

7. What is the flow rate $\dot{V}$ flowing in the valve for θ = 35° ?

Finally, the possibility to use the **same control valve** has to be checked when a 30% increase of the upstream pressure P_1 and a 50% increase of the nominal flow rate $\dot{m}$ occur.

8. Is the flow coefficient of the selected valve in agreement to the sizing criterion of a valve for these flow conditions?
9. Does cavitation occur?
10. Can the selected valve be used in this case?