Surname **First Name**

Section 1. TRUE/FALSE QUESTIONS

1. The **membrane valve** got this name just because has a **ceramic membrane** in contact with the flowing fluid
true ○ false ○

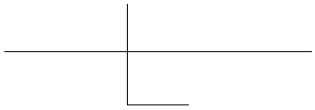
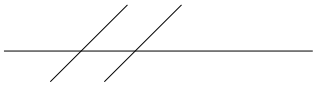
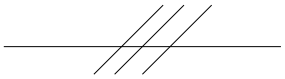
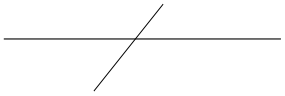
2. The **sonar level sensors** always provide the contemporary measurement of the temperature
true ○ false ○

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. **Closed liquid column manometers** ("U" tube manometers) containing mercury are used for measuring pressure in a vacuum
true ○ false ○

Section 2. MULTIPLE CHOICE QUESTIONS

1. **Butterfly valves** are:
a. ○ rotary motion control valves
b. ○ linear stem motion control valves
c. ○ ball control valves
d. ○ motorized control valves

2. What is the **hydraulic signal** from the following symbols?
a. ○ 
b. ○ 
c. ○ 
d. ○ 

3. Which one is a dimensionless **sensor property**?
a. ○ accuracy at the full scale
b. ○ accuracy at the measured value
c. ○ *rangeability*
d. ○ sensitivity

4. The working principle of a **pressure transducer** can be:

NOTE: check only the wrong answer!

a. ○ piezoelectric
b. ○ radio
c. ○ inductive
d. ○ electric resistance

Section 3: SENSORS AND INSTRUMENTATION FOR PROCESS MEASUREMENTS

3.1. Temperature measurement with a thermocouple

A **K-type thermocouple** is used to measure the temperature of a molten salt mixture in a tank. The **cold junction temperature** of the measuring circuit is: T_{cj} = 298.16 K.
The voltmeter connected to the cold junction provides a measure of the **electromotive force**:
V = 19.7 mV.

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

3.2 Contraction-based flow meters

Draw a sketch of two different **contraction-based flow meters.**

3.3 Sensor properties

Describe briefly differences between the definitions of **accuracy** and **repeatability**.

3.4 Capacitance level sensor

Provide the **working principle** and the **main characteristics** of this sensor

3.5 Rotameter

1. Draw a sketch of its general **working principle**
2. Derive its flow rate equation
3. Extend the flow rate equation assuming P and T different from calibration condition.
4. Discuss briefly advantages e disadvantages

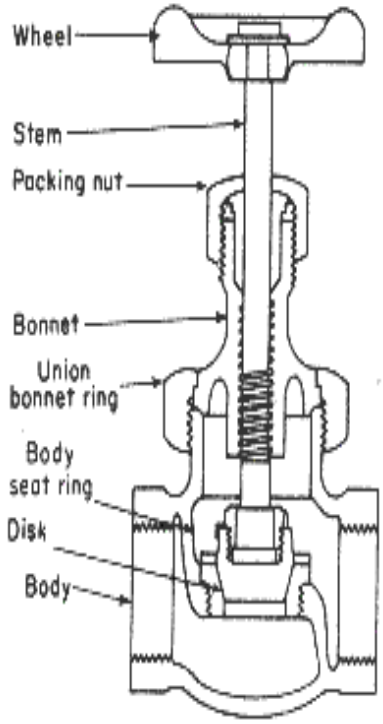
NOTE: A well organized and short text will be assessed more than a long and confused one!

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 following figure



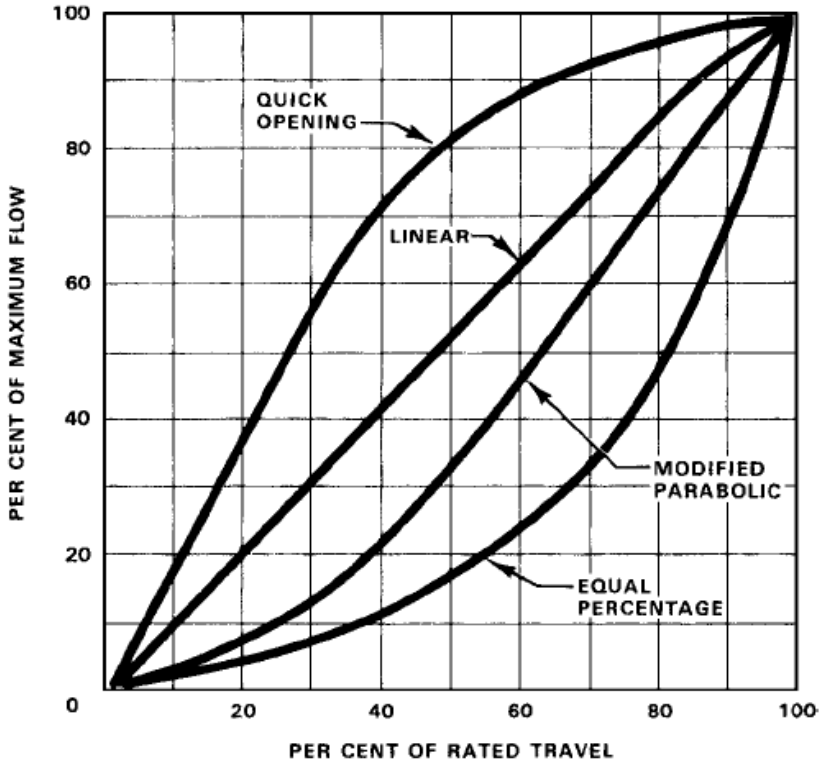
4.2 Sizing problem

A control valve for a seawater flow has to be chosen and sized at the following conditions:
density: $\rho_f = 64$ lb/ft^3
nominal flow rate: $\dot{m} = 4.9$ kg/s
nominal pipe size: NPS = 2”
upstream pressure: $P_1 = 2.5 \div 3$ atm
downstream pressure: $P_2 = 1.2$ atm
vapor pressure: $P_v = 4000$ Pa
recovery factor: $F_L = 0.9$
liquid critical pressure ratio factor: $F_F = 0.956$

1. Calculate the **flow coefficient C_v** for the valve pressure drop that appears to be the most demanding

A single seat control globe valve, *rangeability* r = 20, is available. The inherent characteristic diagram and the C_{vn} values are provided:

Valve size	C_{vn}
1”	14
1.5”	31
2”	54
3”	115



Commonly observed inherent flow characteristic types

2. **Size the valve** and choose that one with the most appropriate nominal diameter and inherent characteristic.
3. Plot the **flow characteristic diagram** selecting the valve pressure drop that appears to be the most demanding for the cavitation occurrence and verify the flow condition of the fluid.

4. Check **cavitation** according to the IEC norm.

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 following case of the **user's equipment pressure drop**:
$\Delta P_u = 3$ bar

5. What is the **valve authority** V?
6. What is the new value of the flow rate $\dot{V}_n$ flowing in the valve?
7. What is the flow rate $\dot{V}_1$ flowing in the valve for $h_1 = 0.4$?
8. What is the valve pressure drop ΔP_1 for $h_1 = 0.4$ when the valve is installed in a circuit plant?
9. What is the value of the relative stroke h_2 which determines a flow rate $\dot{V}_2 = 95$ gal(US)/min in the circuit?