# Mid-term Exam
# Principles of Measurement Systems

*(NAPMS05E.2010-2011)*
*Wednesday 06/10/2010 (09:00-11:00)*

- Write your **name, student ID number and date of birth on the first page.**
- Write your **name on all pages and number the pages**
- This is **NOT an open book exam** - only a regular calculator is allowed.
- Pay attention to units. A numerical result without a unit will be considered wrong !
- You have **2 hours to complete the exam.**

## Question 1

The table below characterizes a pressure gauge designed for operation at room temperature (25 °C, standard condition).

| Pressure [bar] | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| $I_{out}$ [mA] (25 °C) | 4.0 | 7.2 | 10.4 | 13.6 | 16.8 | 20.0 |
| $I_{out}$ [mA] (35 °C) | 3.5 | 7.2 | 10.9 | 14.6 | 18.3 | 22.0 |

We consider the "generalized model" : $O = a + K_I.I_I + K.I + K_M.I_M.I$

1.a. : To what "real-life" parameters correspond O, I, $I_I$ and $I_M$ in this particular case and what units do they have ? Motivate your answer based on the values in the above table.

1.b. : Determine values for a, K, $K_I$, $K_M$. Also note down the units of these parameters !

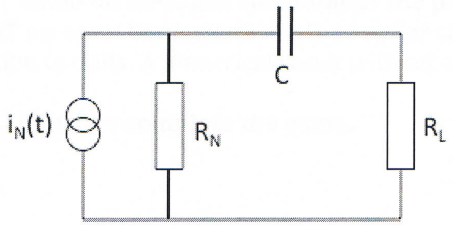
## Question 2

A potentiometer ("potentiometric displacement sensor") has a total length of 10 cm and a resistance of 100 Ω.

2.a. : Calculate the supply voltage so that the power dissipation is 1 Watt
2.b. : Draw the Thévenin equivalent circuit for 7 cm displacement. Indicate the values for $E_{Th}$, $Z_{Th}$ and include as well a load impedance.
2.c. : The potentiometer is connected to a recorder with a resistance $R_L$. Find $R_L$ such that the recorder voltage is 5 % less than the open circuit voltage at 7 cm displacement.

**Question 3**

A current source i(t) with an internal impedance of 100 kΩ is capacitively coupled (C = 1 μF) to a recorder with impedance 100 kΩ. Both source and recorder are connected to the same ground potential. The corresponding circuit is shown in the figure below.




3.a. : Show that the transfer function G(s) has the form : $G(s)=\frac{\Delta \bar{V}_L(s)}{\Delta \bar{i}_L(s)} = \frac{ks}{1+\tau s}$

3.b. : Determine k and τ AND their units !

3.c. : What is the order of this system ?

3.d. : What is the amplitude ratio of an output sine wave when it's input to this system ?

3.e. : What is the asymptotic value of this amplitude ratio for very high frequency.

3.f. : For what value of ω is the amplitude ratio reduced to $1/\sqrt{2}$ of it's maximum value ? Make a comment about the bandwidth of this system.

3.g. : What is the phase of the output sine wave when it's input to this system ? Make a comment for very small and very large frequencies ($\omega \to 0$ and $\omega \to \infty$)

3.h. : Derive an expression for the step-function response of this system in the time domain ( $V_L(t)$ ). Use for this the following Laplace transforms :

$1/s \to$ u(t) = step function

$\frac{1}{\alpha + s} \to e^{-t\alpha}$