Mid-term Exam - PMS, 05/10/2011

- Write your **name** and **student ID** on the first page.
- Write the name of your **homework assistant** 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 **1 hour and 50 minutes** to complete the exam.
- Note: $\mathscr{L}(t^n\, e^{-\alpha t}) = \frac{n!}{(s+\alpha)^{n+1}}$.

Question 1

The following results were obtained when a pressure transducer was tested in a laboratory under the following conditions:
(I) Ambient temperature 25 °C, supply voltage 10 V (standard conditions)
(II) Ambient temperature 25 °C, supply voltage 14 V
(III) Ambient temperature 28 °C, supply voltage 10 V

Input (barg) Output (mA)	0	2	4	6	8	10
(I)	6	9.2	12.4	15.6	18.8	22
(II)	6	10.8	15.6	20.4	25.2	30
(III)	7	10.2	13.4	16.6	19.8	23

a) Explain whether the environment variables are modifying, interfering, or both modifying and interfering.

b) Determine the values of K_M, K_I, a, and K associated with the generalized model equation $O = (K + K_M \cdot I_M) \cdot I + a + K_I \cdot I_I$. Note down the units of the parameters!

Question 2

A temperature measurement system consists of a thermocouple, an amplifier, and a recorder. The thermocouple can be represented by a 1[st] order system with a time constant τ=10 s and a steady-state sensitivity of 10^{-4} V/°C. The amplifier has a multiplication factor of 10^3. The recorder can be described by a 2[nd] order element with a natural undamped frequency ω_n=200 rad/s, a damping ratio of ξ=1.0, and a steady-state sensitivity of 10 °C/V.

a) The true temperature changes suddenly by 10 °C from a steady-state condition. Find an expression of the change of the temperature given by the recorder.

b) Estimate the bandwidth of the measurement system.

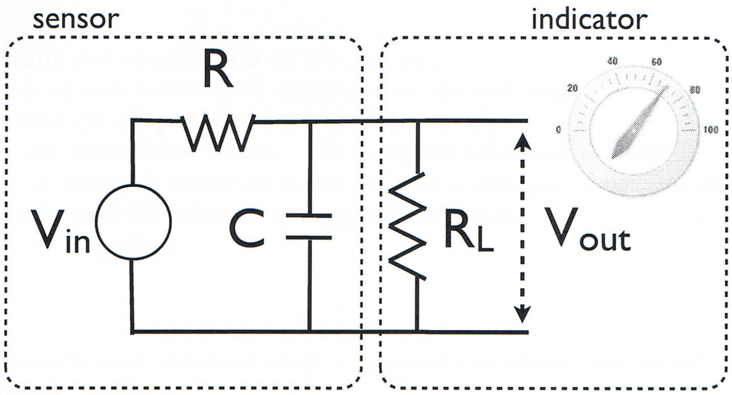

Figure 1: A temperature sensor with indicator.

Question 3

Consider the schematic diagram for a temperature sensor as given in Fig. 1. Here, the impedances R=100 kΩ, C=10 μF, and R_L=10 MΩ. The input voltage depends on the temperature, T, by $V_{in}=\alpha T$ with α=1 mV/°C and T in units of °C. The indicator shows a temperature $T_{out}=V_{out}/\alpha$.

a) What is the steady-state output of the indicator in the case the temperature T=20 °C.

b) Find the Thévenin equivalent network for the sensor and specify E_{th} and Z_{th}.

c) At t=0, the temperature, T, increases linearly with a speed of 10 °C/s starting from a temperature of 20 °C. Find an expression for the indicator temperature, T_{out}, as a function of time, t, and make a sketch of its time dependence.

d) The variations of the temperature in time can be approximated by a superposition of a sine function with a period of 2 hours and an amplitude of 10 °C with a sine function with a period of 0.5 s and an amplitude of 1 °C. The average temperature is 20 °C. Give an expression of $T_{out}(t)$.

2