Extra re-exam - PoMS, 15/05/2014

- Write your **name** and **student ID** 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.
- You are allowed to bring **one A4 page** with your own notes (one side only)
- Pay attention to **units**. A numerical result without a unit will be considered wrong!
- You have **3 hours** to complete the exam.
- Note: $\mathscr{L}(t^n\, e^{-\alpha t}) = \frac{n!}{(s+\alpha)^{n+1}}$.

Question 1 (2 points)

a) What is the Nyquist sampling theorem and explain its underlying principle.

b) What is reluctance and explain qualitatively the working principle of a variable reluctance tachogenerator.

c) What is the working principle behind Amplitude Modulation (AM) and explain how such a technique can help to reduce external interferences?

d) What is a Schmitt trigger and what is its application? Describe briefly its working principle.

Question 2 (2 points)

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 3 (2 points)

A potentiometer has a total length of 10 cm and a resistance of 200 Ω.

a) Calculate the supply voltage so that the power dissipation is 1 W.

b) Draw the Thévenin equivalent circuit for an 8 cm displacement.

c) The potentiometer is connected to a recorder with a resistance R_L. Find R_L such that the recorder voltage is 7% less than the open circuit voltage at an 8 cm displacement.

Question 4 (2 points)

A temperature measurement system consists of a thermocouple, an amplifier, and a recorder. The thermocouple can be represented by a 1st 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 2nd 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. Motivate your answer.

Question 5 (2 points)

A Copper (Cu)-Constantan (C) thermo-couple is used to measure the temperature T of a process. The temperature is obtained by coupling the thermo-couple to a voltmeter that consists internally of copper wires.

a) Design and sketch a measurement system for which the voltage measured by a voltmeter (V) is proportional to the temperature difference $T - T_{REF}$. The reference temperature T_{REF} is placed at 0°C by using an icebath as part of the setup. You may assume that the Seebeck coefficient α_{CuC} is constant for the temperature range considered in the system.

b) The dynamic response of the system is given by

$$\frac{\Delta\tilde{V}}{\Delta\tilde{T}}(s) = \frac{\alpha_{\mathrm{CuC}}}{1+\tau s},$$

with the Seebeck coefficient α_{CuC}=60 μV/°C and the time constant τ=1 s. At t=0, the temperature, T, increases linearly with a speed of 10 °C/s starting from a steady-state condition with a temperature of 100 °C. The voltage read by the voltmeter is connected to an indicator giving a temperature $T_{out}=V/\alpha_{\mathrm{CuC}}$. Find an expression for the indicator temperature, T_{out}, as a function of time, t, and make a sketch of its time dependence.