Tfy-3.4411 Experimental methods in physics **Examination 17.12.2009**

Answer all the five questions.

1. Describe briefly (1 – 5 lines) the following concepts:

   (a) Active and passive sensor.
   (b) Sensor sensitivity.
   (c) Capacitive sensor.
   (d) Active and passive filter.
   (e) Systematic and statistical error.
   (f) Transfer function.

2. Design an operational amplifier based circuit that gives as output the opposite number of the weighted average of five (5) inputs. Show (by calculating the response) that the circuit works as designed.

3. **Essay**: The main aspects of the operation of a lock-in amplifier. Why does it improve the signal-to-noise ratio? How can it be used in a typical physics experiment, where one measures the value of the measurand Y as function of an environmental variable X (Y = f(X))? Explain also how the different modulating and filtering frequencies should be chosen for the experiment.

4. Write a brief answer to the following:
   (a) Explain the main limitations to get the ultimate pressure in a pumping system.
   (b) Sticking coefficient. In which pumps is it important? Why?
   (c) What causes the pumping speed of a turbomolecular pump to fall at its low pressure extreme?

5. Your job is to design a setup that will cool an aluminum sample (area 1×1 cm^2 and thickness 0.3 cm) down to temperatures in the range 20 – 300 K. You have a closed-cycle He cryostat together with the compressor in the lab. Describe the main features of the setup. Justify your choices of vacuum components, sensors and materials. Illustrate your answer with figures (drawings).

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