FYS S300 Mittaustekniikka
Lectures: K. Arutyunov
Exam 11.01.2013

Problem 1 (4 points)
A liquid of density ρ flows through the two horizontal pipes of different cross sections A_1 and A_2 (Fig. 1). Two manometers measure the corresponding pressures P_1 and P_2. What is the flow (amount of liquid per unit time)? Neglect the liquid viscosity and compressibility.

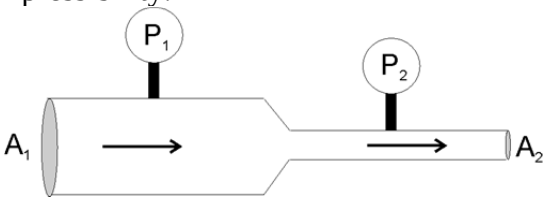

Fig. 1

Problem 2 (5 points)
A voltage $V_{in}(t)$ (Fig. 2.2, solid lines) is applied to the inputs of a device, schematically represented by Fig. 2.1.
2.1 (2 points) Devise circuit providing output $V_{out}(t)$ plotted in Fig. 2.3
2.2 (3 points) Devise circuit providing output $V_{out}(t)$ plotted in Fig. 2.4

Fig. 2.1

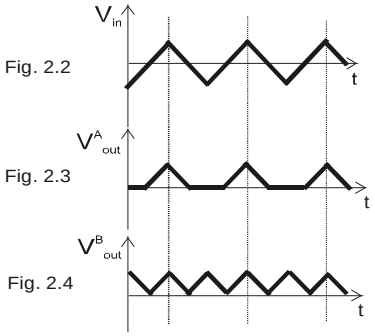

Fig. 2.2
Fig. 2.3
Fig. 2.4

Problem 3 (5 points)
Electromagnetic wave is penetrating from the medium I (top) with dielectric constant ε_1 at the angle $\alpha_1 = 30°$ into the medium II (bottom) with constant ε_2 and propagate at the angle $\alpha_2 = 60°$ (Fig. 3).
Consider the magnetic permeability μ is the same in both materials: $\mu_1=\mu_2=1$.
3.1 (4 points) What is the relation between ε_1 and ε_2 ?
3.2 (1 point) If medium I is vacuum, what is the speed of light in medium II?

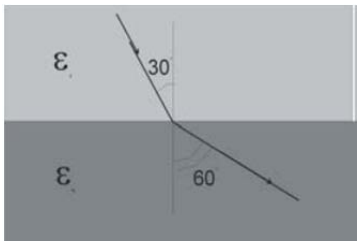

Fig. 3

Problem 4 (5 points)
4.1 (3 points) Explain principle of operation of a lock-in amplifier. Draw schematic diagram, input and output signals.
4.2 (2 points) Explain how a lock-in amplifier can be used to measure derivative of the current-voltage characteristic dV/dI of a non-linear element.

Problem 5 (6 points)
AC voltage $V_{in} = V_o \sin(\omega t)$ is provided to the input of the circuit (Fig. 4) .
5.1 (2 points) Draw the dependence of the normalized output voltage $|V_{out} / V_{in}|$ on the frequency of the input signal ω.
5.2 (1 point) At what frequency ω^* there is an extremum of the function $(|V_{out} / V_{in}|)(\omega)$? Is it MIN or MAX?
5.3 (3 points) At what frequency $|V_{out}| = |V_{in}| / \sqrt{2}$?

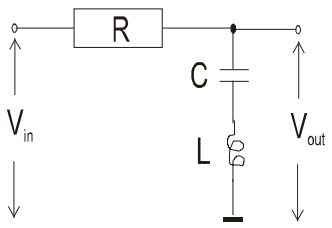

Fig. 4