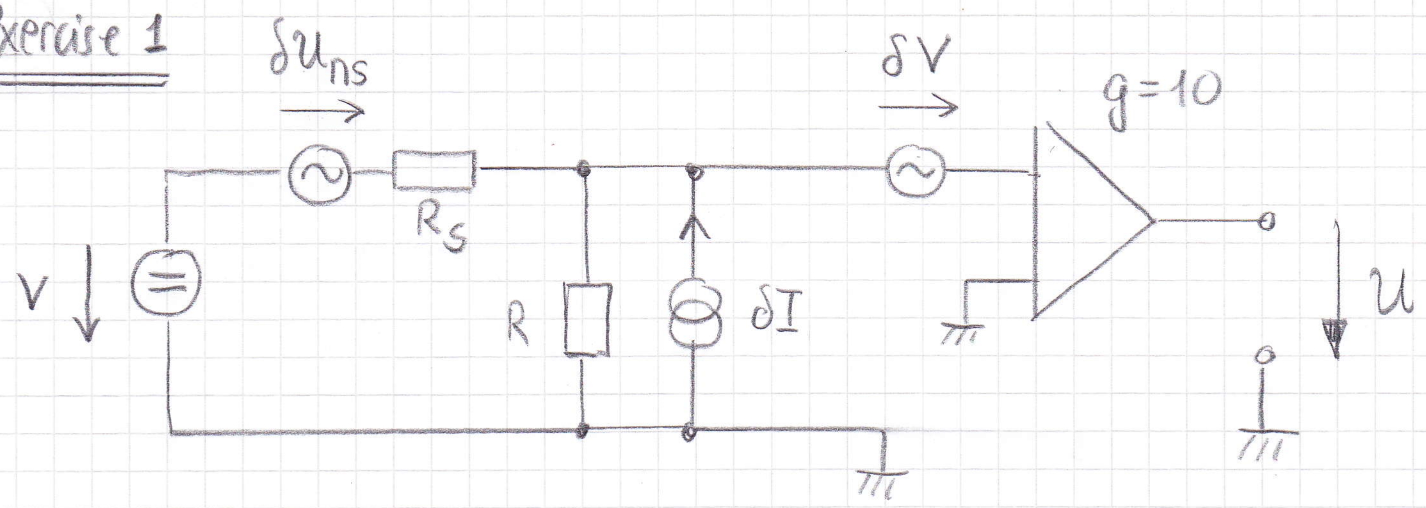
Exercises Noise

Exercise 1



$$\delta u_{ns} = \sqrt{S_{ns}}$$
$$\delta I = \sqrt{S_I}$$
$$\delta V = \sqrt{S_V}$$

where S_V, S_I and S_{ns} are spectral noise powers

(amplifier has infinite input impedance)

assume: R_s, R, g = gain = 10 and S_{ns}, S_I, S_V are given. Calculate S_u

Hint: We assume that noise signals are small and the circuit is linear. In this case the contribution of each noise source can be calculated independently and at the end one only has to add the three noise powers together.

For example: Contribution from δu_{ns} is:

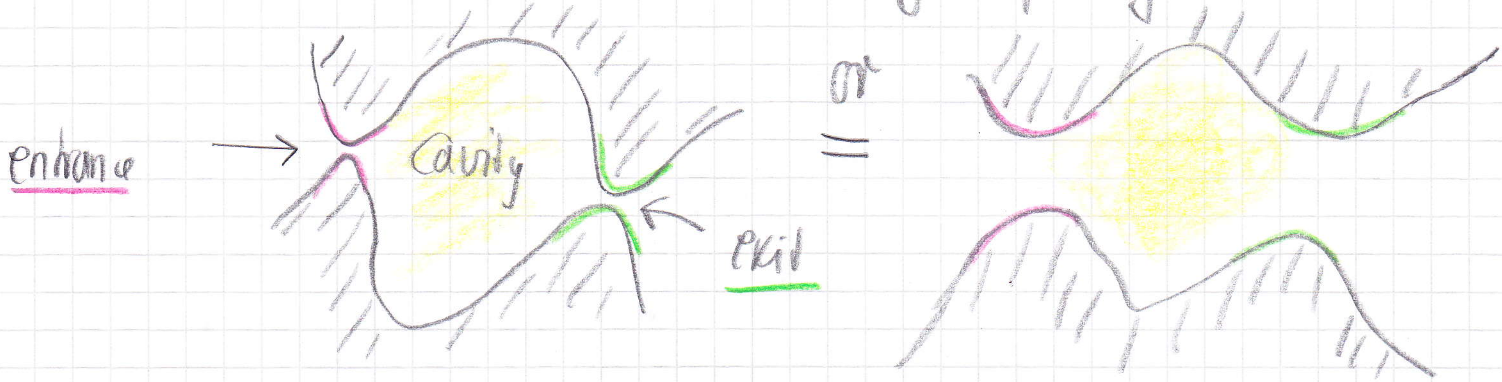
$$\frac{g^2 R^2}{(R + R_s)^2} S_{ns}$$

Exercise 2

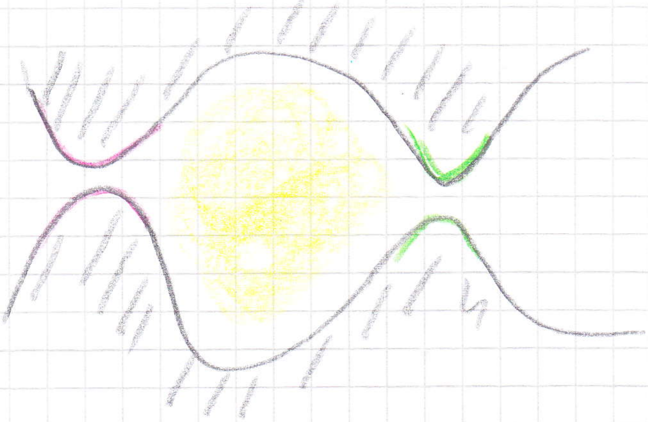
Read publication Physics Today May issue 2003, p 37

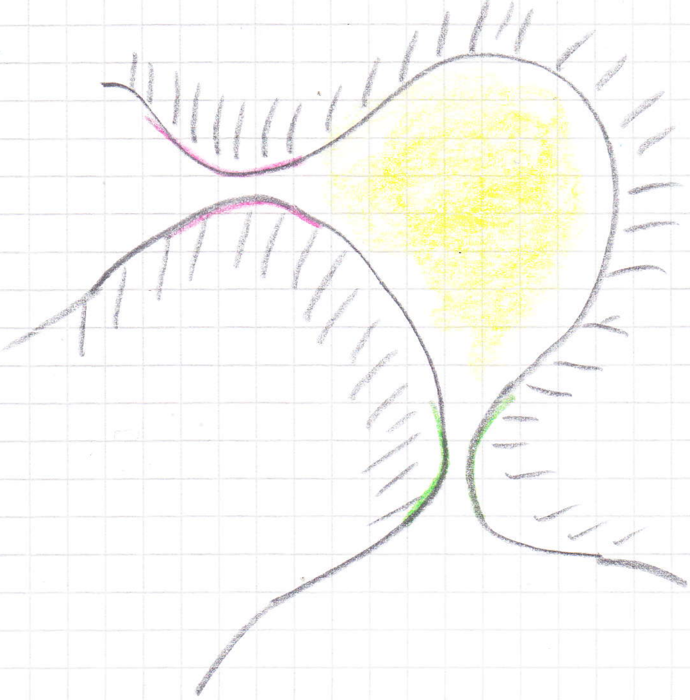
Question (after reading paper)

a) in order to obtain $F = 1/4$ for a chaotic cavity, is it better to have a large opening or a small?



b) which one is better of the following two?





Exercise 3

average current

$$I(t) = \bar{I} + \delta I(t)$$

time dependent current

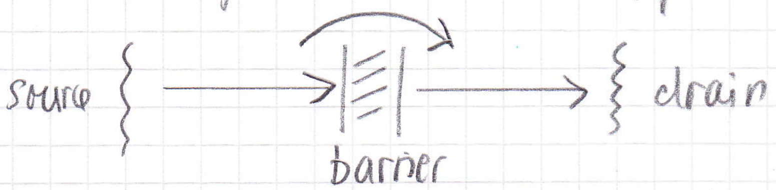
Under what condition is $S_I(\omega) = S_{\delta I}(\omega)$?

Hint:

Write down an expression between $C_{\delta I}$ and C_I and then consider the Fourier transform.

Exercise 4

assume 1 mode channel in Landau-Büttiker picture with transmission probabilit T (temp. = 0)



Assume there are n charges incident during time τ.

Distribution that k out of n particles are transmitted is binomial:

$$p_n(k) = \binom{n}{k} T^k (1-T)^{n-k} \quad ; \quad k = 0, 1 \cdots n$$

probability for k out of n

$$\langle k \rangle_n = \sum_{k=0}^{n} p_n(k) \cdot k = \sum_{k=0}^{n} \binom{n}{k} k T^k (1-T)^{n-k} = ?$$

average can be deduced by using equation

$$(a+b)^n = \sum_{k=0}^{\infty} \binom{n}{k} a^k b^{n-k} = 1 \quad (\text{we assume } a+b=1)$$

look at $\frac{\partial}{\partial a}(a+b)^n$ and then use $a := T$ and $b = 1-T$

a) to show that $\langle k \rangle_n = n \cdot T$

next, we look at the second moment

$$\langle \Delta k^2 \rangle_n = \langle k^2 \rangle_n - \langle k \rangle_n^2 = \langle k^2 \rangle_n - n^2 T^2$$

b) Determine now $\langle k^2 \rangle_n$ using the same trick as before by writing $\frac{\partial^2}{\partial a^2}(a+b)^n = \ldots$

One obtains $\langle k^2 \rangle_n = nT + n(n-1)T^2$

Then one obtains : $\langle \Delta k^2 \rangle_n = nT(1-T)$

Therefore $\langle \Delta k^2 \rangle_{\text{averaged}} = \bar{n}\, T(1-T)$

$$\underline{\underline{\langle \Delta I^2 \rangle = \frac{e}{\tau} \bar{I}\,(1-T)}}$$

<u>exercise 5</u>

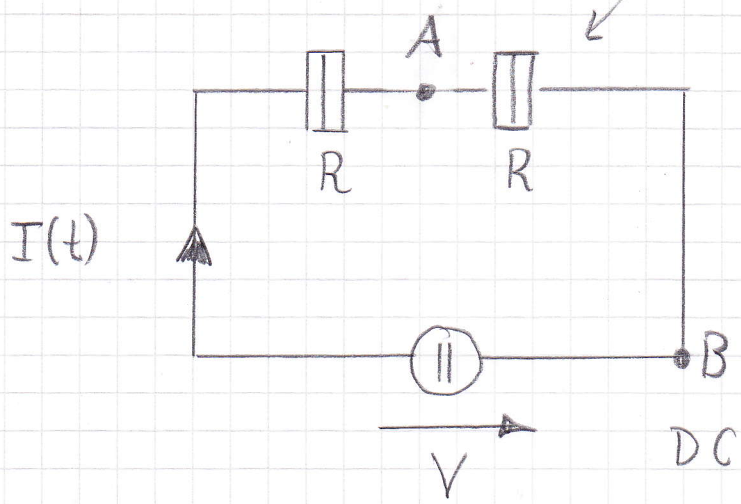
Use equation (6.39) Heikkilä to <u>derive the Fano factor</u> for a wire for which $L \gg \ell_{elastic}$, but $L \ll \ell_{inelastic}$ at zero temperature

In this case $\bar{f}(E, x) = (1-\frac{x}{L}) f_0(E-eU) + \frac{x}{L} f_0(E)$

with $f_0(E) = \begin{cases} 0, & \text{if } E \geq 0 \\ 1, & \text{if } E < 0 \end{cases}$ "Fermi-Dirac"

you should obtain $\underline{\underline{1/3}}$!

exercise 6



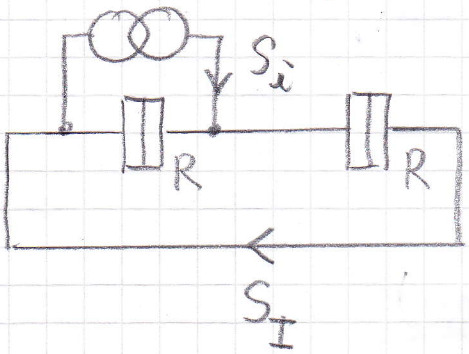
two tunnel junctions in series
each one with resistance R

DC voltage source

a) how large is S_I measured in the outer circuit
i.e. S_I is given by $\langle \delta I^2 \rangle$!

Hint: Each tunnel junction alone has $S_i = 2e\bar{I} = 2e\frac{V}{2R}$

to find out draw situation for one noise source only, i.e.:



the voltage source is set to "zero"

b) what is S_V measured between points A and B ?