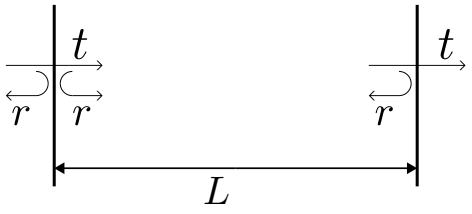
Problem Set 10 - LV 141.A55 QISS - 6.6.2014

1. **Transmon Qubit** For this problem use the Python function `CPB(EJ,Ec,ng,nmax)` created in problem set 8.

   (a) Show that sensitivity on gate charge vanishes exponentially as a function of increasing E_J/E_c. Thus calculate the resonance frequency ($\hbar\omega_{10} = E_1 - E_0$) at $n_g = 0$ and $n_g = 0.5$. Make sure that the product of E_J and E_c stays constant.

   (b) For the same E_J and E_c values, calculate the anharmonicity $\alpha = \frac{\omega_{21}-\omega_{10}}{\omega}$

2. **Resonance**



As demonstrated in class, one gets a resonance with two scatterers

$$\begin{aligned} S &= te^{ikL}t \\ &\quad + te^{ikL}re^{ikL}re^{ikL}t \\ &\quad + ... \\ &= \frac{t^2e^{ikL}}{1 - r^2e^{i2kL}} \end{aligned}$$

Typically the transmission coefficient is very small, $t \ll 1$. Furthermore the total probability has to be preserved $r^2 + t^2 = 1$. Note that $k = \omega/c$, where c is the propagation speed of the wave.

(a) Identify the resonances. Show that the expression in the vicinity of the resonance has the form

$$S_L = \frac{i\gamma}{\omega - \omega_0 + i\gamma}$$

What is γ?

(b) What is the transmission on resonance, width of the resonance (FWHM-full width half max) $\delta\omega$ and the quality factor $Q = \omega_0/\delta\omega$.