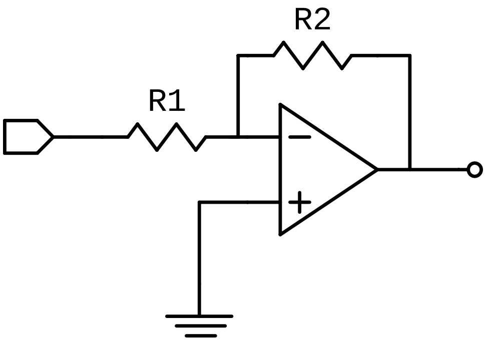
E2.2 Analogue electronics
Problem sheet 3 (Week 5)

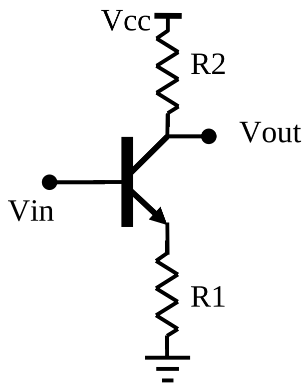
Q1: **(Tutorial question for Week 6/7)**

a) What is the difference between an ideal op-amp, an ideal voltage amplifier and a commercial op-amp?
b) Write an expression for the input impedance of the inverting amplifier below if R1=1k, R2=100k, the op-amp has a DC gain $G=10^4$ and its dominant pole is at f=1.59Hz. Evaluate the input impedance of this circuit at f=15.9 kHz. The op-amp has zero input conductance and output resistance.

The open loop gain of a "dominant pole amplifier" is given by $G(f)=\frac{G_{DC}}{1+s\tau}=\frac{G_{DC}}{1+s/\omega_0}$, with G_{DC} the DC gain and $\omega_0 = 1/\tau$ the pole (also called the "break") frequency.

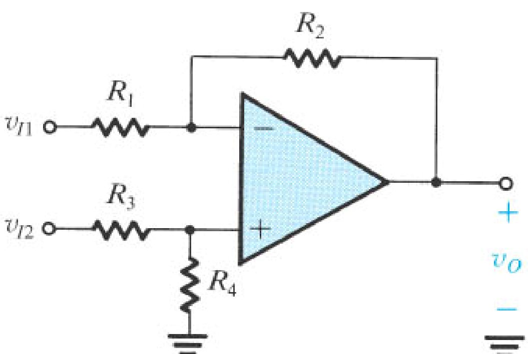
c) Calculate the DC voltage gain of the emitter degenerated common emitter amplifier below if R1=50 Ohms, R2=200 ohms and I_C=1mA. (leave this item for week 6)



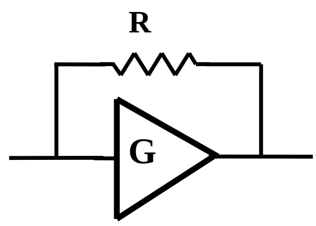


Q2. Use superposition to show that the following circuit, built with an ideal op-amp, has an output equal to: $v_o = v_{i2}\left(\frac{1+R_2/R_1}{1+R_3/R_4}\right) - v_{i1}\frac{R_2}{R_1}$

Chose relative resistor values so that $v_{out} = A(v_{i1} - v_{i2})$. what is the value of the constant A?



Q3: Apply the Miller Theorem to how that the input impedance of the following circuit is: $Z_{in} = \frac{R}{1-G}$. Derive an expression for the input impedance of this circuit if G is a dominant pole inverting amplifier, the open loop gain of the amplifier is given by $G(f) = \frac{G_{DC}}{1+s\tau} = \frac{G_{DC}}{1+s/\omega_0}$.
What are the break frequencies of the impedance as a function of frequency? What is the input impedance at low frequencies and at very high frequencies?
The open loop gain of a "dominant pole amplifier" is given by $G(f) = \frac{G_{DC}}{1+s\tau} = \frac{G_{DC}}{1+s/\omega_0}$, with G_{DC} the DC gain and $\omega_0 = 1/\tau$ the pole (also called the "break") frequency.



Q4: Show that the transfer function of the ideal differentiator below constructed with a dominant pole amplifier is:

$$H(s) = \frac{v_{out}}{v_{in}} = \cdots = \frac{-sRCG_{DC}}{s^2\tau RC + s(\tau + RC) + (G_{DC}+1)}$$

Calculate the maximum gain of this filter which occurs, roughly, when denominator is purely imaginary.