E2.2 Analogue electronics
Problem sheet 2 (Week 4)

Q1: Determine the following small signal model parameters of an NPN bipolar transistor biased connected as a Common Emitter amplifier and biased with a DC collector current of 1mA and 10mA. The transistor DC current gain is $\beta = 200$ and the Early voltage is $V_A = 100V$:

- Transconductance g_m
- Hybrid Pi input resistance R_π
- Collector output resistance R_{CE}

Q2: Repeat question 1 if the transistor is PNP but all its other specifications are the same with those of the NPN transistor in question 1.

Q3: Draw the small signal equivalent circuit for an NPN bipolar transistor, including capacitances. Label all components. Assume the transistor is properly biased, and is connected as a current amplifier: The emitter is grounded, the base is driven by a current source and the collector is connected to the power supply through a current meter.

Calculate the small signal current gain of this amplifier as a function of frequency. Express this gain as a function of the equivalent circuit elements. Calculate the current gain at low and at high frequencies. At what frequency does the current gain start being frequency dependent?

Q4: Determine the C_{BE} and C_{BC} of an NPN bipolar transistor which has an $f_T = 1$ GHz at a bias current $I_C = 1mA$ if $C_{BE} = 9C_{BC}$.

Q5: Draw a diagram of an NPN bipolar transistor connected as a common Emitter voltage amplifier. The base is driven by an ideal voltage source which includes a DC bias V_0 so that the DC collector current is 1mA, and a small AC component *v* so that $V_{BE} = V_0 + v$.

- Choose a load resistance R_C so that the DC gain is 200
- Choose a DC Collector supply so that the collector has a symmetric maximum swing. The Saturation voltage is 0.2V

Q6: Use the Miller Theorem to calculate symbolically the input impedance of an inverting amplifier built with an op-amp whose open loop gain is G=10.

Q7: Draw a small signal model of the circuit in Question 5. Use the Miller Theorem to simplify the circuit. Assume that for this circuit the results of Question 4 are valid. Calculate the frequency response of the voltage gain of this amplifier in the following 2 cases:

- The signal source has a Thevenin impedance $R_T = 0$
- The signal source has a Thevenin impedance $R_T = 1\,\text{k}\Omega$