E2.2 Analogue electronics
Problem sheet 5 (Week 8)

An NPN bipolar transistor is given with $C_{BE} = 5pF, C_{BC} = 1pF,\ C_{CE} = 0.1pF,\ V_A = 100V, \beta = 200$. For the purposes of this problem sheet the transistor is biased at $I_C = 1mA$

QUESTION 1: Use the second form of the Miller Theorem to derive an expression for the input impedance of a common collector amplifier which drives an inductive load L_E. Derive an expression for the frequency at which the input impedance of this amplifier becomes real, and a value for the input impedance at that frequency. Neglect the effect of C_{BC}.

The calculation will be greatly simplified if you use the following substitutions:

$$R = R_\pi, C = C_{BE}, L = (\beta + 1) L_E, \tau = RC, \tau_1 = \frac{L}{R}$$

QUESTION 2: Calculate the value of the load resistance R_L which results in the maximum voltage gain of a Common Emitter amplifier employing Miller Cancellation as a function of the frequency at which Miller cancellation is implemented. You may assume that the source impedance satisfies $R_s << R_\pi$. Sohow that in the limit of very high Miller cancellation frequency the maximum obtainable gain varies as ω^{-2}.

QUESTION 3: A negative feedback amplifier is built with a dominant pole forward amplifier and feedback gain constant with frequency. Prove that the closed loop amplifier is also a dominant pole amplifier whose gain-bandwidth product is constant and equal to the gain-bandwidth product of the forward amplifier.

QUESTION 4: (Tutorial Question Week 8-9)

Show that the admittance matrix of the "Pi" network shown on the left below is:

$$\begin{bmatrix} Y_1 + Y_C & -Y_C \\ -Y_C & Y_2 + Y_C \end{bmatrix}$$

Connect an admittance Y_C between the input and output of a network with the admittance matrix: $\mathbf{Y}_0 = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}$. Use KCL to show that the resulting circuit (shown in the figure below) has an admittance matrix equal to: $\mathbf{Y}' = \begin{bmatrix} y_{11} + Y_C & y_{12} - Y_C \\ y_{21} - Y_C & y_{22} + Y_C \end{bmatrix}$

The admittance matrix of a 2-port is defined as: $Y_{ij} = \left. \frac{\partial i_i}{\partial v_j} \right|_{\delta v_{k \neq j} = 0}$ i.e. the current in port "i" is measured by an ideal ammeter as a voltage differential is applied on port "j".