1. The figure below shows the high-frequency equivalent circuit of a CS amplifier with a resistance \(R_s\), connected to S. The purpose of this problem is to show that the value of \(R_s\), can be used to control the gain and bandwidth of the amplifier, specifically to allow the designer to trade gain for increased bandwidth.

![Amplifier Circuit Diagram]

a) Derive an expression for the low-frequency voltage gain (i.e. set \(C_{gs}\) and \(C_{gd}\) to zero).

b) To be able to determine \(\omega_H\) using the open-circuit time-constants method, derive expressions for \(R_{gs}\) and \(R_{gd}\) (equivalent resistance seen by \(C_{gs}\) and \(C_{gd}\), respectively).

c) Let \(R_{sig} = 100k\Omega\), \(g_m = 4mA/V\), \(R'_L = 5k\Omega\), and \(C_{gs} = C_{gd} = 1pF\). Use the expressions found in a) and b) to determine the low-frequency gain and the 3-dB frequency \(f_H\) for three cases: \(R_s = 0\Omega, 100\Omega,\) and \(250\Omega\). In each case, also evaluate the gain-bandwidth product.

2. Determine -3dB bandwidth of the circuits shown below. Assume MOS transistors in saturation and BJTs in forward active region with \(r_{ds} = \infty\), \(r_o = \infty\). Ignore intrinsic capacitances.
3. Approximate transfer function for the circuits below. Assume MOS transistors operate in saturation with $r_{ds} = \infty$, and BJTs in forward active region with $r_o = \infty$. 