5 a) \[ T(S) = \frac{100S}{(1+S/10^6)(S+10^4)} \]
\[ = 100 \times 10^4 S / \{(1 + S/10^6)(1 + S/10^4)\} \] (by dividing numerator and denominator by \(10^4\))
Now, comparing this with the standard gain transfer function we get,
\[ A_M = 10^2 \text{ or } 40 \text{ dB} \]
\[ \omega_L = 10^4 \text{ rad/s} \text{ and } \omega_H = 10^6 \text{ rad/s} \]
\[ \Rightarrow T_L = 2\pi/\omega_L = 6.28 \times 10^{-4} \text{ s} \]
and \( T_H = 2\pi/\omega_H = 6.28 \times 10^{-6} \text{ s} \)
From the KVL equation for the BE loop we get,
\[ I_E = \frac{V_{BB} - V_{BE}}{R_E + R_B(1+\beta)} \]
Where,
\[ V_{BB} = V_{CC} \times \frac{R_2}{R_1+R_2} \]
\[ = 9 \times 15/(27+15) = 3.21V \]
and
\[ R_B = R_1 || R_2 = 15 || 27 = 9.64 \Omega \]
Thus, \[ I_E = (3.21 - 0.7) / (1.2 + 9.64/101) = 1.94 mA \]

\[ g_m = I_C/V_T = 0.99 \times 1.94/0.025 = 76.8 \text{ mA/V} \]
\[ r_{\pi} = \beta/g_m = 100 / 76.8 = 1.3 \text{ k\Omega} \]
\[ r_o = V_A/I_C = 100/(0.99 \times 1.94) = 52.1 \text{ k\Omega} \]
\[ R_i = R_B || r_{\pi} = 9.64 || 1.3 = 1.15 \text{ k\Omega} \]
\[ r_{\pi} = g_m = -76.8 \text{ mA/V} \]
\[ R_o = R_C || r_o = 2.2 || 52.1 = 2.11 \text{ k\Omega} \]

\[ A_v = \frac{V_o}{V_i} = \frac{V_o}{V_i} \times \frac{V_i}{V_i} = \frac{R_i}{(R_i+R_i)} \times G_m(R_o || R_L) \]
\[ = -1.15/(10 + 1.15) \times 76.8 \times (2.11 || 2) = -8.13 \]
\[ A_i = \frac{i_o}{i_i} = \frac{(V_o/R_L)/(V_i/(R_i+R_i))}{-8.13 \times (10 + 1.15)/2} \]
\[ = -45.3 \]
From equation 6.60 of the book we have: \( \omega_z = g_m/C_{gd} \)
\( \Rightarrow f_z = \frac{g_m}{(2\Pi C_{gd})} = 5 \text{ m} / (2\Pi \times 0.1 \text{ p}) = 7.96 \text{ GHz} \)

\( f_{p1} \) and \( f_{p2} \) are the poles of the transfer function of equation 6.60, whose denominator is a quadratic polynomial with coefficient of \( S^2 \):
\[
= [C_{gs} + C_{gd}(1+g_mR_L')] R_{sig} + (C_L + C_{gd}) R_L' \\
= [2 +0.1(1 + 5\times20)]20 + (1+0.1)\times20 \\
= 264 \text{ ns}
\]
Coefficient of \( S^2 \):
\[
= [(C_L+C_{gd})C_{gs} + C_L C_{gd}] R_{sig} R_L' \\
= [(1+0.1)2 + 1\times0.1] \times 20k \times 20k \\
= 920 \times 10^{-18} \text{ S}^2
\]

Therefore the quadratic equation is
\[
1+ 264\times10^{-9} S + 920\times10^{-18} S^2 = 0
\]

Denoting the frequencies of this equation with \( \omega_{p1} \) and \( \omega_{p2} \) we have,
\[
\omega_{p1} = 3.84\times10^6 \text{ rad/s} \Rightarrow f_{p1} = 611.15 \text{ kHz}
\]
\[
\omega_{p2} = 283.12\times10^6 \text{ rad/s} \Rightarrow f_{p2} = 45.06 \text{ kHz}
\]

Since \( f_{p1} < f_{p2} \) and \( f_{p1} < f_1 \), a good estimate for \( f_1 \) is \( f_{p1} \)
\( \Rightarrow f_1 \approx f_{p1} = 611.15 \text{ kHz} \)

Using equation 6.70:
\[
A_M = -r_{\Pi} (g_m R_L')/(R_{sig} + r_x + r_{\Pi})
\]
\[
r_{\Pi} = \beta/g_m = 100/20 = 5 \text{ k\Omega}
\]
\[
\Rightarrow A_M = -5(20\times5)/(1+0.2+5) = 80.65
\]

Using Miller’s theorem and equation 6.71,:
\[
C_{in} = C_{\Pi} + C\mu (1 + g_mR_L') = 10+0.5(1+0.2+5) = 60.5 \text{ pF}
\]

Equation 6.69:
\[
R_{sig'} = r_{\Pi} \parallel (R_{sig} + r_x) = 5k \parallel (1k + 0.2) = 0.97 \text{ k\Omega}
\]

Equation 6.72:
\[
f_1 = 1/(2\Pi C_{in} R_{sig'}) = 1/(2\times60.5p\times0.97k) = 2.7 \text{ MHz}
\]

\[4.54\]
\[i_{D1} = i_{D2} \]
\( \Rightarrow \frac{1}{2} K_n' (W/L)_1 (V_{GS1} - V_t)^2 = \frac{1}{2} K_n' (W/L)_2 (V_{GS2} - V_t)^2 \)

Note that \( V_{GS1} = V_1 \) and \( V_{GS2} = V_{DD} - V_o \)
\( \Rightarrow (W/L)_1 (V_1 - V_t)^2 = (W/L)_2 (V_{DD} - V_o - V_t)^2 \)
\[
[(W/L)_1 (W/L)_2]^{1/2} (V_1 - V_t) = (V_{DD} - V_o - V_t)
\]
or, \( V_{DD} = V_o - V_t + [(W/L)_1 (W/L)_2]^{1/2} (V_1 - V_t) \)

If \( (W/L)_1 = 50/0.5 \) = 100 and \( (W/L)_2 = 5/0.5 = 10 \)

Then,
\[A_V = dV_o/dV_t = -(100/10)^{1/2} = -3.16\]
4.77 Refer to fig. P4.77:

a) 
\[ V_{CI} = 15 \times 5 / (10 + 5) = 5 \text{V} \]
\[ V_S = 3 \times I_D \Rightarrow V_{GS} = 5 - 3 I_D \]
\[ I_D = \frac{1}{2} \times k' W/L \left( V_{GS} - V_T \right)^2 \]
\[ \Rightarrow I_D = \frac{1}{2} \times 2 \times (5 - 3 I_D - 1)^2 \]
\[ \Rightarrow 16 - 251 - 9 I_D^2 = 0 \Rightarrow I_D = 1 \text{mA} \]
\[ \Rightarrow V_{GS} = 2 \text{V} \text{ and } V_D = 15 - 7.5 = 7.5 \text{V} \]

b) 
\[ g_m = 2I_D/V_{OV} = 2 \times 1/(2-1) = 2 \text{mA/V} \]
and \( r_o = V_A / I_D = 100 \text{k\Omega} \)

c) 
\[ R_m = 5 \text{M} \parallel 10 \text{M} = 3.33 \text{ M\Omega} \]
\[ V_A = 182 \text{V} \]

\[ R_{Sig} = 100 \text{k}\Omega \]

\[ V_{gs} / V_{sig} = R_m / (R_m + R_{sig}) = 3.33 / (0.1 + 3.33) = 0.97 \]

\[ V_o / V_{gs} = 2 \times r_o / (R_D R_L) = 2 \times 4.1k = 8.2 \]

\[ V_o / V_{sig} = 8.2 \times 0.97 = 7.95 \]