a) $V_g = 15 \times 5/(10+5) = 5$ V.

Assume $V_{gs} = 2$ V. $V_i = 5 - 2 = 3 = 3I_D$. $I_D = 1$ mA.

Also $I_D = 0.5 \times (2-2)^2 = 1$ mA, consistent with the previous result.

$V_d = 15 - 7.5I_D = 7.5$ V.

(or you can solve $V_{gs}$, $I_D$ and so on and compare with the values given)

b) $\frac{1}{r_m} = 2 \times \frac{1}{I_D} = 2 \times \frac{1}{1} = 2$ mA/V. $r_m = V_A/I_D = 100$ KΩ.

c) $R_{in} = 5M/10M = 3.33$ MΩ.

$\frac{V_o}{V_{gs}} = -g_m \times \frac{r_m}{R_D/R_L} = -2 \times \frac{1}{4.1} = -8.2$ V/V.

$V_{gs}/V_{sig} = R_m/(R_m + R_{sig}) = 3.33M/(3.33M + 0.1M) = 0.97$.

$\frac{V_o}{V_{sig}} = -8.2 \times 0.97 = -7.95$ V/V.
From the section on common gate amplifiers,

\[ R_{\text{in}} = \frac{1}{g_m} = \frac{200 \Omega}{1} \]

\[ G_v = g_m \frac{(R_D//R_L)/(1+ g_m R_{\text{sig}})}{5*(5K//2K)/(1+5*0.2)} = \frac{3.57 \text{ V/V}}{} \]

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As \( I_D \) is made 4 times,

\[ g_m = 2* I_D/ (V_{gs} - V_t) \]

But \( I_D \) is proportional to \((V_{gs} - V_t)^2\)

Or \((V_{gs} - V_t)\) is proportional to \(\sqrt{I_D}\)

So \( g_m \) is proportional to \( I_D/\sqrt{I_D} \). i.e \( \sqrt{I_D} \)

\[ g_{m2}/g_{m1} = \sqrt{I_{D2}/I_{D1}} = \sqrt{4I_{D}/I_{D}} = 2 \]

so \( g_{m2} = 2* g_{m1} = 10 \text{mA/V} \)

\[ R_{\text{in}} = 100 \Omega \quad G_v = 4.76 \text{ V/V} \]

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From the section on source followers, \( A_{vo} = r_o/ (r_o + 1/g_m) = 20/(20+1/5) = \frac{0.99 \text{ V/V}}{} \)

\[ R_{\text{out}} = 1/g_m // r_o = (1/5) \text{K} // 20 \text{ K} = \frac{200 \Omega \text{ (approx.)}}{} \]

With \( R_L = 1 \text{ K} \Omega \), \( A_v = (R_L//r_o) / [(R_L//r_o) + 1/g_m] = (1K//20K)/[ (1K//20K)+1/5] = \frac{0.83 \text{V/V}}{} \]

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Noting that \( R_{\text{in}}=R_G \),

a) \[ A_M = - R_G/(R_G+R_{\text{sig}})g_{m1}(r_o//R_D//R_L) = -15.24 \text{ V/V} \]

b) \[ C_{in} = C_{gs} + C_{gd} [1 + g_m*(r_o//R_D//R_L)] = 12.02 \text{ pF} \]

\[ R'_{\text{sig}} = R_{\text{sig}}//R_g = 400k\Omega \]

\[ f_H = 1/(2\pi*C_{in}*R'_{\text{sig}}) = \frac{33.1 \text{ KHz}}{} \]