1.91

$$g_m = \frac{2I_D}{V_{OV}} = \frac{2\times 0.1}{0.25} = 0.8\,mA/V$$

$$f_T = \frac{g_m}{2\pi(C_{gs}+C_{gd})} = \frac{0.8\times 10^{-3}}{2\pi(20+5)\times 10^{-15}} = 5.1\,GHz$$

4.95

$R_{sig} = 100K\Omega$, $R_{in} = 100K\Omega$, $C_{gs} = 1pF$, $C_{gd} = 0.2pF$

$$A_M = -\frac{R_G}{R_G + R_{sig}}\, g_m (r_o \| R_D \| R_L) \quad \text{(Eq. 4.119)}$$

Also $R_{in} = 100K\Omega = R_G$

$$A_M = \frac{-100}{100+100}\, 3(50^K \| 8K \| 10^k) = \underline{-6.1\,V/V}$$

$$f_H = \frac{1}{2\pi C_{in} R'_{sig}} \quad \text{(Eq. 4.132)}$$

$$R'_{sig} = R_{sig} \| R_G = 100 \| 100 = 50K\Omega$$

$$C_{in} = C_{gs} + C_{gd}(1 + g_m R'_L)$$

$$R'_L = r_o \| R_D \| R_L = 4.1K\Omega$$

$$C_{in} = 1 + 0.2(1 + 3\times 4.1) = 3.66pF$$

Now we can calculate f_H:

$$f_H = \frac{1}{2\pi \times 3.66\times 10^{-12} \times 50\times 10^3} = \underline{870^{KHz}}$$

In order to double f_H, we have to either decrease C_{in} (by reducing R_{out}) or reduce R'_{sig} by reducing R_{in}.

If we reduce $R_{out} = R_D \| r_o$:

$$\frac{f_{H2}}{f_{H1}} = \frac{C_{in1}}{C_{in2}} \Rightarrow 2 = \frac{3.66\,pF}{1 + 0.2(1 + 3\times R'_L)}$$

$\Rightarrow R'_L = 1.27K\Omega \qquad R'_L = R_{out} \| R_L = R_{out} \| 10^k$

$\Rightarrow \underline{R_{out} = 1.45K\Omega}$

Therefore in order to double f_H to $870 \times 2 = 1.74^{MHz}$, we have to reduce $R_{out} = r_o \| R_D$ to $1.45^{K\Omega}$ or equivalently reducing R_D to $1.5^{K\Omega}$. The new midband gain would be:

$$\frac{A_{M2}}{A_{M1}} = \frac{R'_{L2}}{R'_{L1}} \Rightarrow A_{M2} = -6.1 \times \frac{1.27}{4.1} = \underline{-1.9 V/V}$$

Gain is almost reduced by a factor of $\underline{3}$.

If we reduce $R_{in} = R_G$:

$$\frac{f_{H2}}{f_{H1}} = \frac{R'_{sig1}}{R'_{sig2}} \Rightarrow 2 = \frac{50^K}{R'_{sig2}} \Rightarrow R'_{sig_2} = 25^{K\Omega}$$

$$\Rightarrow 25 K\Omega = 100K \| R_G \Rightarrow \underline{R_G = 33^{K\Omega} = R_{in}}$$

Therefore in order to double f_H, R_{in} is reduced by a factor of 3, from $100 k\Omega$ to $33 K\Omega$.

The new midband gain would be:

$$\frac{A_{M2}}{A_{M1}} = \frac{R_{G2}}{R_{G1}} \cdot \frac{R_{G1} + R_{sig}}{R_{G2} + R_{sig}} \Rightarrow A_{M_2} = -6.1 \times \frac{1}{3} \times \frac{100+100}{33+100}$$

$$\underline{A_{M2} = -3.06 V/V}$$

Gain is almost reduced by a factor of $\underline{2}$.

4.100

$$f_{C_{C_2}} = \frac{1}{2\pi C_{C_2}(R_L + R_D \| r_o)} \leq 10^{Hz}$$

$$\Rightarrow C_{C_2} \geq \frac{1}{10 \times 2\pi \times (10^K + 15^K \| 150^K)} \Rightarrow C_{C_2} \geq 0.67 \mu F$$

$$\Rightarrow C_{C_2} = 0.7 \mu F \Rightarrow f_{C_{C_2}} = 9.62 Hz$$

If I_D is doubled with both r_o and R_D halved:

$$f_{C_{C_2}} = \frac{1}{2\pi \times 0.7^{\mu}(10^K + \frac{15^K}{2} \| \frac{150^K}{2})} = 13.5^{Hz}$$

For higher-power designs, where I_D is increased and consequently r_o and R_D are reduced.
For smallest r_o and R_D where $r_o \| R_D \ll R_L$, R_L becomes dominant in determining the corner frequency:

$$f_{c_{c2}max} = \frac{1}{2\pi C_{c2} (R_L)} = \underline{22.75\,Hz}$$