

#1, as $V_{out} \approx V_{in} = 0$ both transistors should be in saturation;
so assume & check.

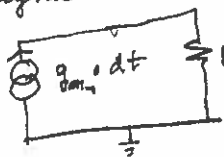
$$\begin{aligned}
 I_{D_n} &= -I_{D_p} \Rightarrow \frac{K_{P_n}}{2} \left(\frac{W}{L} \right)_n (V_{in} - (-5) - V_{T_n})^2 (1 + \lambda_n (V_{out} - (-5))) \\
 &= \frac{K_{P_p}}{2} \left(\frac{W}{L} \right)_p (5 - V_{in} - |V_{T_p}|)^2 (1 + \lambda_p (5 - V_{out})) \\
 \Rightarrow \frac{20.54 \times 10^{-6}}{2} \times \frac{144}{8} (5 - 1.3)^2 (1 + 15 \times 10^{-3} (V_{out} + 5)) &= 10.32 \times 10^{-6} \times \frac{328}{8} (5 - 1.5)^2 (1 + 15 \times 10^{-3} (5 - V_{out})) \\
 \Rightarrow \frac{(1.075 + 15 \times 10^{-3} V_{out})}{(1.075 - 15 \times 10^{-3} V_{out})} &= \frac{10.32}{20.56} \times \frac{328}{144} \left(\frac{3.5}{3.7} \right)^2 = 1.023059 \Rightarrow (1.075 [1.023059 - 1] \\
 &= 15 \times 10^{-3} [1 + 1.023059] V_{out} \\
 \Rightarrow V_{out} &= \frac{24.19 \times 10^{-3}}{30.354 \times 10^{-3}} = 0.817V \Rightarrow V_{G_n} - V_{T_n} = 5 - 1.3 = 3.7 < V_{D_n} = 5 + 0.817 = 5.817 \\
 &\Rightarrow M_n \text{ in saturation, } V_{G_p} - V_{T_p} = 3.5 < V_{D_p} = 4.183 \Rightarrow M_p \text{ sat.} \\
 \Rightarrow I_{D_n} &= \frac{20.54}{2} \times 10^{-6} \times \frac{144}{8} (5 - 1.3)^2 (1 + 15 \times 10^{-3} \times 5.817) = 2.53 \times 10^{-3} (1.0873) = 2.75 \mu A = I_{D_n} = -I_{D_p} \\
 V_{G_n} &= V_{in} - V_{G_S} = 5 = -V_{G_Sp}, V_{D_n} = -V_{G_S} + V_{out} = 5.817, V_{D_Sp} = -(V_{Dn} - V_{out}) = -4.183
 \end{aligned}$$

#2, KCL into mid: $0 = -g_{m1}(V_{out} - V_{in}) + G_1(V_{out} - V_{mid}) - C \alpha V_{mid} + G_2(V_{out} - V_{mid})$
 KCL into out: $0 = -g_{m2}(V_{mid} - 0) + G_2(V_{mid} - V_{out}) - C_2 \alpha V_{out} + G_1(V_{mid} - V_{out})$
 in matrix form $\begin{bmatrix} g_{m1} & V_{in} \\ 0 \end{bmatrix} = \begin{bmatrix} -g_{m1} + G_1 + G_2 & -G_1 - C \alpha - G_2 \\ -G_2 - C_2 \alpha - G_1 & -g_{m2} + G_2 + G_1 \end{bmatrix} \begin{bmatrix} V_{out} \\ V_{mid} \end{bmatrix}$
 The last row gives: $V_{mid} = -\frac{(C_2 \alpha + G_1 + G_2)}{[g_{m2} - (G_1 + G_2)]} V_{out}$
 Substitute in 1st row: $g_{m1} V_{in} = \left\{ (-g_{m1} + (G_1 + G_2)) - (G_1 \alpha + (G_1 + G_2) \times (-1)) \left[\frac{C_2 \alpha + (G_1 + G_2)}{g_{m2} - (G_1 + G_2)} \right] \right\} V_{out}$
 $\therefore \frac{V_{out}}{V_{in}} = \frac{g_{m1} [g_{m2} - (G_1 + G_2)]}{\frac{g_{m1} [g_{m2} - (G_1 + G_2)]}{C_2 \alpha^2 + [2C(4g_{m1})] \alpha + 0} = \frac{-3g_{m1}^2}{C \alpha (C \alpha + 8g_{m1})}$
 a) $\frac{V_{out}}{V_{in}} = \frac{g_{m1} [g_{m2} - (G_1 + G_2)]}{C_1 C_2 \alpha^2 + [(G_1 + C_2)(G_1 + G_2)] \alpha + (G_1 + G_2)(g_{m2} - g_{m1})}$
 b) $\frac{V_{out}}{V_{in}} = \frac{g_{m1} [g_{m2} - 4g_{m1}]}{C^2 \alpha^2 + [2C(4g_{m1})] \alpha + 0} = \frac{-3g_{m1}^2}{C \alpha (C \alpha + 8g_{m1})}$; Zeros: $2 @ \infty$
 poles: $0, -8g_{m1}/C$

#3. a) The top capacitor node is "floating". Put $R \approx 1G\Omega$ in parallel with C_1
 b) IT in G value is a parameter. Put $\pm$ around it

#4 $i_D = I_S (e^{v_D/V_T} - 1)$, $\partial i_D / \partial T = \frac{\partial I_S}{\partial T} \frac{\partial v_D}{\partial T} = I_S e^{v_D/V_T} \left(\frac{1}{V_T^2} \right) \frac{k}{q} = g_{m_T}$ when $V_D = E/2$

$\therefore$ small signal



$$\begin{aligned}
 \Rightarrow \frac{dV_0}{dT} &= R g_{m_T} = -\frac{R I_S}{|q| V_T^2} e^{E/2V_T} \\
 &= -\frac{R}{TV_T} (I_D + I_S) \quad V_T = 26mV \\
 &\approx -\frac{R}{7.8} I_D \quad \text{with } TV_T = 200/26m
 \end{aligned}$$