P1 as $V_{DS} = 5V > V_{GS} - V_T$, the transistor is in saturation region

$$I_X = I_D = \frac{\mu C_{ox} W}{2L} (V_{GS} - V_T)^2 (1 + \lambda V_{DS})$$

$$= 1 \times 10^{-4} \cdot 20 \cdot (1.5)^2 (1 + 0.01 \cdot 5)$$

$$= 4.725 mA$$

P2.

$$R_{FET} = \frac{1}{V_{GS} - V_T} \left(\frac{L}{\mu C_{ox} W} \right) = \frac{6}{3 \cdot 1 \times 10^{-4} \cdot 10} = 2 k\Omega$$

$$\therefore A_V = 1 + \frac{50k}{2k} = 26$$

P3. assume M_2 is in saturation.

$$\begin{cases} I_D = \frac{\mu C_{ox} W}{2L} (V_{GS} - V_T)^2 \\ I_D = \frac{5 - V_{out}}{R} \end{cases}$$

$$\therefore 1 \times 10^{-4} \cdot 5 \cdot 1^2 = \frac{5 - V_{out}}{5k} \Rightarrow \underline{V_{out} = 2.5V}$$

$V_{out} - 0 = V_{DS} > V_{GS} - 1$, conform assumption

P4 diameter of a 24ga Copper wire cross section $= 0.02\,in$
$= 254\,um$

$$\# \text{ of transistors} = \frac{\pi \cdot (\frac{d}{2})^2}{WL} \approx 10^8 \text{ gates}$$

P5 $V_{DS} < V_{GS} - V_T$ in triode region

$$I_D = \frac{u C_{ox} W}{L} (V_{GS} - V_T - \frac{V_{DS}}{2}) V_{DS}$$

$$= 10^{-4} (5 - 1 - \frac{2}{2}) \cdot 2 \cdot (\frac{W}{L})$$

$$= 6 \times 10^{-4} \frac{W}{L}$$

$$= 20\,mA$$

$\therefore \frac{W}{L} = \frac{100}{3}$ e.g. $W = 100u$, $L = 3u$

P6 $V_{DS} = V_{out} < V_{GS} - V_T$ in triode region

$$I_D = \frac{u C_{ox} W}{L} (V_{GS} - V_T - \frac{V_{DS}}{2}) V_{DS}$$

$$= 2.5 \times 10^{-4} \frac{W}{L}$$

$$I_D = \frac{5 - V_{out}}{20K} = \frac{4}{20k} = 0.2\,mA$$

$\Rightarrow \frac{W}{L} = 0.8$ e.g. $W = 8u$, $L = 10u$

P7. when $V_{GS} > V_T$

$$R_{FET} = \frac{1}{V_{GS} - V_T} \left(\frac{L}{\mu C_{ox} W} \right) = \frac{250}{V_{GS} - 0.5}$$

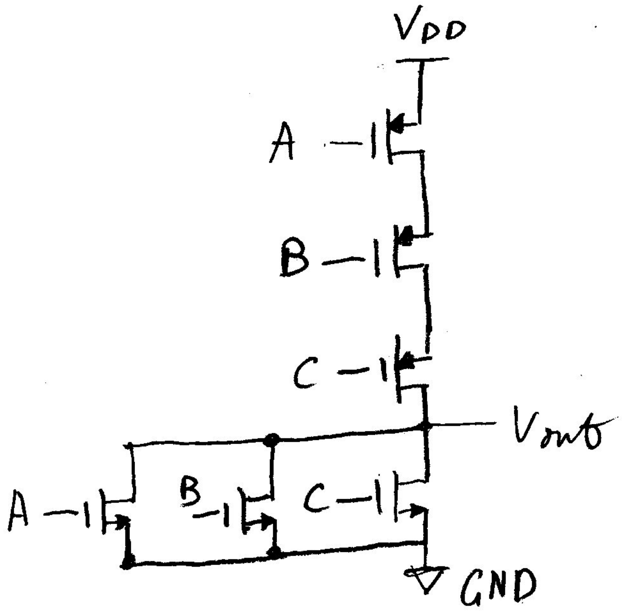
S is closed when $V_{GS} > V_T$

S is open when $V_{GS} < V_T$

P8 Xor Gate

$$V_{out} = \overline{(A \cdot B \cdot C)} = \begin{cases} 1 & \text{if } A=B=C=0 \\ 0. & \text{o.w.} \end{cases}$$

A B C	V_{out}
0 0 0	1
all the other cases	0



P9. ① $V_{GS} = 3.5V$ read from the figure $\Rightarrow I_X \approx 3.5mA$

$V_{DS} = 8V$

② Saturation

③ $I_X = 3mA$ in triode region

P10 Apparently $\lambda \neq 0$ and it is very small

$\Rightarrow$ using points from saturation could introduce large error

so, selecting 2 points from triode region

e.g. $I_{D_1} = 1mA$, $V_{DS_1} = 1V$ $V_{GS_1} = 2.5V$

$I_{D_2} = 2mA$, $V_{DS_1} = 1V$ $V_{GS_1} = 3.5V$

$\because I_D = \frac{uC_{ox}W}{L}(V_{GS} - V_T - \frac{V_{DS}}{2})V_{DS}$

$$\therefore \frac{I_{D_2}}{I_{D_1}} = \frac{2}{1} = \frac{(3.5 - 0.5 - V_T)}{(2.5 - 0.5 - V_T)} \Rightarrow V_T = 1V$$

$$\therefore 2 \times 10^{-3} = uC_{ox} \cdot \frac{20}{4} \cdot 2 \Rightarrow uC_{ox} = 2 \times 10^{-4} \, A/V^2$$

P11 (a) $V_{GS} = V_{DS} = 3 \quad \therefore V_{DS} > V_{GS} - V_T$ in Saturation.

$I_D = \frac{u C_{ox} W}{2L} (V_{GS} - V_T)^2 = 5\times10^{-4} \cdot 2^2 = 2\,mA$

$\therefore V_{out} = 3 + I_D \cdot R = 3 + 8 = 11\,V$

(b) $V_{DS} = 2 < V_{GS} - V_T$ triode

$I_D = \frac{u C_{ox} W}{L} (V_{GS} - 1 - \frac{V_{DS}}{2}) V_{DS}$

$= \frac{1\times10^{-4}}{2} \cdot (4-2) \cdot 2 = 0.2\,mA$

$\therefore V_{out} = 2 + R \cdot I_D = 2 + 6 = 8V$

(c) $V_{DS} = 4 > V_{GS} - V_T$ Saturation

$I_D = 0.5\,mA$

$V_{out} = 4 + I_D \cdot R = 4 + 5 = 9\,V$

(d) $V_{GS} < V_T \quad I_D = 0$

$\therefore V_{out} = 4V$