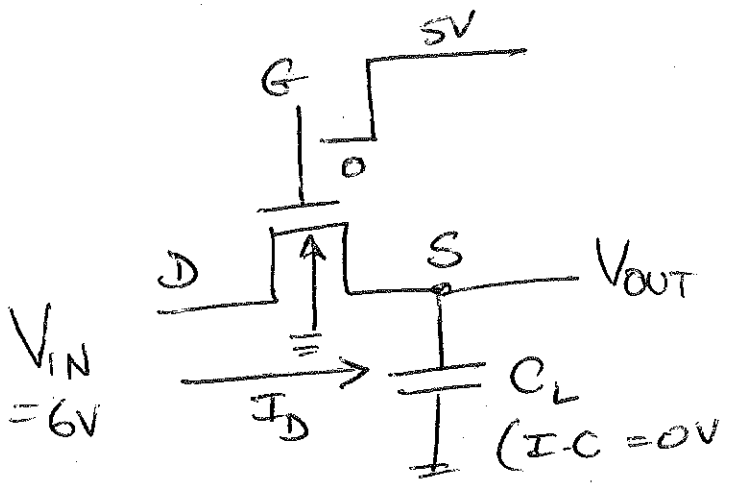
115 HW#7 Solutions

1. (a)



$V_{GS} = V_G - V_{OUT}$

V_{OUT} charging

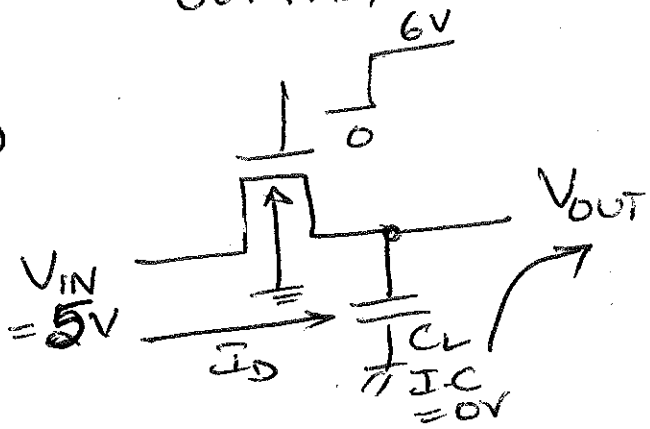
$\Rightarrow V_{GS}$ changes.

$V_{GS} > V_T \Rightarrow V_G - V_S > V_T$

$\Rightarrow 5V - V_S > 1V \Rightarrow V_S < 5-1 = 4V$

$V_{OUT\,max} = 4V$. = Final value of V_{OUT}. (Cannot reach 6V)

(b)



$V_{GS} > V_T$

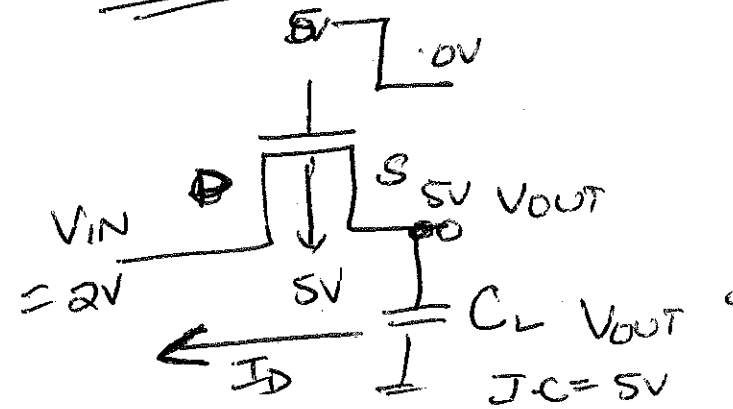
$6V - V_{OUT} > 1$

$V_{OUT} < 6-1$

$V_{OUT\,max} = 5V$

$\Rightarrow$ Final $V_{OUT} = 5V$ as $\leq V_{OUT\,max}$

(c)



$V_{GS} < V_T$

$0V - V_{OUT} < V_T$

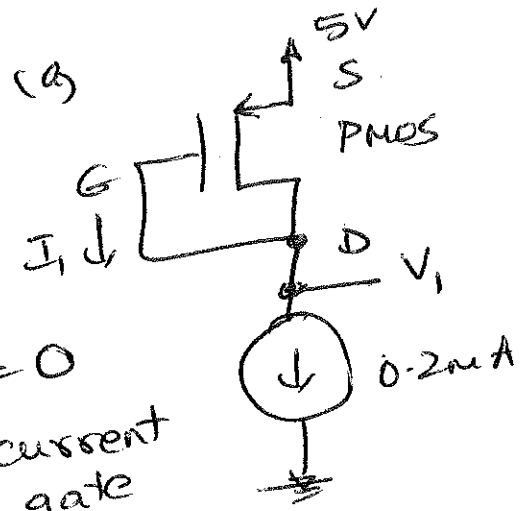
$V_{OUT} > -V_T = -(-1)$

$V_{OUT\,min} = 1V$

V_{OUT} discharges

Final $V_{OUT} = 2V$ as $> V_{out\,min}$.

2. (a)



$I_1 = 0$

no current in gate

$\underline{I_1 = 0}$

$\underline{V_1 = 2V}$

D&G connected $\Rightarrow$ saturation

$$I_{D1} = \frac{1}{2} * k_p' \frac{W}{L} \left(V_{GS1} - V_T\right)^2$$

$$0.2mA = \frac{1}{2} * 10\frac{\mu A}{V^2} * \frac{100}{10} \left(V_{GS1} - (-1)\right)^2$$

$$\left(V_{GS1} + 1\right)^2 = 4 \qquad V_{GS1} + 1 = \pm\sqrt{4}$$

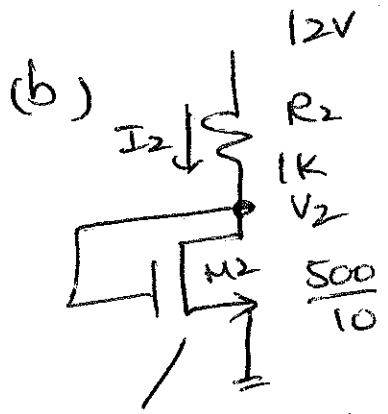
$$V_{GS1} = \pm 2 - 1 = \begin{matrix} +1 \\ \text{or} \\ -3 \end{matrix} \quad < -1$$

$\Rightarrow -3V$

$\Rightarrow V_{GS1} = -3 \Rightarrow V_{G1} - V_{S1} = -3$

$\Rightarrow V_{G1} = V_{S1} - 3 = 5 - 3 = 2V$

(b)



D&G connected $\Rightarrow$ M2 saturated

$$\frac{12 - V_{GS}}{1K} = \frac{1}{2} * 20\frac{\mu A}{V^2} * \frac{500}{10} \left(V_{GS} - 1\right)^2$$

$$12 - V_{GS} = 0.5 \left(V_{GS} - 1\right)^2$$

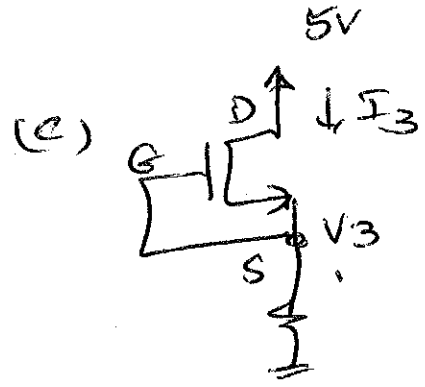
$$V_{GS}^2 - 2V_{GS} + 1 = 24 - 2V_{GS}$$

$$V_{GS}^2 = 23 \qquad V_{GS} = \pm\sqrt{23} = \pm 4.79$$

$\Rightarrow V_2 = V_{GS2} = \underline{4.79V} \quad > 1$

$$I_2 = \frac{12 - 4.79}{1K} = \underline{7.204mA}$$

(c)



$V_{GS3} = 0 < V_T = 1V$

$\Rightarrow$ M3 off. $\underline{I_3 = 0}$

$\underline{V_3 = 0V}$