Gabriel Emerson gte0002 | Mosfet HW1 | Due 3/8 | Pg. 1

1.) $V_{GS}=3$ $V_{TO}=0.5V$ $KP=50$ $W=2mm$ $L=1mm$

$I_{dsat}=\frac{1}{2}KP\frac{W}{L}(V_{GS}-V_{Th})^2 \Rightarrow \frac{1}{2}(50)(\frac{2}{1})(3-0.5)^2$

$\boxed{I_{dsat}=0.3125mA}$

$V_{GT}=3V-0.5V=2.5V>0 \Rightarrow \boxed{V_{dsat}=2.5V}$

2.) $I_{dsat}=\frac{1}{2}KP\frac{W}{L}V_{GT}^2$ $V_{GT}=V_{GS}-V_{TO}$

$\Rightarrow \frac{1}{2}(25)(\frac{4}{1})(-2.5)^2$ $V_{GT}=-2.5V<0$

$V_{dsat}=-2.5V$

$\boxed{I_{dsat}=-0.313mA}$

3.) 4.16 a) $R_{on}=\frac{1}{KP\frac{W}{L}(V_{GS}-V_{TH})} > 50\Omega=\frac{1}{100(\frac{W}{L})(5-0.75)}$

$\frac{W}{L}=\boxed{\frac{4.706}{1}}$

b.) $V_{GS}=3.3V$ $\frac{W}{L}=\frac{1}{100(500)(3.3-0.75)}=\boxed{\frac{7.8431}{1}}$

4.) 4.17 $R_{on}=\frac{V_{DS}}{I_D}=\frac{0.1V}{10A}=0.01\Omega \Rightarrow \boxed{R_{on}=10m\Omega}$

b.) $V_S=0V$ $V_{GS}=V_G-V_S \Rightarrow 5-0=5V$

$I_D=KP(V_{GS}-V_{TN}-\frac{V_{DS}}{2})V_{DS}$

$KP=\frac{10}{5-2-\frac{0.1}{2})0.1} \Rightarrow KP=\boxed{33.89\ A/V^2}$

5.) a) $V_{GS} = 2V$
$V_{DS} = 2.5V$

$V_{GT} = 2 - 0.75 = 1.25 < V_{DS}$

$\boxed{\text{Saturation}}$

b.) $V_{GS} = 2V$
$V_{DS} = 0.2V$

$V_{GT} = 2 - 0.75 = 1.25 > V_{DS}$

$\boxed{\text{Linear}}$

c.) $V_{GS} < V_{Th}$

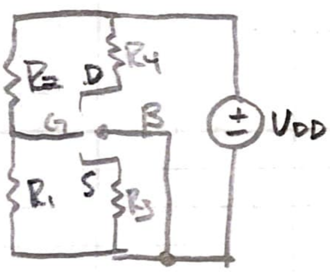
$\boxed{\text{Cut-off}}$

$V_{GS} = 0V$
$V_{DS} = 4V$ $\boxed{I_D = 0A}$

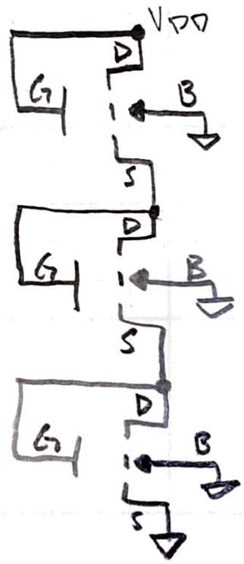
d.) $KP = 300\ mA/V^2$

a.) $I_D = 2.344mA$
b.) $I_D = 0.69mA$
c.) $I_D = 0A$

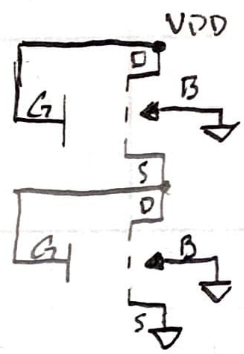
6.) 4.25 a)



7.) 4.26 a)



b.)



8.) 4.27

$V_{GT} = V_{GS} - V_{TH} = 2 - 0.7 = 1.3V$
$1.3 < 3.3 (V_{DS}) \Rightarrow$ Saturation

$g_m = 250\left(\frac{20}{1}\right)(1.3) = \boxed{6.5mS}$

$V_{GT} = 3.3 - 0.7 = 2.6V$
$2.6 < V_{DS} \Rightarrow$ Saturation

$g_m = 250(20)(2.6)$
$\boxed{= 13mS}$

9.) 4.30 $I_{DS} = \frac{1}{2} \underset{(K_n)}{KP \frac{W}{L}} V_{GT}^2 (1 + \lambda V_{DS})$

$I_{DS} = \frac{1}{2} K_n V_{GT}^2 (1 + \lambda V_{DS})$

$V_{GS} = 5V \quad V_{DS} = 6V$

$V_{GT} = 5 - 0.75 = 4.25V$

$= \frac{KP}{2} V_{GT}^2 (1 + \lambda V_{DS})$

$= \frac{250}{2} (4.25^2)(1 + 6(0.02)) \Rightarrow \boxed{I_{DS} = 2.53mA}$

b.) $\lambda = 0$

$= \frac{250}{2} (4.25^2)(1 + 6(0)) \Rightarrow \boxed{I_{DS} = 2.26mA}$

10.) 4.50 a)

$V_{GS} = -1.1V \quad V_{TO} = -0.75V \quad V_{GT} = -1.1 - (-0.75) = -0.35V$

$V_{DS} = -0.2V \quad KP = 40 \quad V_{GT} < V_{DS} < 0 = \boxed{\text{Linear}}$

$I_{SD} = 40(\frac{20}{1})(-0.35(-0.2) - \frac{(-0.2)^2}{2}) = \boxed{40mA}$

b.) $V_{GT} = -1.3 - (-0.75) = -0.55V$

$V_{GT} < V_{DS} < 0 = \boxed{\text{Linear}}$

$I_{SD} = 40(20)\left[-0.55(-0.2) - \frac{(-0.2)^2}{2}\right] = \boxed{72mA}$

11.) 4.52 $R_{on} = \frac{1}{KP \frac{W}{L} (V_{GS} - V_{TP}}$

$\frac{W}{L} = \frac{1}{(40)(2000)|-5-(-0.7)|}$

$\boxed{= \frac{2.907}{1}}$

b.) $\frac{W}{L} = \frac{1}{100(2000)(4.3)}$

$V_{GT} = 5 - 0.7 = 4.3$

$\boxed{\frac{W}{L} = \frac{1.163}{1}}$

12) $C_{GS} = \frac{1}{2} C''_{ox} + CGSO \cdot W$ $C''_{ox} =$

$C_{GS} = \frac{1}{2}\left(\frac{3.5\times10^{-2}}{4\times10^{-8}\,m}\right)\left(\frac{1}{1\times10^{6}}\right) + 3.4\times10^{-10}(170)$

$\boxed{= 0.4375\,uF}$

(2.) $C_{DB} = 0V$ at Zero volt Drain → Body

(3) $C_{GS} = CGSO \cdot W \Rightarrow 3.4\times10^{-10} \cdot 170$

$= 578\,uF$

$C_{GD} = CGDO \cdot W \Rightarrow 3.4\times10^{-10} \cdot 170$

$= 578\,uF$

$C_{GB} = CGBO \cdot L \Rightarrow 5.75\times10^{-10} \cdot 10$

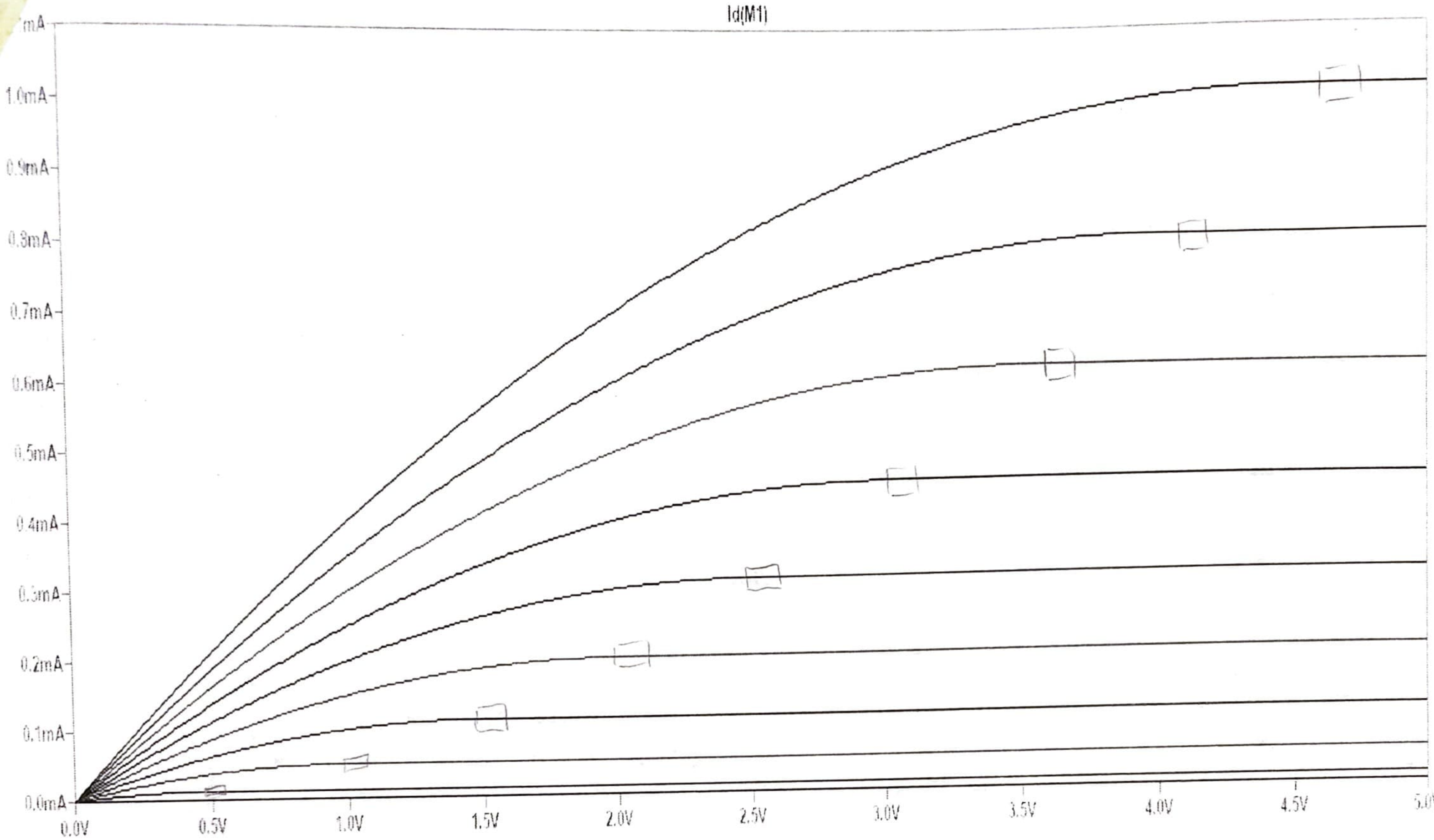
$= 5750\,uF$

13.) As V_{DS} → from $0 \rightarrow V_{DD}$

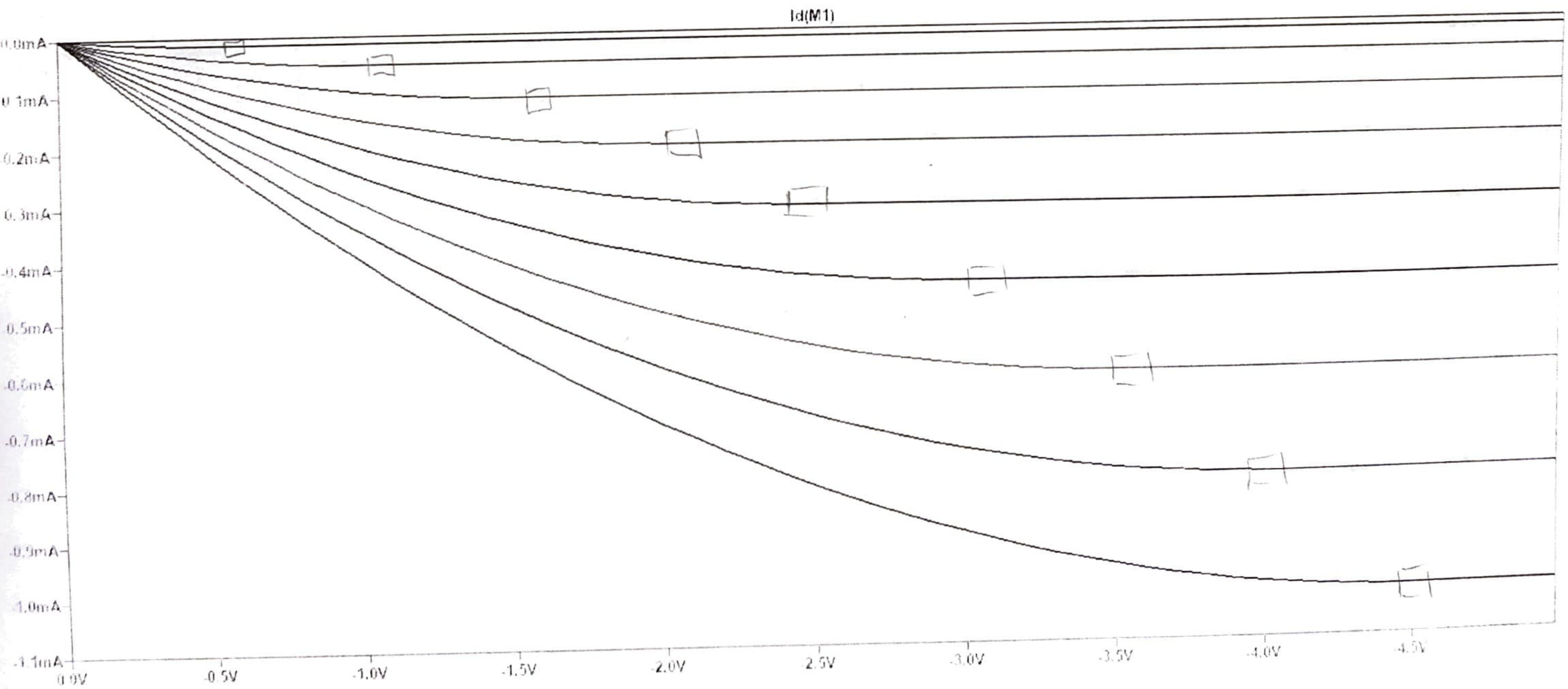
C_{GS} and C_{GD} grow more ↑

C_{GS} is equal to $\frac{1}{2} C''_{ox} WL$

when V_{DS} is exactly $\frac{V_{DD}}{2}$



Id(M1)
1.0mA
0.9mA
0.8mA
0.7mA
0.6mA
0.5mA
0.4mA
0.3mA
0.2mA
0.1mA
0.0mA
0.0V
0.5V
1.0V
1.5V
2.0V
2.5V
3.0V
3.5V
4.0V
4.5V
5.0V



Id(M1)
0.0mA
-0.1mA
-0.2mA
-0.3mA
-0.4mA
-0.5mA
-0.6mA
-0.7mA
-0.8mA
-0.9mA
-1.0mA
-1.1mA
0.0V
-0.5V
-1.0V
-1.5V
-2.0V
-2.5V
-3.0V
-3.5V
-4.0V
-4.5V