1.

(a) $C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.9 \times \varepsilon_0}{4 \times 10^{-9}} = \frac{3.45 \times 10^{-11}}{4 \times 10^{-9}} = \underline{8.625 \times 10^{-3}\ F/m^2}$ #

$\frac{8.625 \times 10^{-11}}{11}\ F/cm^2$

$k_n' = \mu_n \cdot C_{ox} = \underline{3.88 \times 10^{-4}\ A/V^2}$ #

(b) $I_D = \frac{1}{2} k_n' \frac{W}{L} V_{ov}^2$

$\Rightarrow 0.1 \times 10^{-3} = \frac{1}{2} \times 3.88 \times 10^{-4} \times \frac{2.4}{0.18} \times V_{ov}^2$

$\Rightarrow V_{ov} = \underline{0.197\ V}$ #

$V_{GS} = V_{ov} + V_t = \underline{0.697\ V}$ #

$V_{DS(min)} = V_{ov} = \underline{0.197\ V}$ #

(c) At triode region :

$r_{DS} = \frac{1}{k_n' \frac{W}{L} \cdot V_{ov}}$

$\Rightarrow 500 = \frac{1}{3.88 \times 10^{-4} \times \frac{2.4}{1.8} \times V_{ov}}$

$\Rightarrow V_{ov} = \underline{0.387\ V}$ #

$\Rightarrow V_{GS} = V_{ov} + V_t = \underline{0.887\ V}$ #

2.

(a) $I_D = \frac{1}{2} k_n' \left(\frac{W}{L}\right) (V_{gs} - V_t)^2$

$50 \times 10^{-6} = \frac{1}{2} \cdot 2 \times 10^{-3} \cdot (V_{gs} - V_t)^2$

$\Rightarrow V_{gs} = \underline{0.6236\ V}$ #

$V_{DS,min} = V_{gs} - V_t = \underline{0.2236\ V}$ #

(b) $200 \times 10^{-6} = \frac{1}{2} \cdot 2 \times 10^{-3} \cdot (V_{gs} - V_t)^2$

$V_{gs} = \underline{0.8472\ V}$ #

$V_{DS,min} = \underline{0.4472\ V}$ #

3.

Case	V_S	V_G	V_D	V_{SG}	$\lvert V_{ov}\rvert$	V_{SD}	Region
a	+2	+2	0	0	+1	+2	Cutoff
b	+2	+1	0	+1	0 <	+2	Sat.
c	+2	0	0	+2	+1 <	+2	Sat.
d	+2	0	+1	+2	+1 =	+1	Sat.
e	+2	0	+1.5	+2	+1 >	+0.5	triode
f	+2	0	+2	+2	+1 >	0	triode

cut off : $V_{th} > V_{GS}$

sat. : $V_{DS} \geq V_{ov}$

linear : $V_{ov} > V_{DS}$

4.

(a) $I_{D1} = \frac{1}{2} k_n' \frac{W_1}{L_1} (V_{GS1} - V_t)^2$

$100\times10^{-6} = \frac{1}{2} \cdot 0.4\times10^{-3} \frac{1.8}{0.36} (V_{GS1} - 0.5)^2$

$\Rightarrow V_{GS1} = 0.816\ V$

$\frac{1.8 - 0.816}{R_1} = 100\times10^{-6}$

$\Rightarrow R_1 = \underline{9840\ \Omega}$ #

(b) $I_{D2} = \frac{1}{2} k_n' \frac{W_2}{L_2} (V_{GS2} - V_t)^2$

$0.5\times10^{-3} = \frac{1}{2} \cdot 0.4\times10^{-3} \frac{W_2}{0.36\times10^{-6}} (0.816 - 0.5)^2$

$\Rightarrow W_2 = 9\ \mu m$ #

At the edge of sat. – linear :

$V_{D2} = V_{ov} = 0.816 - 0.5 = 0.316$

$\frac{1.8 - 0.316}{R_2} = 0.5\times10^{-3}$

$\Rightarrow R_2 = \underline{2968\ \Omega}$ #