

Assume it operates in saturation

$$I_D = \frac{V_{DD} - V_X}{100k}$$

$$I_D = \frac{\beta_n}{2} (V_X - V_{thn})^2$$

$$\frac{5 - V_X}{100k} = \frac{120\mu}{2} \frac{10}{2} (V_X - 0.8)^2$$

$$\frac{5 - V_X}{100k} = 3.00 \text{M} (V_X^2 + 0.64 - 1.6V_X)$$

$$5 - V_X = 300 V_X^2 + 19.2 - 48 V_X$$

$$300 V_X^2 - 47 V_X + 14.2 = 0$$

$$\begin{aligned}
 V_x &= \frac{47 \pm \sqrt{47^2 - 4 \times 30 \times 14.2}}{60} \\
 &= \frac{47 \pm \sqrt{2209 - 1704}}{60} \\
 &= \frac{47 \pm 22.47}{60} \\
 &= \underline{1.158 \text{ V}} \text{ or } 0.409 \text{ V}
 \end{aligned}$$

$$V_x = 1.158 \text{ V}$$

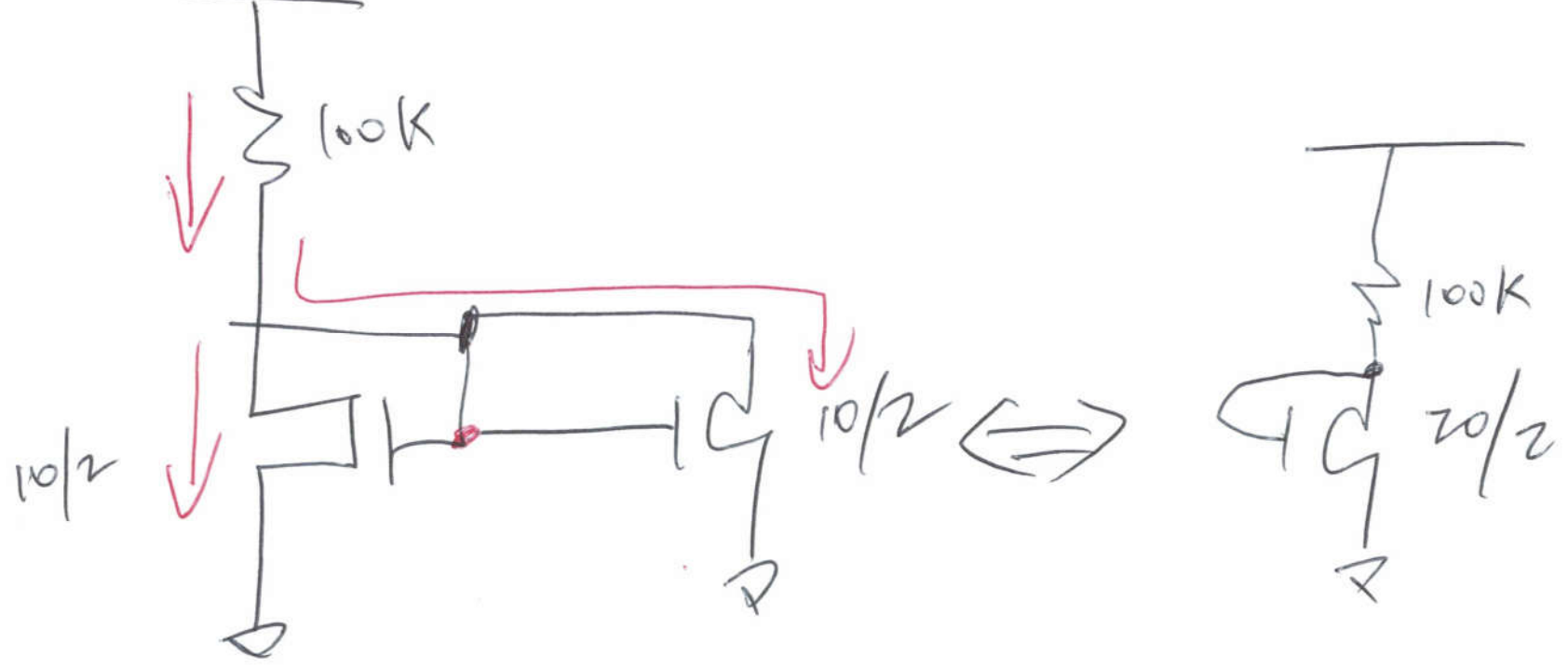
$$I_D = \textcircled{b} \frac{V_{in} - V_o}{100 \text{ k}} = \frac{5 - 1.158}{100 \text{ k}} = \frac{3.842}{100 \text{ k}} = 38.42 \mu\text{A}$$

V_x	I_D
1.03 V	39.67 μA

	Cal (V)	Sim (μA)
V_x	1.158	1.03
I_D	38.42	39.67

(2)

4.10.
 $V_{DD} = 5V$



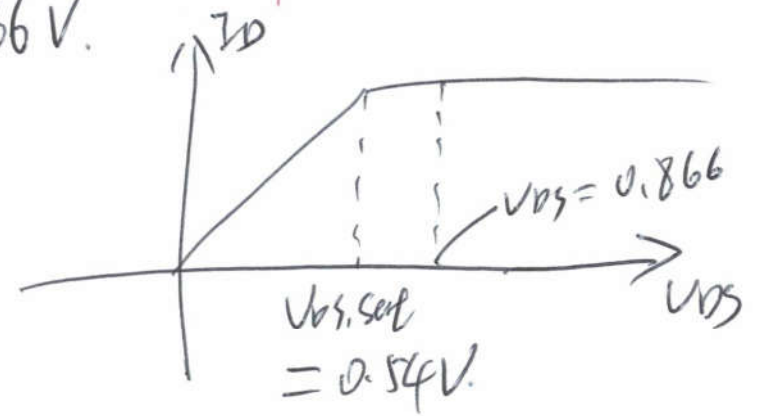
(3)

$$R = 100k$$

$$M11, M17, V_{GS} = 1.21V$$

$$V_{DS, sat} = V_{GS} - V_{th} = 1.21 - 0.67 = 0.54V$$

$$V_{DS} = 0.866V$$



$$M10, M16: V_G = 2.42V$$

$$V_S = 0.866V$$

$$V_{GS} = 1.534 \quad V_{DS, sat} = V_{GS} - V_{th} =$$

$$= 1.534 - 0.67$$

$$= 0.864V$$

$$V_{DS} = 1.12V - 0.866 = 0.254V$$



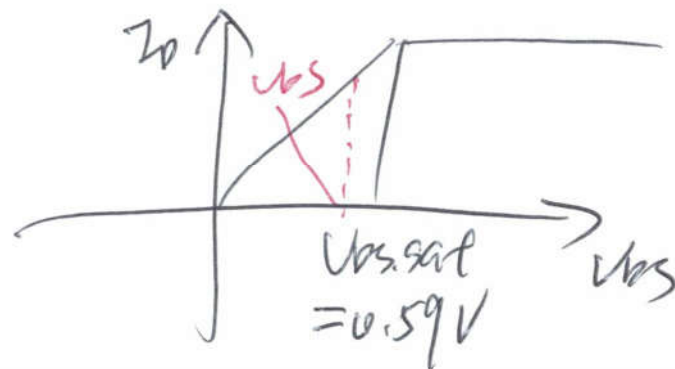
(4)

$$R = 200k$$

$$M_{10}, M_{16}: V_{GS} = 2 - 0.74 = 1.26V$$

$$V_{DS, sat} = 1.26 - 0.67 = 0.59V$$

$$V_{DS} = 1.22 - \frac{0.67}{0.74} = 0.48V$$



Poly1 - Poly2 capacitor.

~~tox~~ $\frac{\epsilon_r \cdot \epsilon_0}{t_{ox}} \cdot A = C_{ox}$ 10 pF

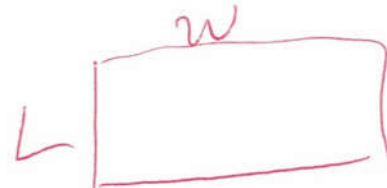
$$A = \frac{10 \text{ pF}}{\frac{\epsilon_r \cdot \epsilon_0}{t_{ox}}}$$

$$10 \text{ pF} = \frac{3.97 \times 8.5 \times 10^{-18} \text{ F}/\mu\text{m}}{3.97 \times 10^{-8} \mu\text{m}} \cdot A$$

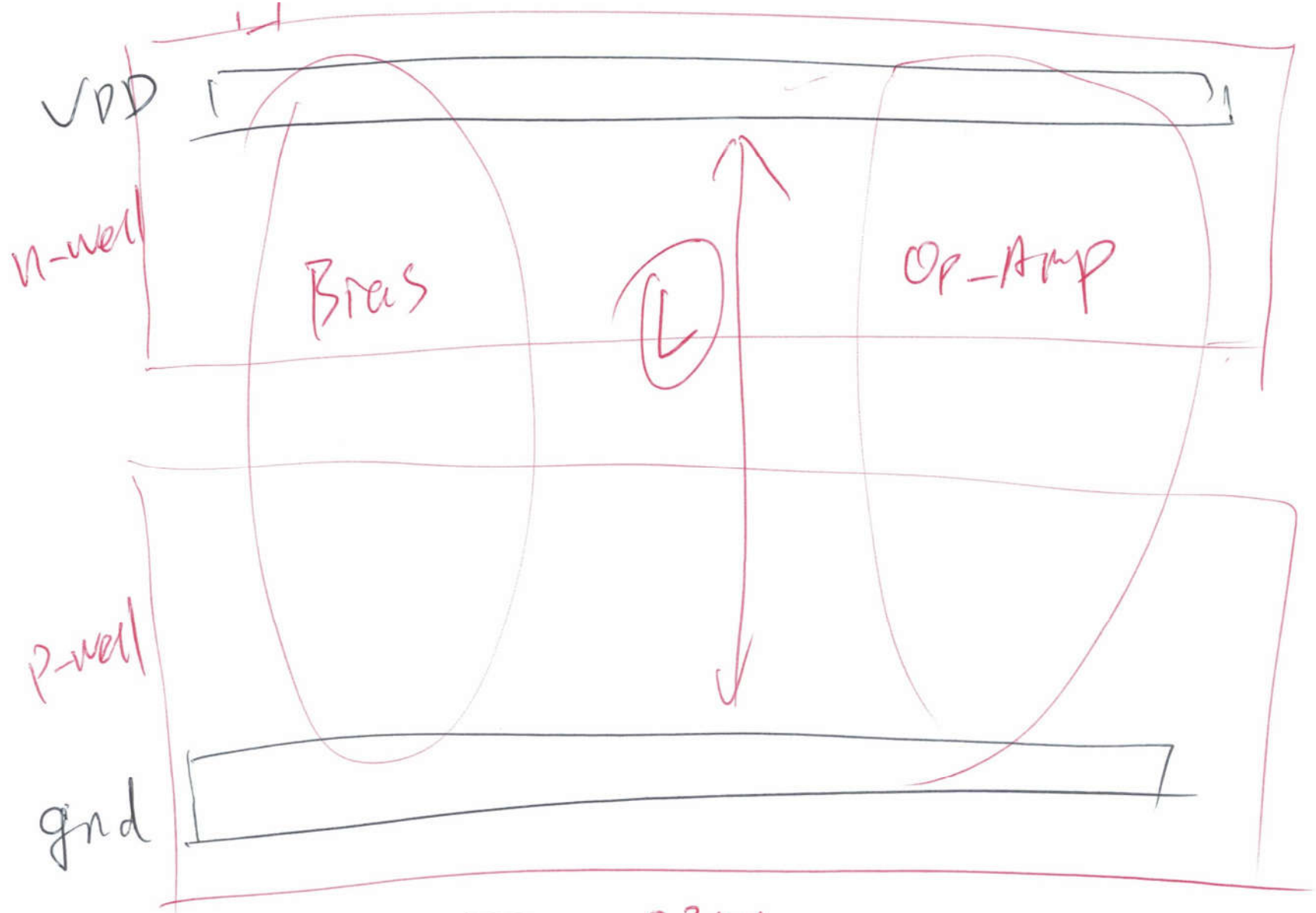
$$= (8.5 \times 10^{-16} \text{ F}/\mu\text{m}^2) \cdot A$$

$$A = \frac{10 \text{ pF } 10^{-12} \text{ F}}{8.5 \times 10^{-16} \text{ F}/\mu\text{m}^2}$$

$$= 1.176 \cdot 10^4 \cdot \mu\text{m}^2 = 11760 \mu\text{m}^2$$



(6)

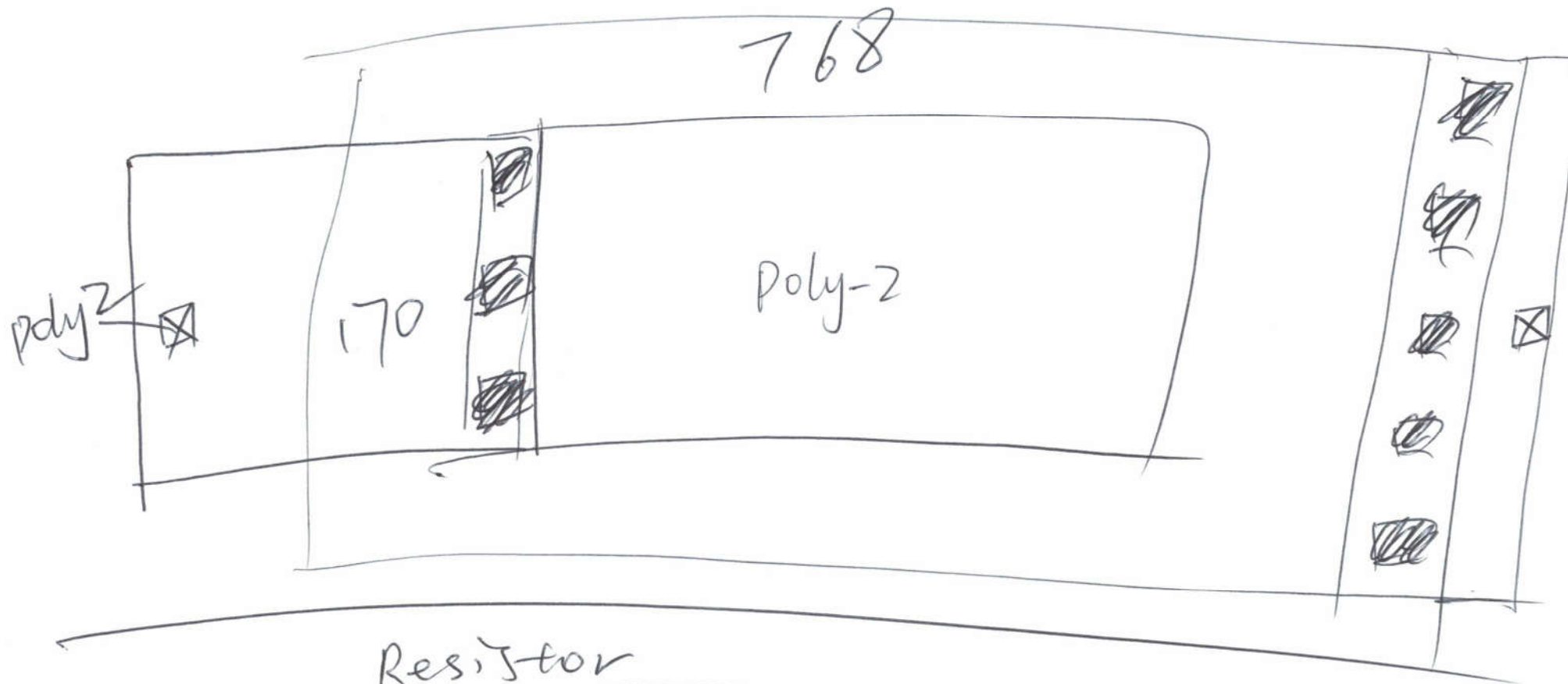


$$L = 170 \times \frac{0.3 \mu\text{m}}{300 \mu\text{m}} = 5 \mu\text{m}$$

$$W = 230.6 \mu\text{m}$$

$$\bullet W = \frac{230.6 \mu\text{m}}{0.3 \mu\text{m}} = 768$$

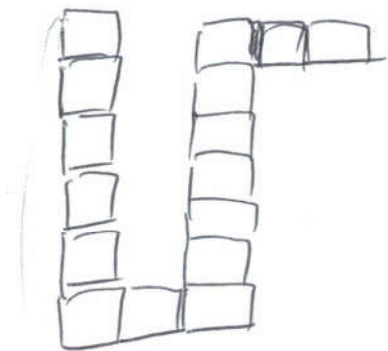
①



Resistor

$$9 \begin{array}{c} 9 \\ \square \end{array} = 23.4 \Omega$$

$$9 \begin{array}{c} 9 \\ \text{---} \\ 18 \end{array} \begin{array}{c} 27 \\ \text{---} \\ 27 \end{array} = 23.4 \times 3 =$$



⑧