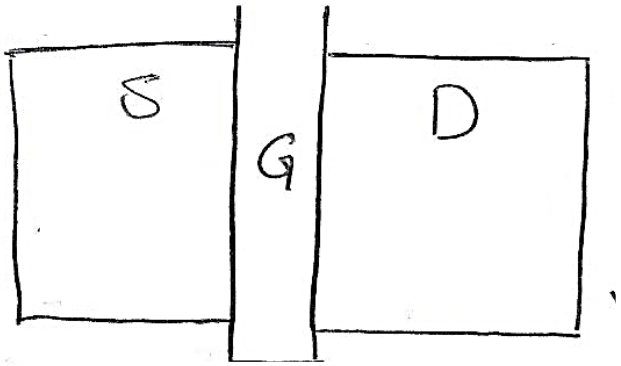
Exercise 7



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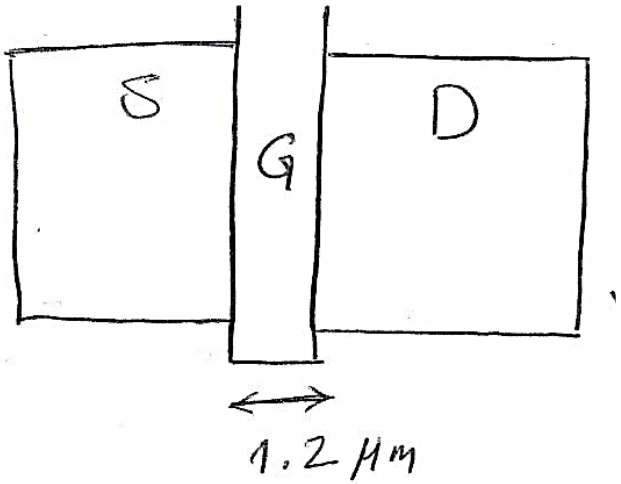

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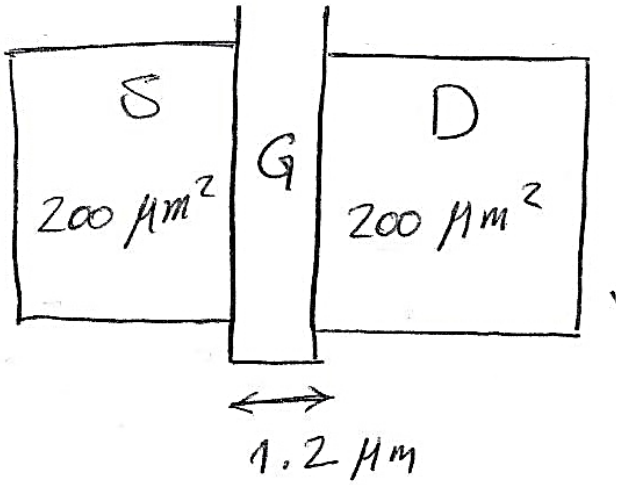

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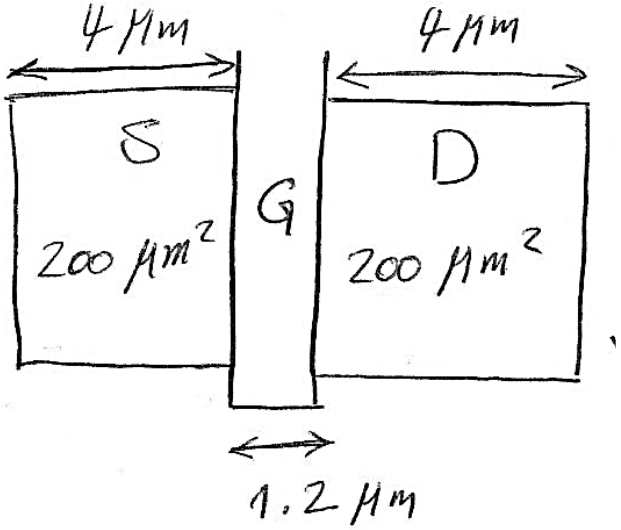

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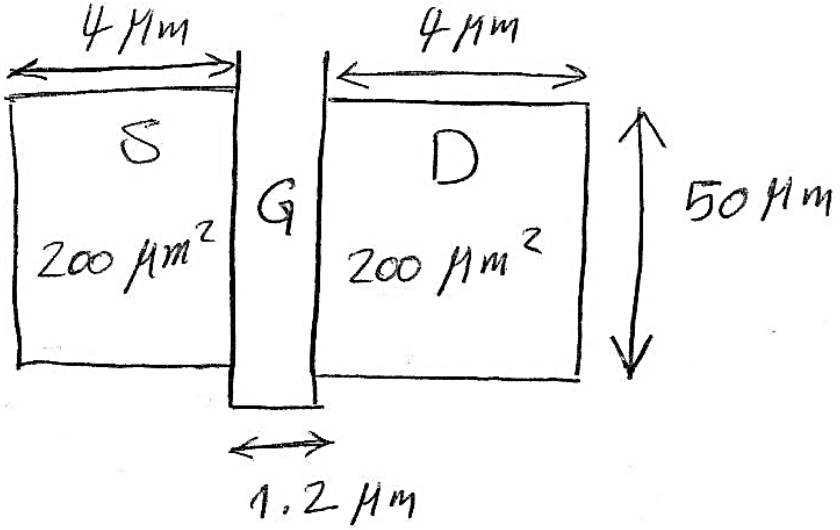
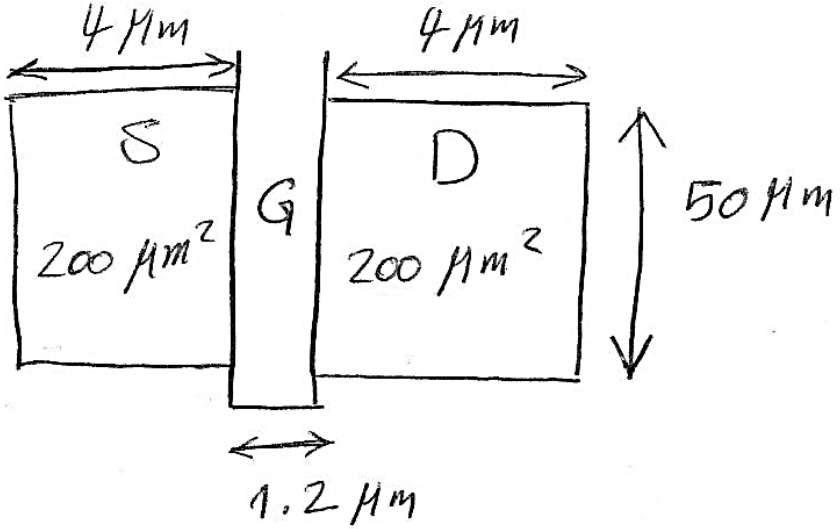


Exercise 7

find C_{gs}, C_{gd}, C_{db}, C_{sb}



$A_S = A_D = 200\,\mu m^2$

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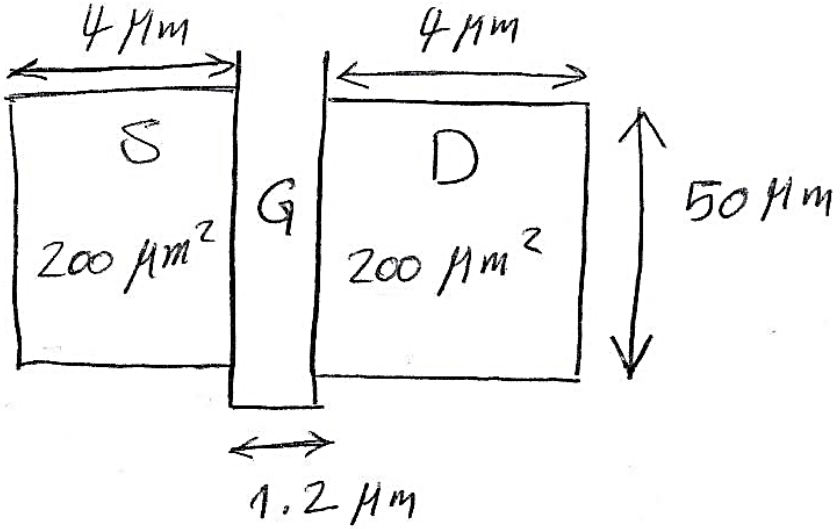

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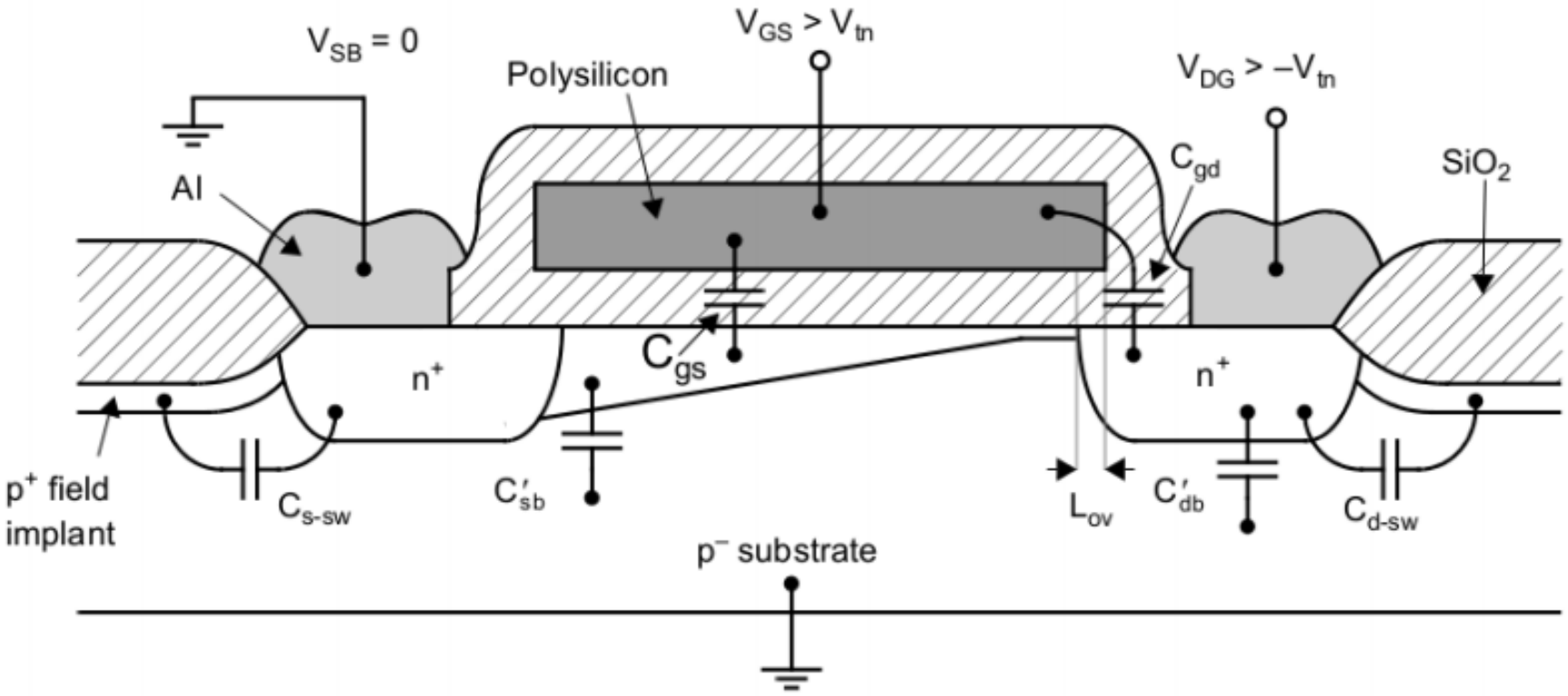
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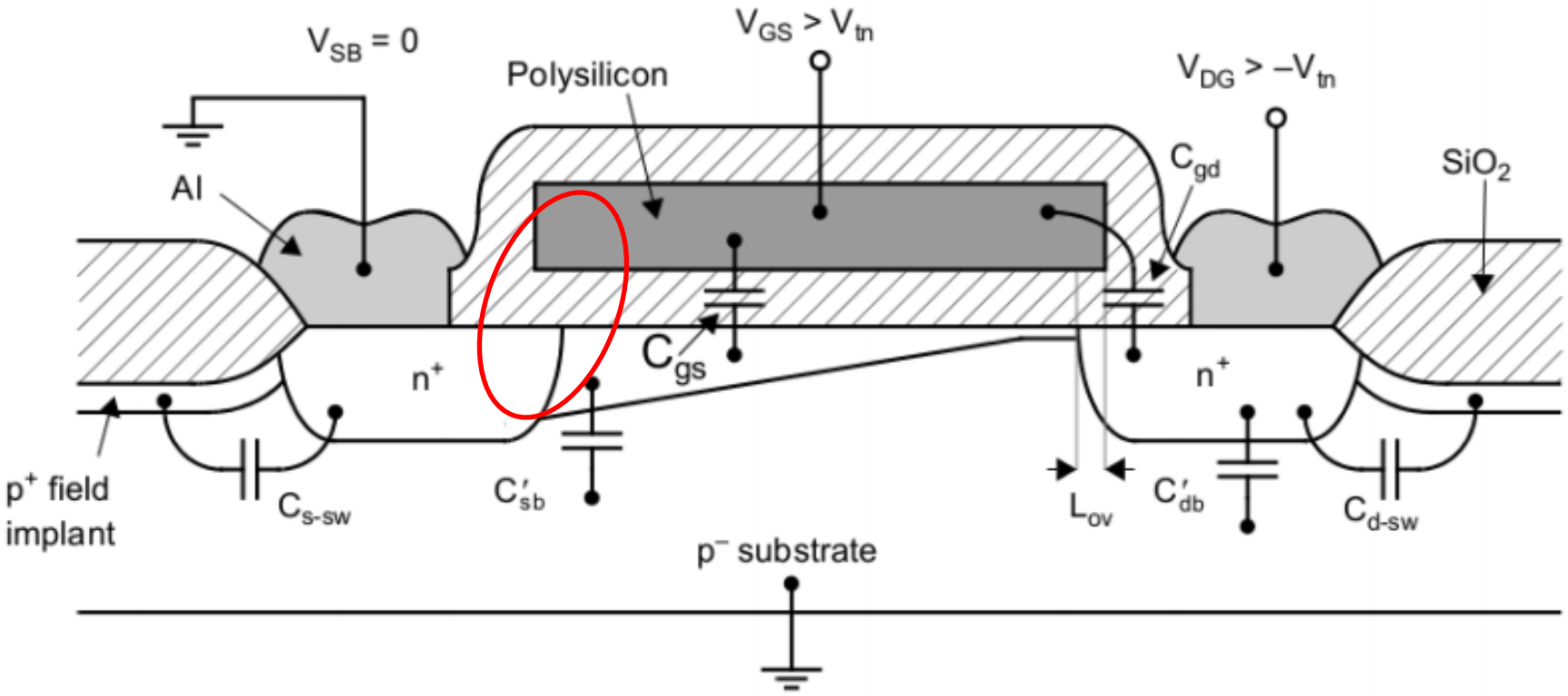
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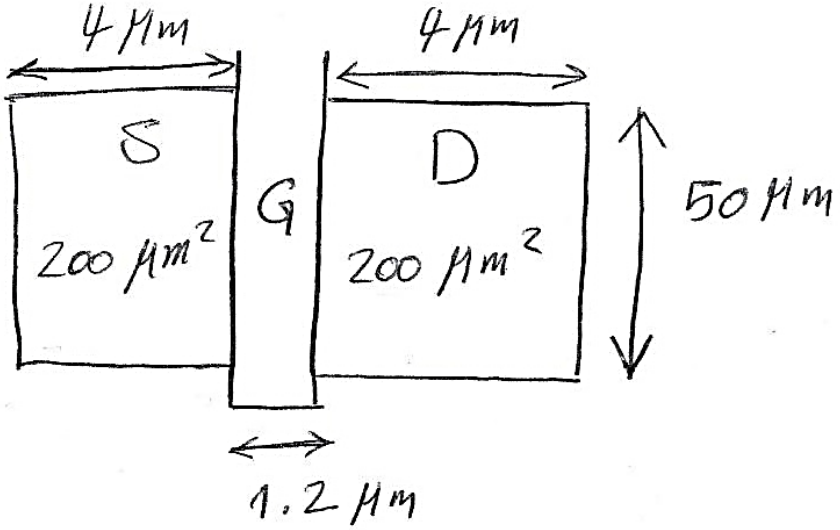

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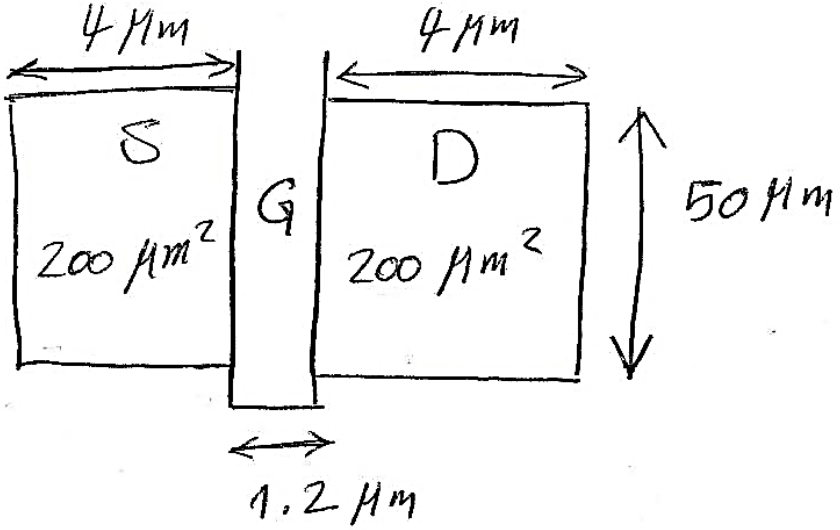

$$C_{gs} = \frac{2}{3} W L C_{ox} + \underbrace{W L_{ov} C_{ox}}_{\downarrow}$$

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$$= \frac{2}{3} \times 50 \times 1.9 \times 10 + 50 \times 2 \times 10$$

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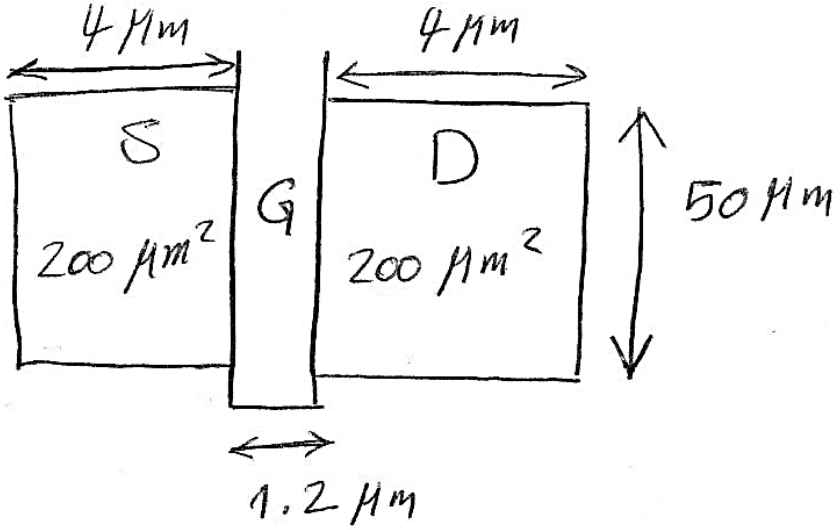

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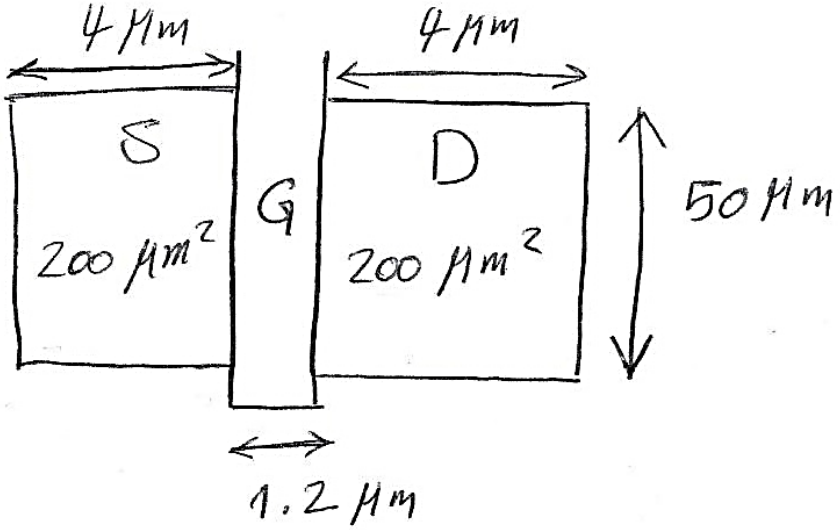

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1 Femto Farad = 10^{-15} farad

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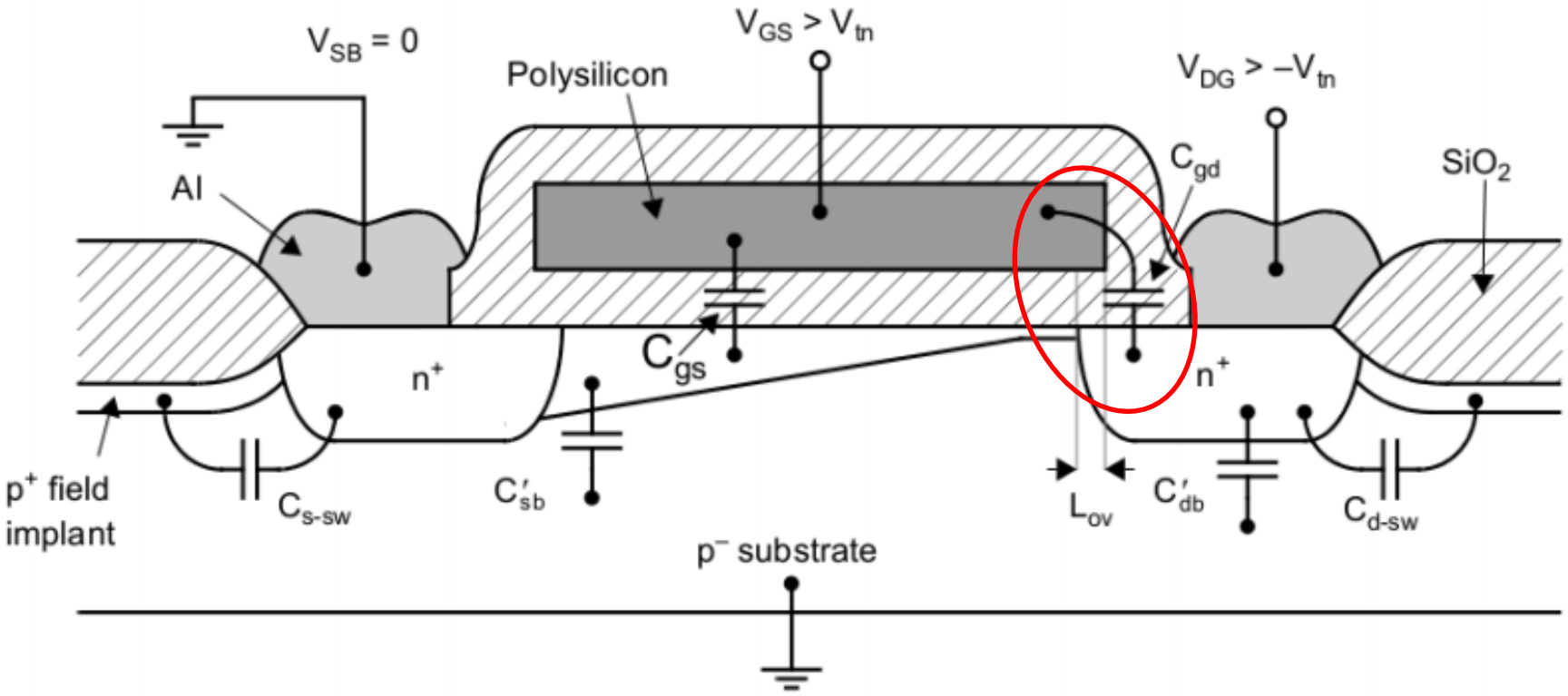
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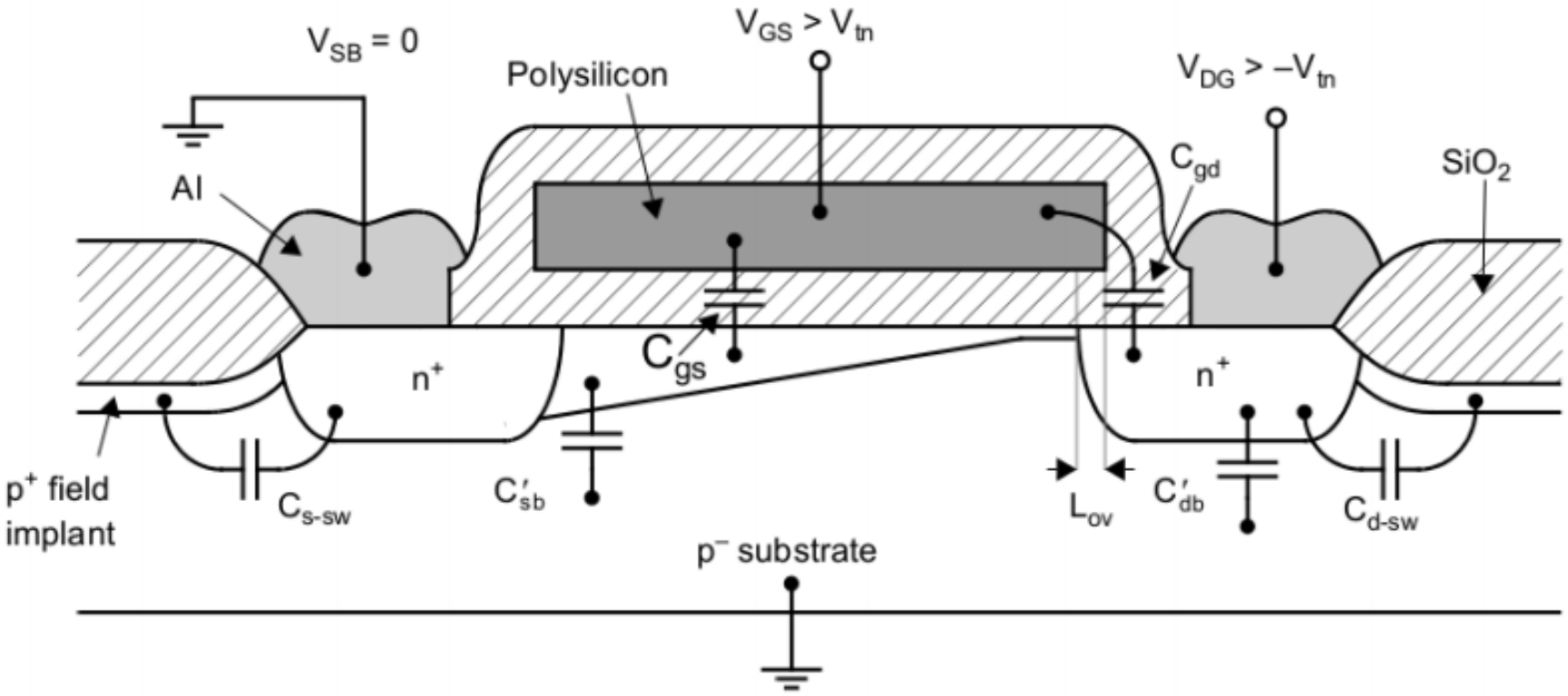
$$C_{sb} = (A_s + A_{ch}) C_{js} + P_s C_{j-sw}$$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$$C_{jS} = \frac{C_{j0}}{\sqrt{1 + \frac{V_{sb}}{\Phi_0}}} = \dots = 2.4 \times 10^{-4}\,fF/\mu m^2$$

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$$C_{sb} = (A_S + WL) C_{jS} + P_S C_{j\text{-}sw} = (200 + 50 \times 1.2) \times 2 \times 10^{-4} + 58 \times 2 \times 10^{-4} = 74\,fF$$

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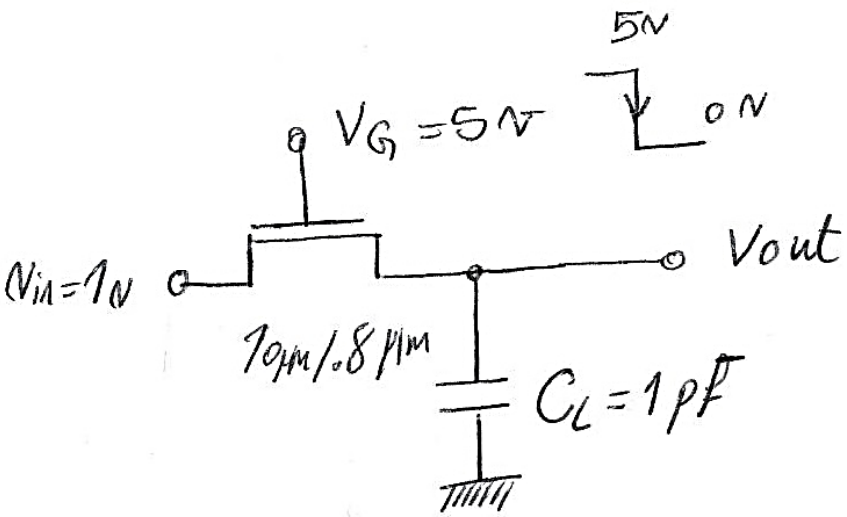
$$C_{db} = A_d C_{jd} + P_d C_{j-sw} = 200 \times 2.4 \times 10^{-4} + 58 \times 2 \times 10^{-4} = 60\,fF$$

Exercise 8



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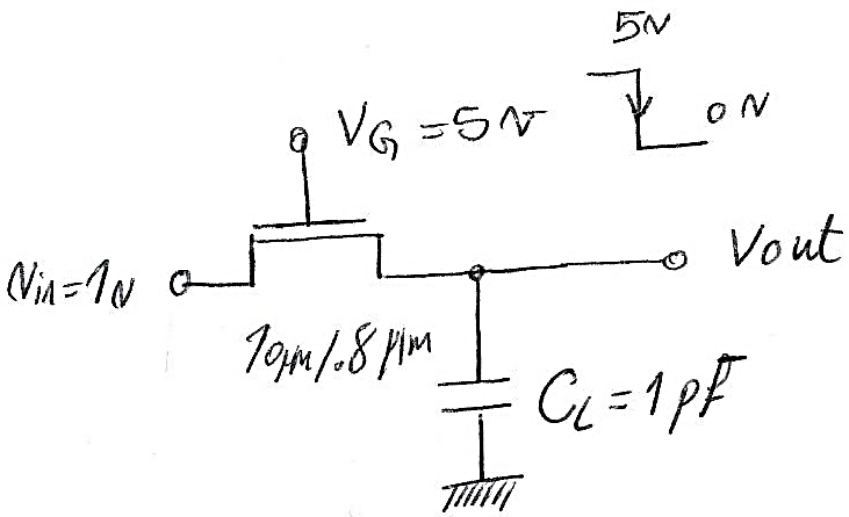

Charge stored in the channel:

$$Q_{ch} = WLC_{ox}(V_{GS} - V_{th})$$

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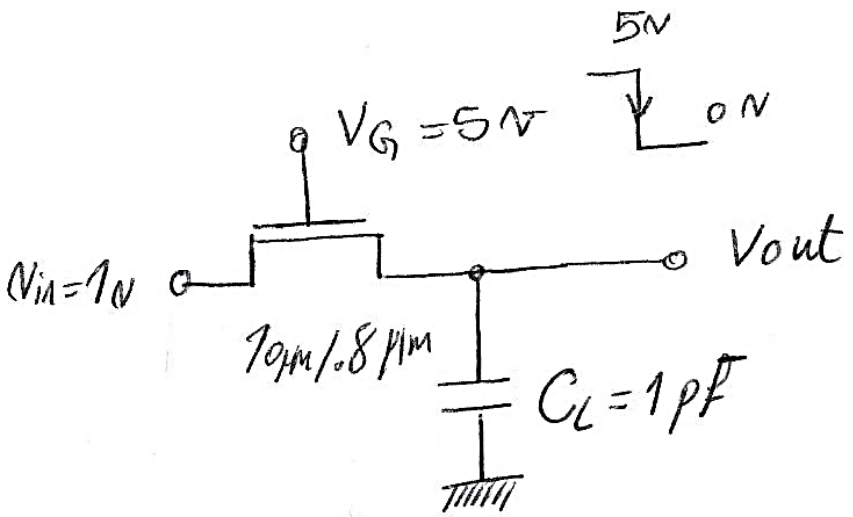

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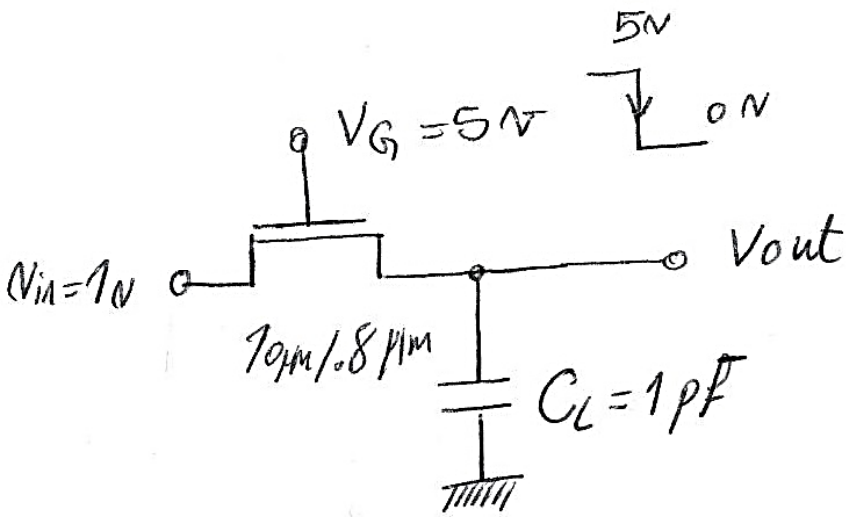

Charge stored in the channel:

$$Q_{ch} = WLC_{ox}(V_{GS} - V_{th})$$

$$= WLC_{ox} V_{eff}$$

$$= 10 \times 0.8 \times 1.9 \times 10^{-3} (4 - 0.8)$$

$$= 48.6\ fC$$

Exercise 8

Assuming $\frac{1}{2}$ Qch is "injected" into the CL

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Assuming $1/2\ Q_{ch}$ is "injected" into the C_L

reminder:

$$Q = C V \rightarrow V = \frac{Q}{C} \rightarrow \Delta V = \frac{\Delta Q}{C}$$

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Assuming $\frac{1}{2} Q_{ch}$ is "injected" into the C_L

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$$Q = CV \rightarrow V = \frac{Q}{C} \rightarrow \Delta V = \frac{\Delta Q}{C}$$

$$\Delta V = -\frac{\frac{1}{2} Q_{ch}}{C_L} = -\frac{1}{2} \times \frac{48.6 \times 10^{-15}}{10^{-12}} = -24\ mV$$

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Assuming $\frac{1}{2} Q_{ch}$ is "injected" into the C_L

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$$Q = CV \rightarrow V = \frac{Q}{C} \rightarrow \Delta V = \frac{\Delta Q}{C}$$

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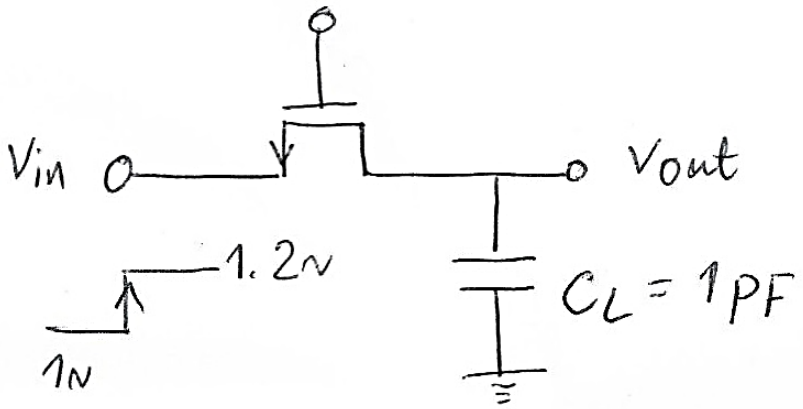
$$\Rightarrow V_{out} = V_{out}(0) - 0{,}024 = 1 - 0.024 = 0.976\,V$$

Exercise 9



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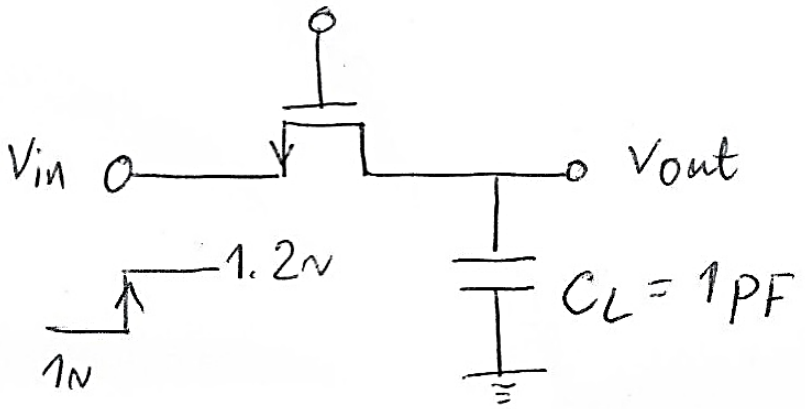
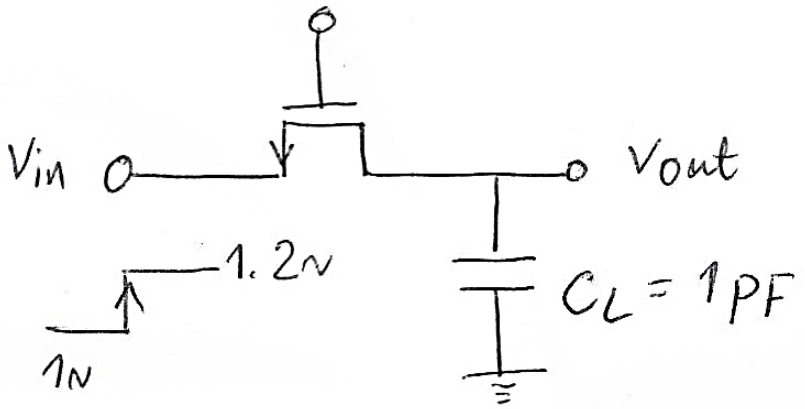


$V_{DS} \ll V_{eff}$

Exercise 9



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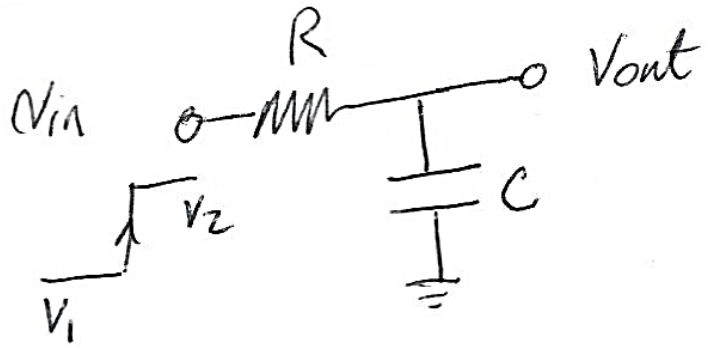
↓ so

We are in TRIODE REGION

Exercise 9 — What is 99% Settling Time?



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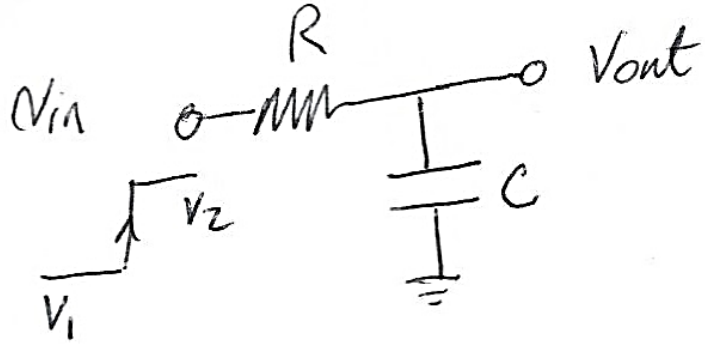

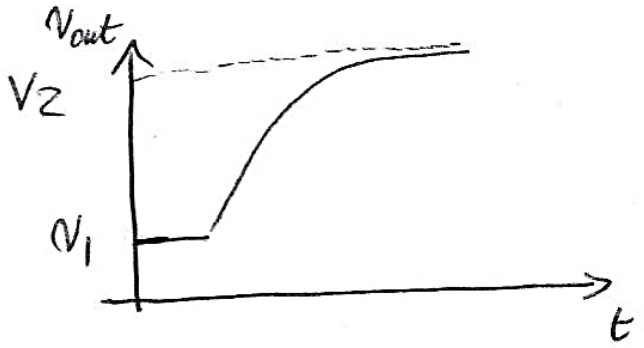

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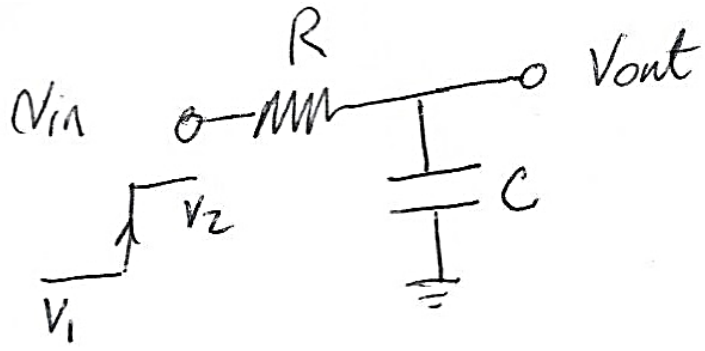

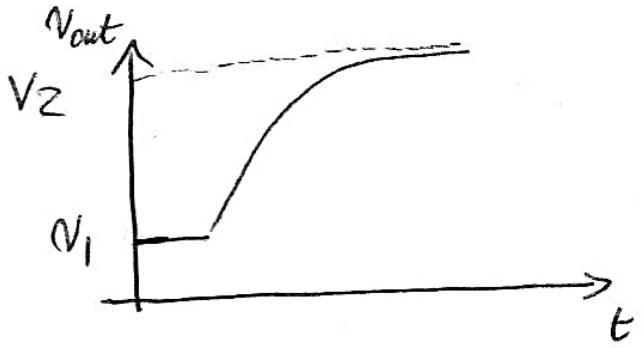

Equations:

$$V_{out}(t) = V_0 + V_2\left(1 - e^{-t/\tau}\right)$$

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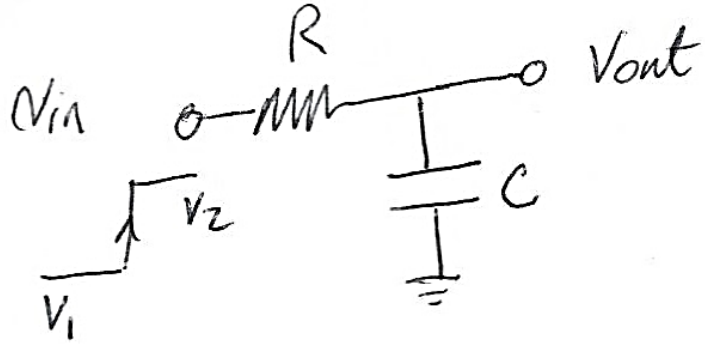

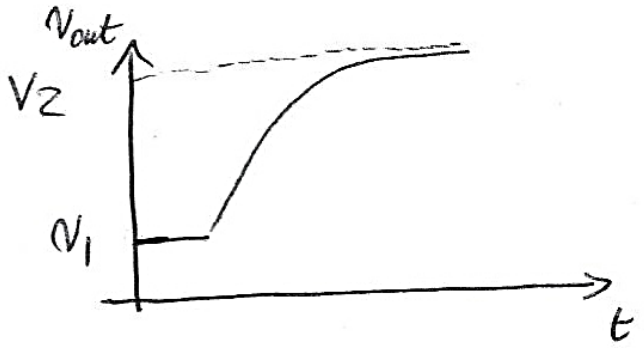

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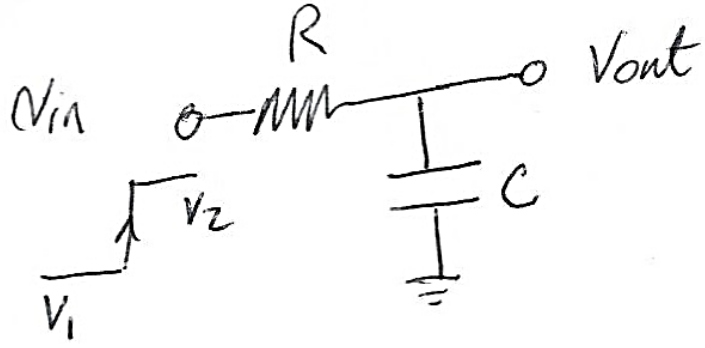

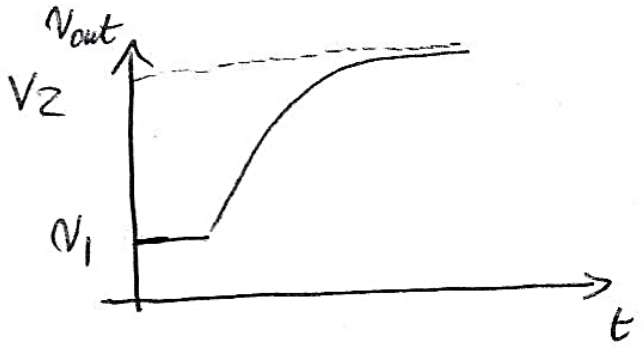

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$$1 - e^{-t/\tau} = 0.99 \Rightarrow e^{-t/\tau} = 0.01 \Rightarrow t = 4.6\,\tau$$

Exercise 9

a)

$$r_{ds} = \frac{1}{\mu_n C_{ox} \frac{W}{L} (V_{eff} - V_{DS})} \cong \frac{1}{\mu_n C_{ox} \frac{W}{L} V_{eff}}$$

Exercise 9

a)

$$r_{ds} = \frac{1}{\mu_n C_{ox} \frac{W}{L} (V_{eff} - V_{DS})} \cong \frac{1}{\mu_n C_{ox} \frac{W}{L} V_{eff}}$$

$$= \frac{1}{92 \times 10^{-6} \times \frac{10}{0.8} (5 - 1 - 0.8)} = 272\ \Omega$$

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Exercise 9

b) $V_{in}: 3 \longrightarrow 3.1\ V$

$$r_{ds} = \frac{1}{92\times10^{-6}\times\frac{10}{0.8}(5-3-0.8)} = 725\ \Omega$$

$$\Rightarrow \tau = 725\times10^{-12} = 0.725\ ns$$

$$\Rightarrow \text{Settling time} = 4.6\times0.725\times10^{-9} = 3.33\ ns$$

Exercise 9

$$V_{th} = V_{tho} + \gamma \left(\sqrt{V_{SB} + 2\varphi_F} - \sqrt{2\varphi_F} \right)$$

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$$\gamma = \frac{\sqrt{2 q k_S \varepsilon_0 N_A}}{C_{ox}} = \dots 0.5$$

Exercise 9

$$V_{th} = V_{tho} + \gamma \left(\sqrt{V_{SB} + 2\varphi_F} - \sqrt{2\varphi_F} \right)$$

$$\gamma = \frac{\sqrt{2 q k_S \varepsilon_0 N_A}}{C_{ox}} = \dots 0.5$$

$$\varphi_F = V_T \ln\left(\frac{N_A}{n_i}\right) = 0.35\,V$$

Exercise 9

$$V_{th} = V_{tno} + \gamma \left(\sqrt{V_{SB} + 2\varphi_F} - \sqrt{2\varphi_F} \right)$$

$$\gamma = \frac{\sqrt{2 q k_S \varepsilon_0 N_A}}{C_{ox}} = \dots 0.5$$

$$\varphi_F = V_T \ln\left(\frac{N_A}{n_i}\right) = 0.35\,V$$

for $V_{in} = 1\,V$:

$$V_{tn} = 0.8 + 0.5\left(\sqrt{1 + 2 \times 0.35} - \sqrt{2 \times 0.35}\right) = 1.03\,V$$

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$$t_{90\%} = 7.35\ ns$$

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$$r_{ds} = 1.32\,k\Omega \quad \Rightarrow \quad t_{99\%} = 6.1\,ns$$