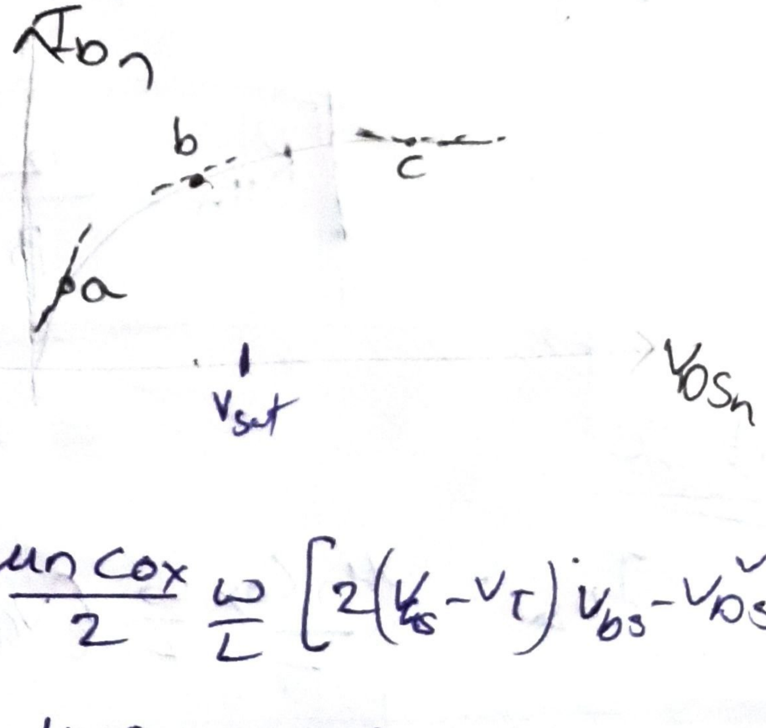
Threshold Voltage and Body bias Effect

↳ If Source and Body are not Shorted / not at Same potential, then it will <u>increase</u> Threshold voltage. This is known as **Body bias Effect**

Resistances:-



Point a:-

$$I_{D(linear)} = \frac{\mu_n C_{ox}}{2} \frac{W}{L} \left[2(V_{GS} - V_T) V_{DS} - V_{DS}^2 \right]$$

$$= \mu_n C_{ox} \frac{W}{L} \left[(V_{GS} - V_T) V_{DS} - \frac{V_{DS}^2}{2} \right]$$

here V_{DS} is small,

at point A,

V_{DS} is small, $\frac{V_{DS}^2}{2}$ is very small

So, $\frac{V_{DS}^2}{2} \approx 0$

$\therefore \; I_D = \mu_n C_{ox} \frac{W}{L} [V_{GS} - V_T] V_{DS}$

WKT, $\boxed{I = V/R}$

$$\Rightarrow \boxed{R_{linear} = \frac{1}{\beta_n [V_{GS_n} - V_{T_n}]}}$$

Point : B

$$I_{D_{lin}} = \frac{\mu_n C_{ox}}{2} \frac{W}{L} [2(V_{GS} - V_T) V_{DS} - V_{DS}^2]$$

here V_{DS} is large so, we won't neglect

$$I_{D_{lin}} = \frac{\mu_n C_{ox}}{2} \frac{W}{L} [2(V_{GS} - V_T) - V_{DS}] V_{DS}$$

$$\boxed{R_{lin} = \frac{2}{\beta [2(V_{GS} - V_T) - V_{DS}]}}$$

Point - C :-

$$I_{D_{sat}} = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_{GS} - V_T)^2$$

$$\boxed{R_{sat} = \frac{V_{DS}}{I_{D_{sat}}} = \frac{2 V_{DS}}{\beta (V_{GS} - V_T)^2}}$$

Capacitance

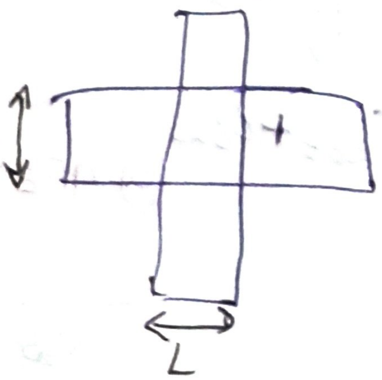
1. Gate capacitance / oxide Capacitance.

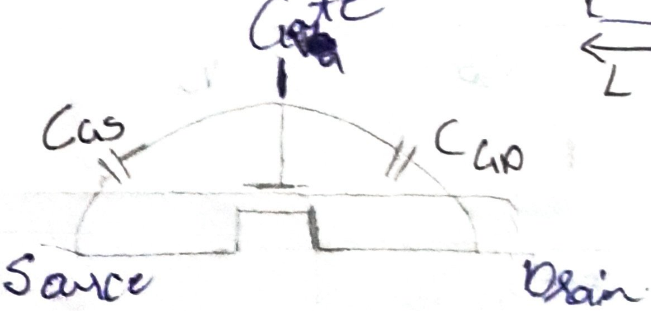
2. junction Capacitance

{ depletion region occur b/w "p" and "n" region. p & n are semiconducting layer. In b/w them acts as insulating layer
∴ It is Capacitance

① oxide capacitance:-

$$\boxed{C_G = C_{ox} W L}$$





$$\boxed{C_{GS} = C_{GD} = \frac{1}{2} C_G}$$

② junction Capacitance

bottom capacitance (like C_{ox})

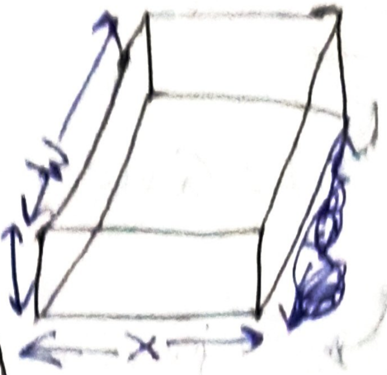
(i) $\boxed{C_{bot} = C_j W X}$

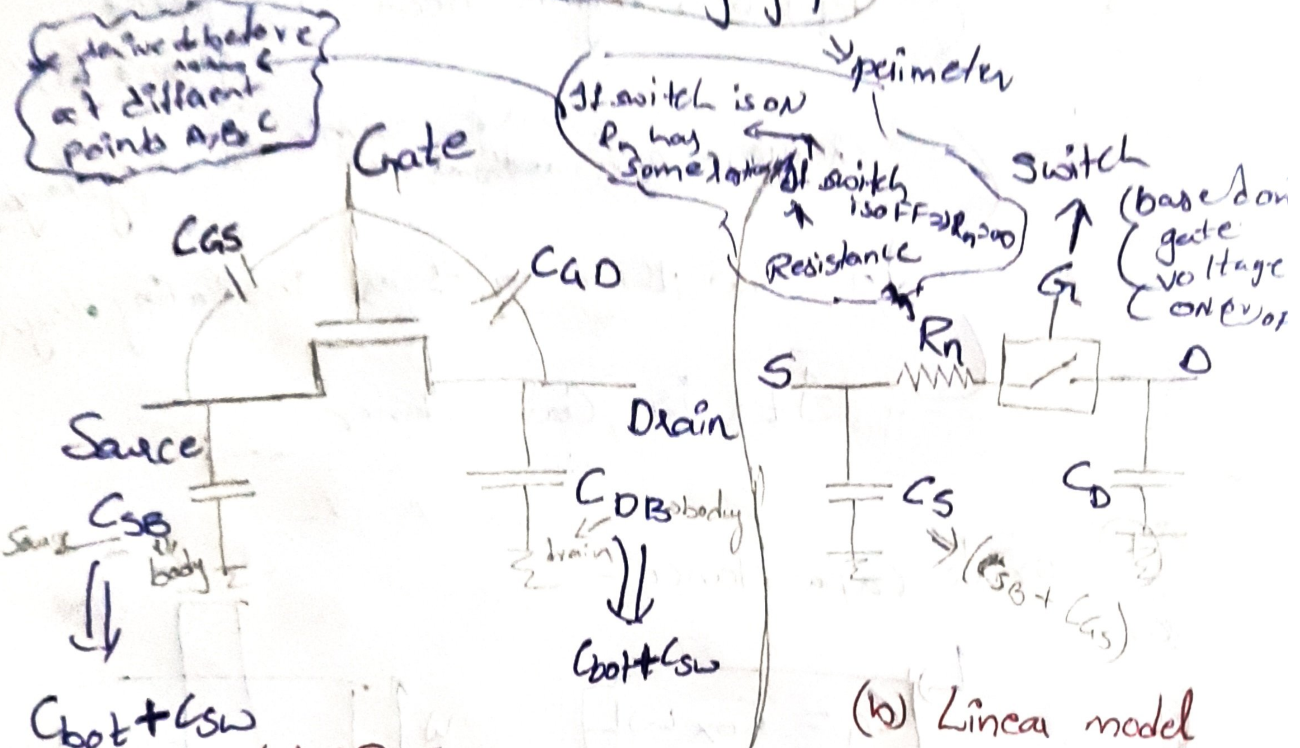
(ii) $\boxed{C_{SW} = C_j[2Wx_j + 2Xx_j]}$

side capacitancies

$\boxed{C_{SW} = C_j x_j P}$

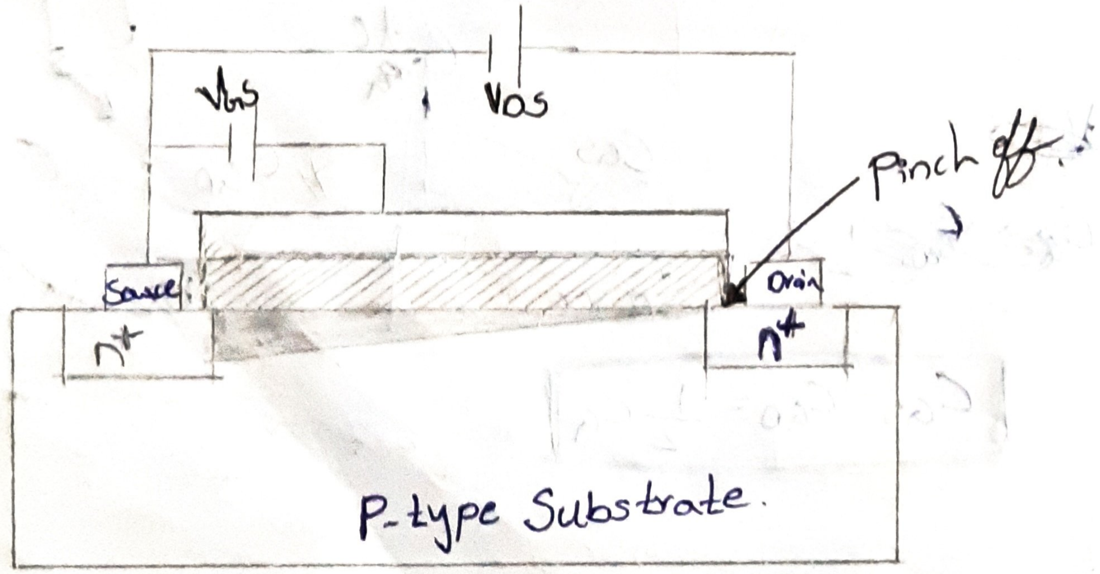
⇒ perimeter





(a) nFET

(b) Linear model for nFET.



Pinchoff Condition: → $\boxed{V_{GS} - V_{DS} = V_{Tn}}$ → $V_{DS_{sat}} = V_{GS} - V_T$

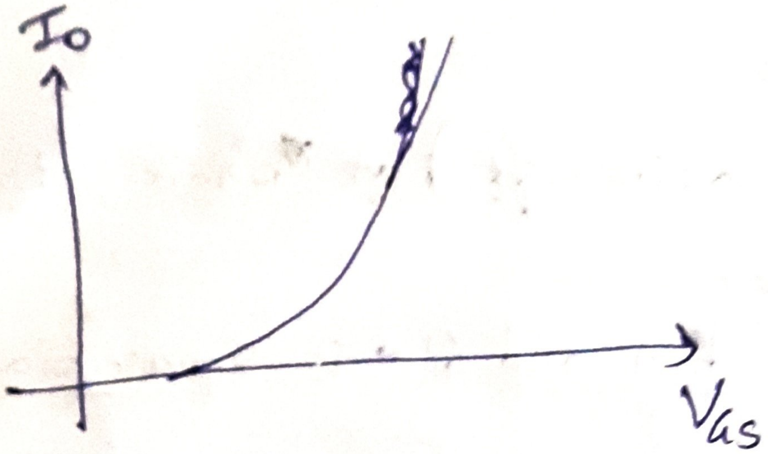
Pinch off :-

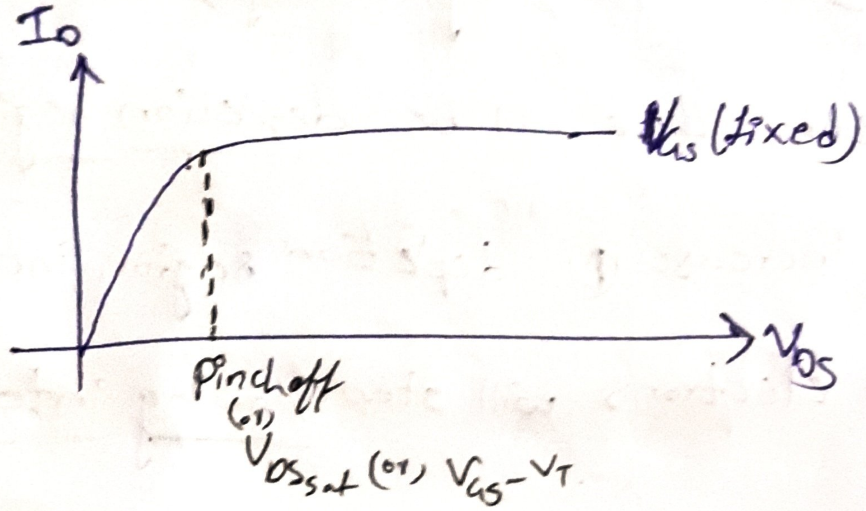
(at a pinch off) at Drain; there is pn junction and it is reverse biased (n^+ is connected to high voltage). Due to reverse biased there will be depletion region; as V_D increases (↑) depletion region increases (↑) so, electrons will stop flowing into n^+ region

This is known as pinch off.

* But the ~~current~~ electrons will flow (at constant rate) because of high electric field. This is known as Hot Carrier Effect.

↳ electrons will flow at constant rate even though V_D is very high. So current flows constantly after pinch off condition.


I_D
V_{GS}


I_D
V_{GS} (fixed)
V_{DS}
Pinchoff
(or)
$V_{DS_{sat}}$ (or) $V_{GS} - V_T$