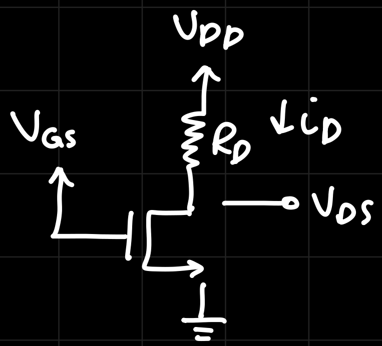
# MOSFET Amplifier Biasing

→ Establish $I_D$ through biasing
↳ DC operating point for a given $V_{GS}$

so that the amp provides adequate gain and undistorted output swing for input transitions



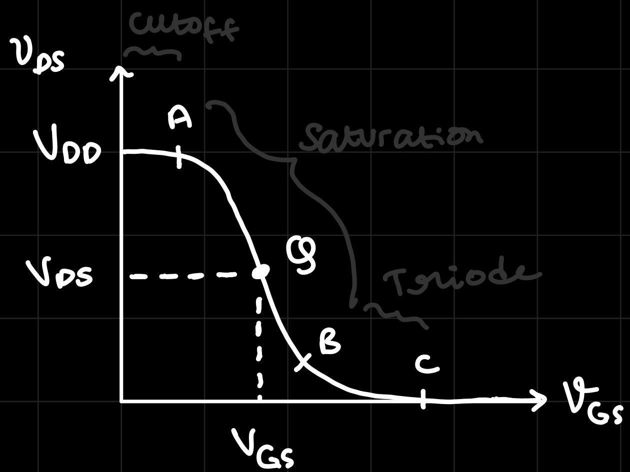

slope → $-\frac{1}{R_D}$

$$V_{DS} = V_{DD} - I_D R_D$$

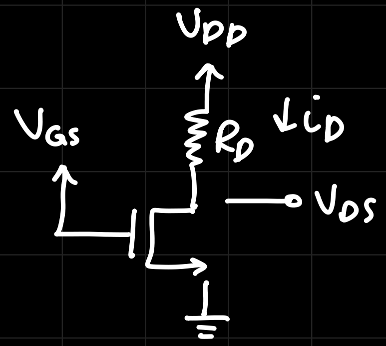
$$I_D = \frac{V_{DD}}{R_D} - \frac{V_{DS}}{R_D}$$

Q point in $\underbrace{\text{Voltage Transfer}}_{}$ characteristics, ($V_{DS}$, $V_{GS}$)
Input - output characteristics

Q point in $I_d - V_{GS}$ curve → ($I_D$, $V_{DS}$)

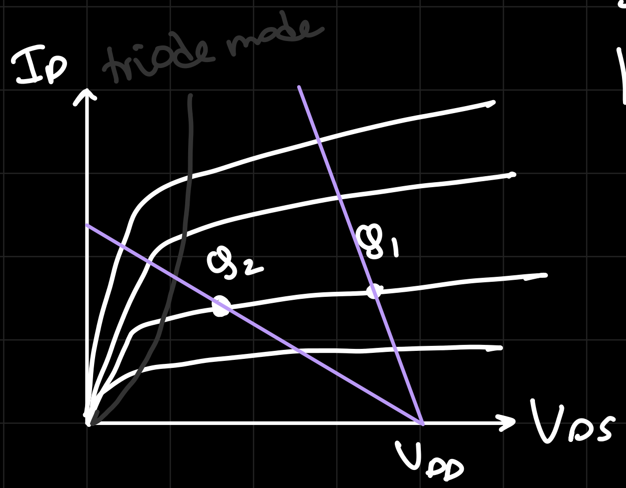



if Q was further down, towards B the output will have non linear distortions because the Amp goes into triode mode. (when input signal swing is high)




What value of $R_D$ to chose?

① suppose we choose $R_D = R_{D2}$ so that the we enter Q point at $Q_2$ for $V_{GS}$

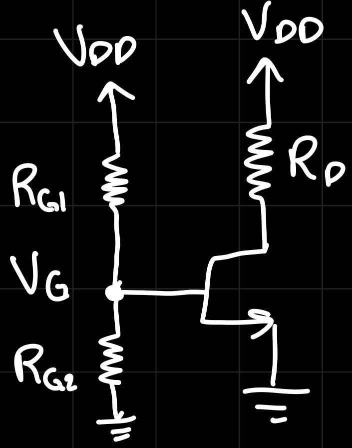



but negative trasients of the input signal might make the amp go into triode mode (not ideal)

for Q point = $Q_1$,
we are very close to $V_{DD}$ and the amplifier might go to cutoff mode for large -ve transients of input signal (distorted output)

we need $R_D$ to be such that Q point is between the above 2 extreme points

$R_D$ should be such that for a given $V_{GS}$ the Q point is well within the saturation point




① since $I_G = 0$ always we can keep higher values of $R_{G1}$ and $R_{G2}$ and hence high input impedance so it help us capture the entire info in the input signal

② $R_{G1}$ and $R_{G2}$ should be high but keep in mind $V_G > V_T$ for saturation.

also $V_D > V_G - V_T$

③ If I fix the value of $V_G$, my ckt is still not stable to variations in device parameters or temperature variation

→ we need a feed back mechanism and for this, an $R_S$ resistance is placed at the source

if $i_D \uparrow$ → $V_G = V_{GS} + I_D R_S$

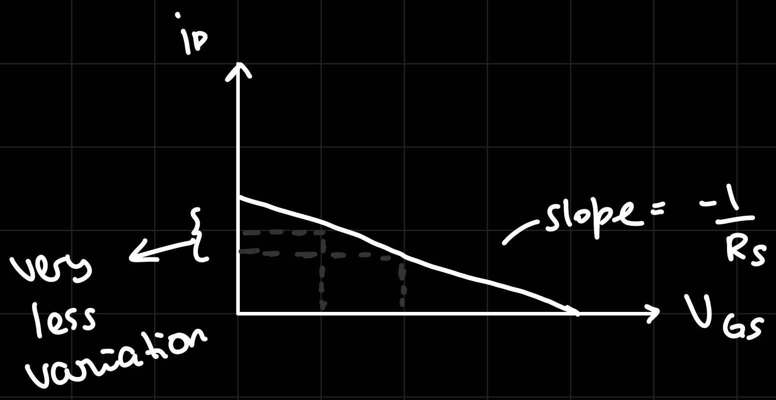
$V_{GS} = V_G - I_D R_S$

↓

$V_{GS} \downarrow$

↳ $i_D \downarrow$

if $i_D \downarrow \rightarrow V_{GS} \uparrow \rightarrow i_D \uparrow$ (feed back)




slope should be lower → $R_S$ should be ↑
but not → ∞

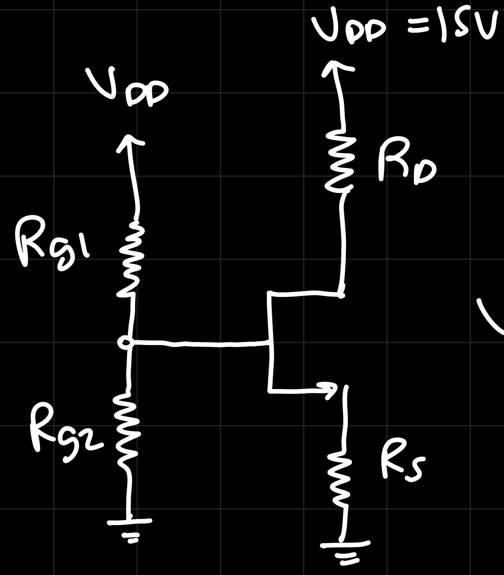
# Summary :

① $R_D$ : should be high provided the cutoff region is avoided

② $R_{G1}, R_{G2}$ : should be high such that MOSFET operates in the saturation region

③ $R_S$ : should also be very high to avoid fluctuations in $i_D$

eg3




$V_{T_1} = 1V$
$K_n = 1mA/V^2$

Q) Calculate the change in $I_D$ if mos is changed with device with same $k_n$ but different $V_{T2} = 1.5V$

Rule of thumb: We choose the $R_D$ and $R_S$ voltage drop as 1/3rd of the supply voltage

Ans)

$$V_D = V_{DD} - \frac{V_{DD}}{3} = 15 - 5 = \underline{10V}$$

$$V_S = V_{DD} - \frac{V_{DD}}{3} - \frac{V_{DD}}{3} = 5V$$

saturation → $I_d = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_T)^2$

$$1 = (V_{GS} - 1)^2$$

$$V_{GS} = 2V$$

$$V_G = V_{GS} + V_S = \underline{7V}$$

$V_{DS} = 5V \qquad V_{GS} - V_T = 1V$

$V_{DS} > V_{GS} - V_T$ ✓

$$V_G = \frac{R_2}{R_1 + R_2} \times 15$$

$7R_1 + 7R_2 = 15R_2$

$7R_1 = 8R_2$

if i assume $R_1 = 8M\Omega \rightarrow R_2 = 7M\Omega$

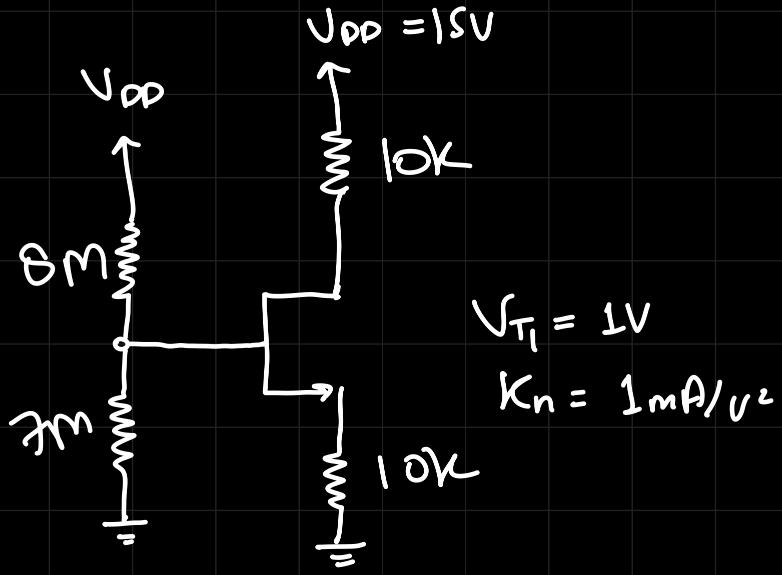
$$R_D = \frac{V_{DD} - V_D}{I_D} = \frac{5}{0.5m} = \underline{10k\Omega}$$

$$R_S = \frac{V_S}{I_D} = \frac{5}{0.5m} = 10k\Omega$$

all resistors found

$\rightarrow$ at $V_T = 1.5V$

$V_{GS}$ and $I_D$ will change




$$-15 + 10k I_D + V_{DS} + 10k I_D = 0$$

$$I_D = \frac{15 - V_{DS}}{20k}$$

$$V_G = V_{GS} + V_S = V_{GS} + I_D R_S$$

$$V_{GS} + 10K I_D = 7$$

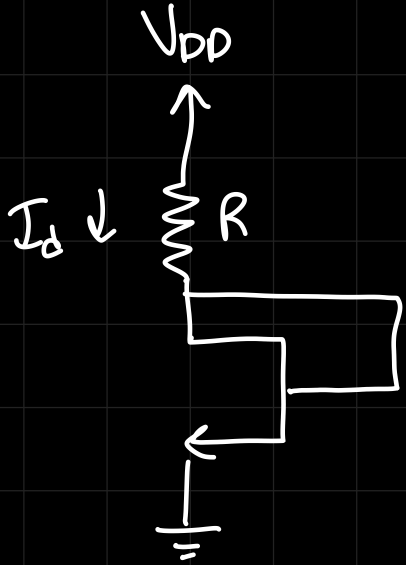
$$I_D = \frac{1}{2}(5.5 - 10K I_D)^2$$

$$2I_D = 30.25 + 100M I_D^2 - 110K I_D$$

$$I_{D2} = 0.5mA \quad , I_{D1} =$$

note: $K_n = \mu_n C_{ox}$

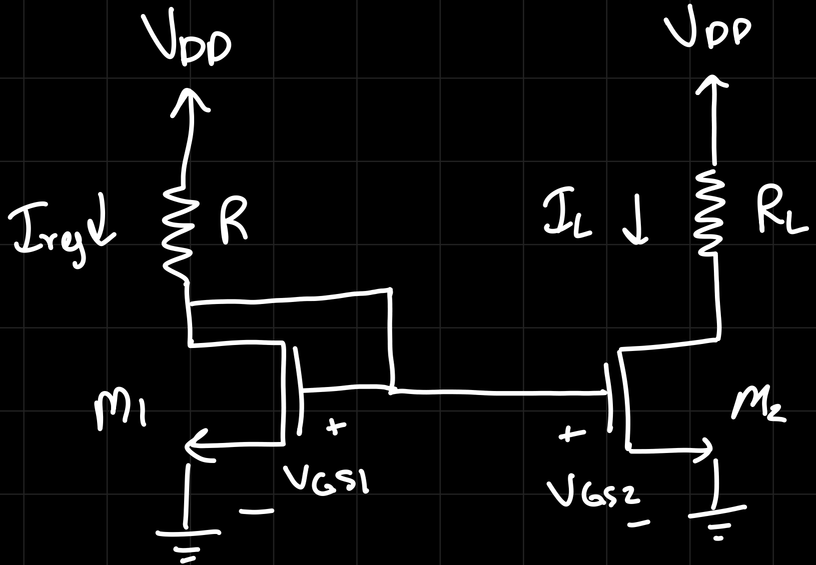
# current mirror circuit




we know,
$V_D = V_G$
$V_G > V_T$ ofc
$V_D > V_G - V_T$
always in saturation mode

$$I_D = K(V_{GS} - V_T)^2$$

$$V_{GS} = \sqrt{\frac{I_D}{K}} + V_T$$



if $V_{T1} = V_{T2}$ and $M_1, M_2$ have same characteristics

$$I_L = K(V_{GS_2} - V_T)^2$$
$$I_{ref} = K(V_{GS_1} - V_T)^2$$

since both gate terminals are shorted
$$V_{GS1} = V_{GS2}$$

So, $I_{ref} = I_L$ only if $R_L$ is such that $M_2$ remains in saturation

8th march → Tut simulation