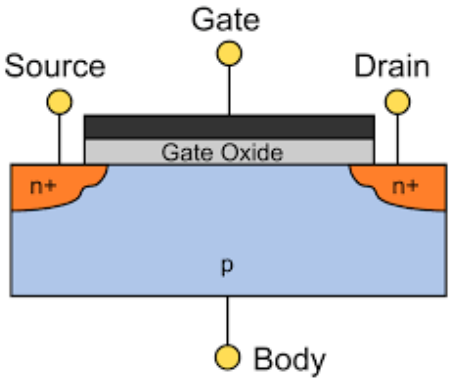
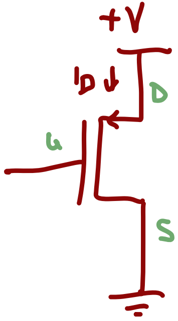
How do fets work?

FET:



NMOS



$$\underbrace{V_{th} = 0.6V}_{V_{GS}}$$

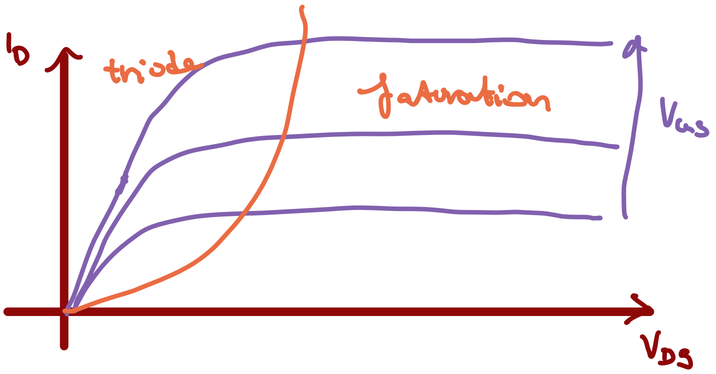
$V_{GS} > V_{th}$: Strong Inversion (essentially ON)

$V_{GS} < V_{th}$: weak inversion

In strong Inversion:

Triode Region: $V_{DS} < V_{GS} - V_{th}$

Saturation Region: $V_{DS} > V_{GS} - V_{th}$



Once it's saturated, changes you make to the voltages you're applying (like V_{DS}) won't change I_D anymore.

$$I_D = \underbrace{\frac{1}{2}\mu_n C_{ox}\frac{W}{L}}_{\text{attributes of the FET}}(V_{GS} - V_{th})^2(1+\underbrace{\lambda V_{DS}}_{\text{usually 0}})$$

But why all of this?

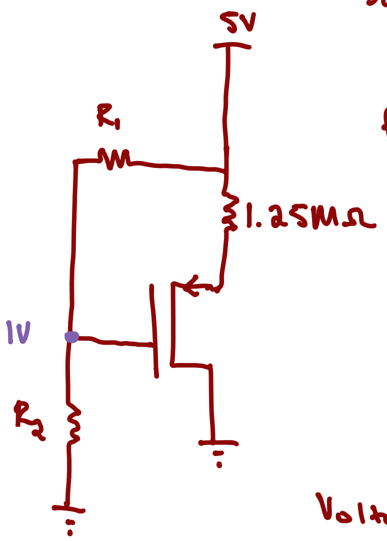
FETs are switches but we can't just flip them like mechanical switches

We tell FETs to be on or off using the gate voltage, making $V_{GS} > V_{th}$

$\mu_n C_{ox} \frac{W}{L} = 32 \mu A/V^2$ $V_{th} = 0.5V$

$\lambda = 0$

Find R_1 and R_2 such that $I_D = 4\mu A$



$V_{GS} = 1V$

$V_{th} = 0.5V$

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{th})^2(1+\lambda V_{DS})$$

$$= 16\mu (V_{GS}-V_{th})^2$$

$$4\mu A = 16\frac{\mu A}{V^2}(V_{GS}-0.5)^2$$

$$0.25V^2 = V_{GS}^2 - V_{GS} + 0.25V^2$$

$$V_{GS} = 1V$$

Voltage divider:

$$1V = \frac{5V\ R_1R_2}{R_1+R_2}$$

$$R_1+R_2 = 5R_1R_2$$

$$R_1 = 1k\Omega$$

$$1k\Omega + R_2 = 5k(R_2)$$

$$R_2(5k-1) = 1k\Omega$$

$$R_2 = \frac{1k\Omega}{4.999k} = 0.2\Omega$$