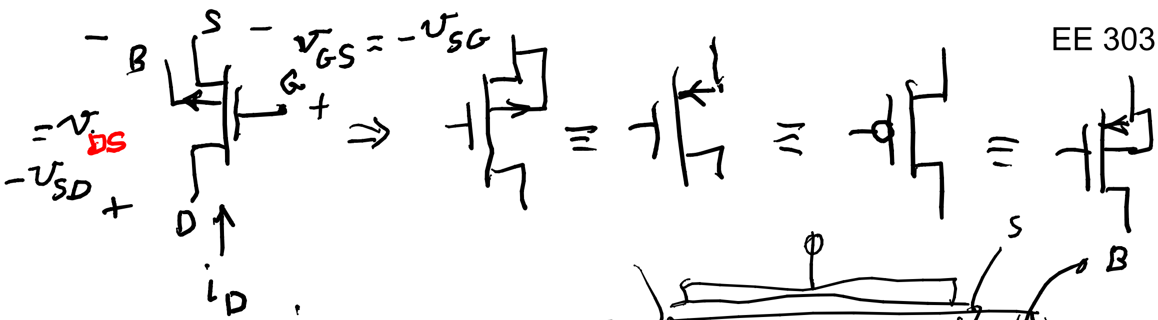
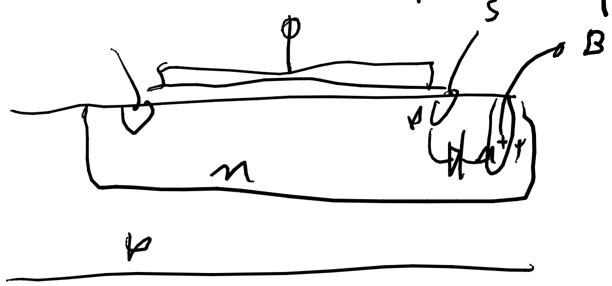
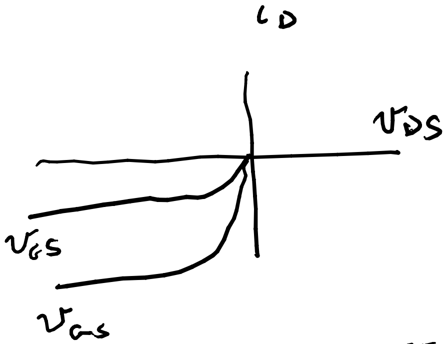
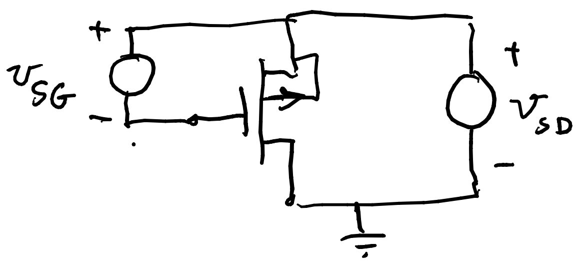
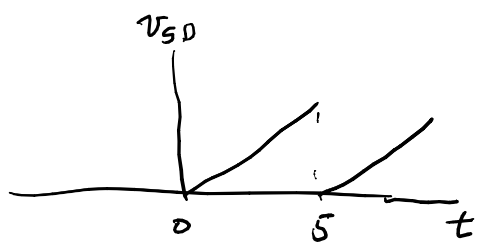
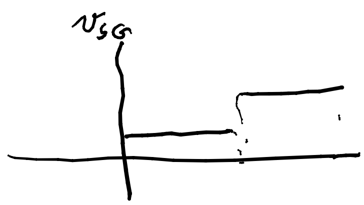






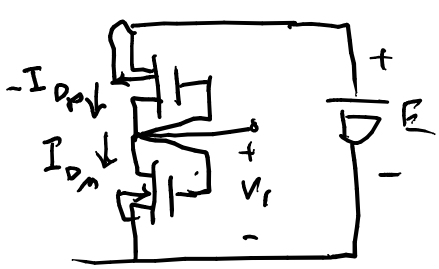


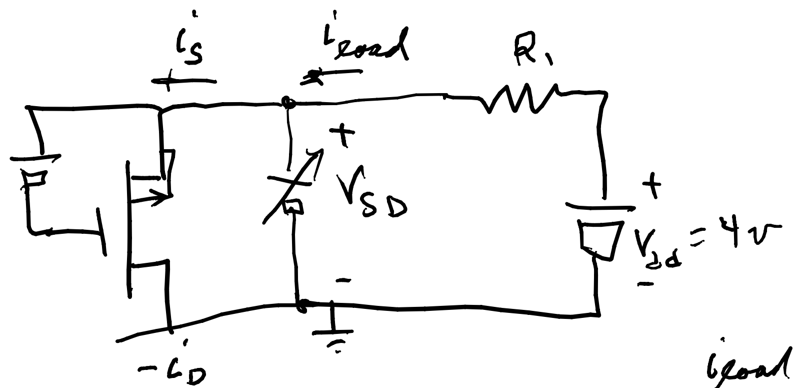




PMOS

$$I_D = -\frac{KP}{2}\frac{W}{L}\left(-V_{GS}-(-VTO)\right)^2\left(1+\lambda(-V_{DS})\right)$$ in saturation



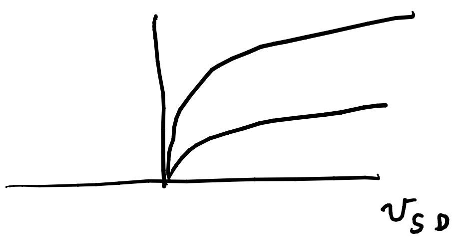


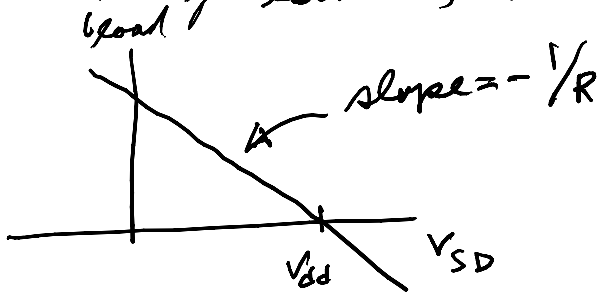
i_{load}:

$$0 = -V_{SD} - R_1 i_{load} + V_{dd}$$

$$i_{load} = \frac{1}{R_1}(V_{dd} - V_{SD})$$

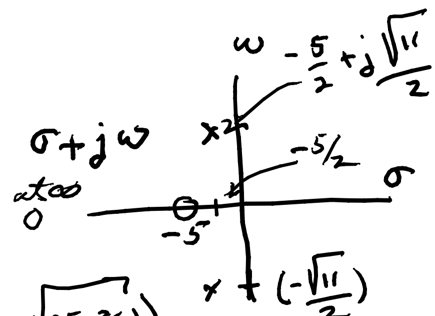
for $i_{load} = 0$, $V_{SD} = V_{dd}$





Poles & zeros

$$\frac{V_o}{V_i}(s) = \frac{3(s+5)}{s^2+5s+9} \quad ; \quad s = \sigma + j\omega$$



$$= \frac{3(s-(-5))}{\left(s-\left(-\frac{5}{2}+\frac{\sqrt{25-36}}{2}\right)\right)\left(s-\left(-\frac{5}{2}-\frac{\sqrt{25-36}}{2}\right)\right)}$$

$$= \frac{3(s+5)}{\left(s-\left(-\frac{5}{2}+j\frac{\sqrt{11}}{2}\right)\right)\left(s-\left(-\frac{5}{2}-j\frac{\sqrt{11}}{2}\right)\right)}$$

$i = C\frac{dv}{dt} \Rightarrow sC \cdot v \Rightarrow s = d/dt$ here

$$(s^2+5s+9)v_o = (3s+15)v_i \Rightarrow \frac{d^2 v_o}{dt^2} + 5\frac{dv_o}{dt} + 9v_o = 3\frac{dv_i}{dt} + 15v_i$$

let $v_i(t) = V_i e^{st}$, $v_o(t) = V_o e^{st}$

$$(s^2 V_o e^{st} + 5V_o \cdot s e^{st} + 9V_o e^{st}) = 3sV_i e^{st} + 15V_i e^{st}$$

can cancel e^{st} as e^{st} is $\neq 0$

$$(s^2+5s+9)V_o = (3s+15)V_i$$

here s is the s in the eigenfunction e^{st}

also can treat s as Laplace transform variable

$$F(s) = \int_{0\,(-\infty)}^{\infty} f(t)e^{-st}\,dt = \mathcal{L}[f]$$

$$\frac{V_o}{V_i}(s) = \mathcal{L}[\text{impulse response}] = \mathcal{L}[h(t)]$$

then $h(t) = \mathcal{L}^{-1}\left[\frac{V_o}{V_i}(s)\right]$

$$v_o(t) = \int_{0\,(-\infty)}^{\infty} h(t-\tau)v_i(\tau)\,d\tau$$

Ex:

$$\frac{V_o}{V_i}(s) = \frac{3(s+5)}{(s+2)(s+3)} = \frac{k_1}{(s+2)} + \frac{k_2}{(s+3)}$$

$$k_1 = \left.\frac{3(s+5)\cancel{(s+2)}}{\cancel{(s+2)}(s+3)}\right|_{s=-2} - \left.\frac{k_2(s+2)}{s+3}\right|_{s=-2} = \frac{3(-2+5)}{-2+3} + 0 = 9$$

$$k_2 = \left.\frac{3(s+5)}{s+2}\right|_{s=-3} = \frac{3(+2)}{-1} = -6$$

$$\frac{V_o}{V_i} = \frac{9}{s+2} + \frac{-6}{s+3} \overset{\text{as a check}}{=} \frac{9(s+3)+(-6)(s+2)}{(s+2)(s+3)} = \frac{3s+15}{(s+2)(s+3)}$$

$$\mathcal{L}^{-1}\left(\frac{V_o}{V_i}\right) = \underbrace{h(t)}_{v_o \text{ when } v_i = \delta(t)} = 9e^{-2t}1(t) - 6e^{-3t}1(t); \quad \underbrace{1(t) = \begin{cases} 1 & t>0 \\ 0 & t<0 \end{cases}}_{= \text{unit step}}$$