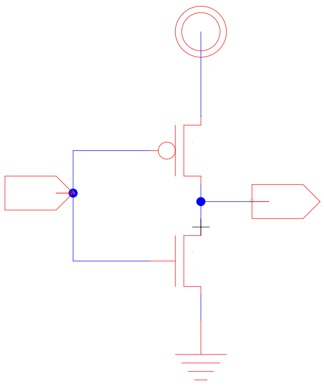
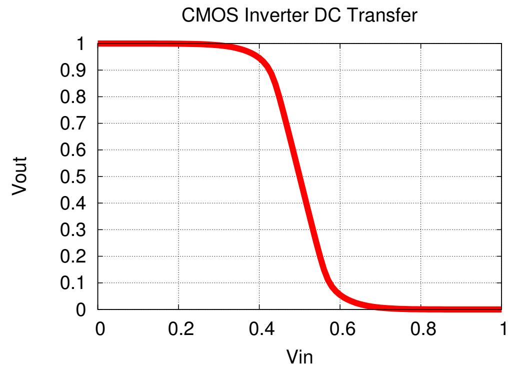
Device	V_{gs}	I_d
NMOS	$V_{gs} < V_{thn}$	$\left(3\times10^{-7}\right)e^{\frac{V_{gs}-V_{thn}}{40mV}}$
	$V_{gs} > V_{thn}$	$1.8\times10^{-4}\left(V_{gs}-V_{thn}\right)$
PMOS	$V_{gs} > V_{thp}$	$\left(3\times10^{-7}\right)e^{-\left(\frac{V_{gs}-V_{thp}}{40mV}\right)}$
	$V_{gs} < V_{thp}$	$-1.8\times10^{-4}\left(V_{gs}-V_{thp}\right)$

Consider an inverter using the pmos and nmos devices described above:





Useful: $e^{-1}\approx 0.37$, $e^{-4}\approx 0.02$, $e^{-7.5}\approx 6\times10^{-4}$,

1. V_{dd}=1V, V_{thn}=300mV, V_{thp}=-300mV, assume the static current is in steady-state operation and dynamic/short circuit current are the peak currents at V_{in} given.

V_{in}	I_{static}	$I_{dynamic}$	I_{sc}	
0V	180pA	126μA	0	A
140mV	6nA	100μA	0	B
400mV	0	36μA	18μA	C
500mV	0	0	36μA	D
600mV	0	36μA	18μA	E
860mV	6nA	100μA	0	F
1V	180pA	126μA	0	G

2. V_{dd}=520mV, V_{thn}=300mV, V_{thp}=-300mV, assume gate is unloaded (no output capacitance to charge).

V_{in}	I_{static}	$I_{dynamic}$	I_{sc}	
0V				A, F
140mV				B, G
260mV				C
380mV				D
520mV				E

Device	V_{gs}	I_d
NMOS	$V_{gs} < V_{thn}$	$(3\times10^{-7})\,e^{\frac{V_{gs}-V_{thn}}{40mV}}$
	$V_{gs} > V_{thn}$	$1.8\times10^{-4}\,(V_{gs}-V_{thn})$
PMOS	$V_{gs} > V_{thp}$	$(3\times10^{-7})\,e^{-\left(\frac{V_{gs}-V_{thp}}{40mV}\right)}$
	$V_{gs} < V_{thp}$	$-1.8\times10^{-4}\,(V_{gs}-V_{thp})$

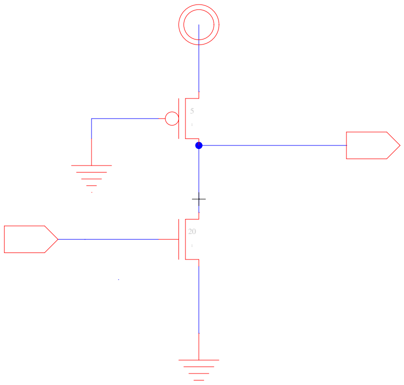
Useful: $e^{-1}\approx 0.37$, $e^{-4}\approx 0.02$, $e^{-7.5}\approx 6\times10^{-4}$,

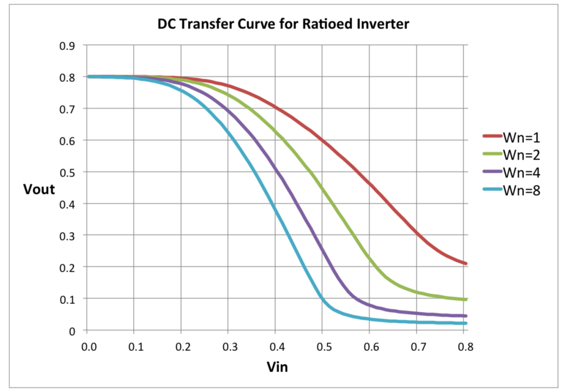
3. V_{thn}=300mV, V_{thp}=-300mV, V_{in}=V_{dd}; estimate $\tau = CV/I$

V_{dd}	I_{dyn}	$\frac{\tau}{\tau(V_{dd}=1V)}$	$\frac{E_{switch}}{E_{switch}(V_{dd}=1V)}$	$E\tau$	
1V		1	1	1	all
700mV					A, E
500mV					B, F
350mV					C, G
260mV					D

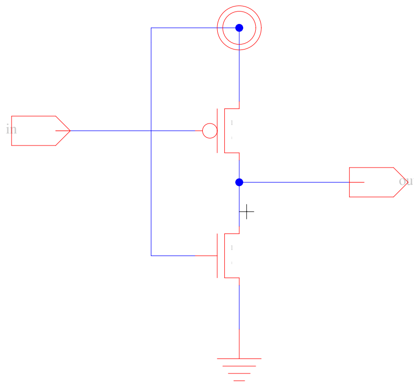
4. V_{dd}=1V, V_{in}=V_{dd}

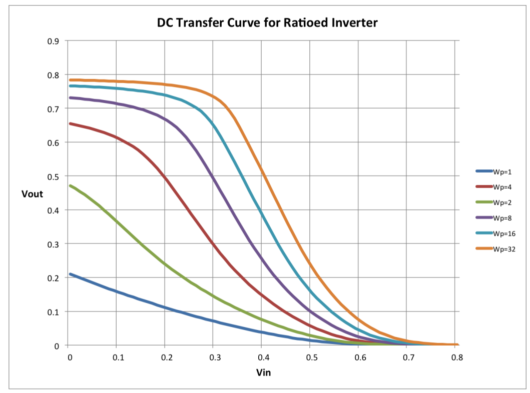
V_{thn} = -V_{thp}	I_{dyn}	$\frac{\tau}{\tau(\lvert V_{th}\rvert=300mV)}$	I_{static}	$\frac{I_{static}}{I_{static}(\lvert V_{th}\rvert=300mV)}$	
300mV		1		1	all
460mV					A, B, C
600mV					D, E, F, G





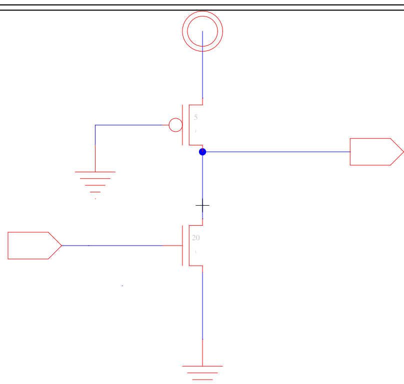
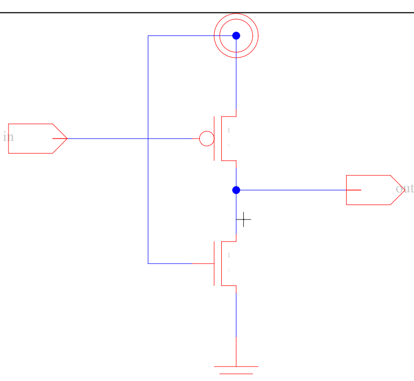
$W_p = 1$





$W_n = 1$

5. Size W_n or W_p for correct operation with $V_{ol} \leq 0.1V_{dd}$ and $V_{oh} \geq 0.9V_{dd}$, where $V_{dd} = 0.8$. Assume extreme velocity saturation, $R_{0p} = R_{0n}$.

	W_p	W_n	C_{in} in multiples of C_0
	1		
		1	