Final Review Session 1

Tuesday, June 7, 2022 2:02 PM

Cheatsheet ~~Physics~~ Eq.
$Q = CV$
⋮
etc.

This Course

→ Foundation: KVL, KCL, MCA, NVA, components
→ Equivalent Circuits, Norton/Thevenin, Superposition
→ 1st and 2nd Order Circuits
→ Nonlinear Components: Diodes, MOSFETs, Op Amps

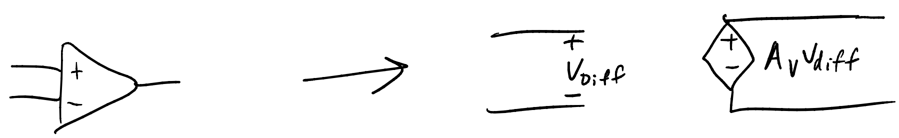
The Final

→ 5 Questions
→ Topics:
1. Thevenin/Norton
2. 1st and 2nd Order
3. MOSFET (Digital)

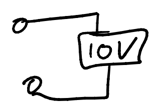
Today

4. MOSFET (SSM)
5. Op Amps

Tomorrow

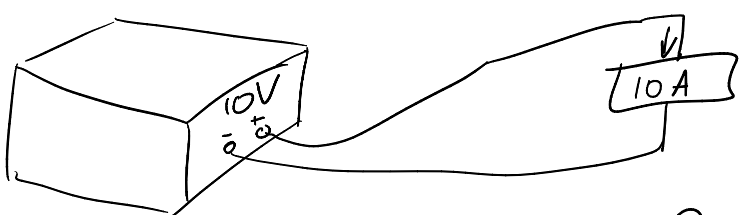


Thevenin/Norton

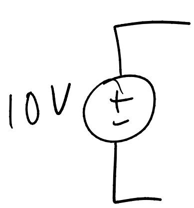


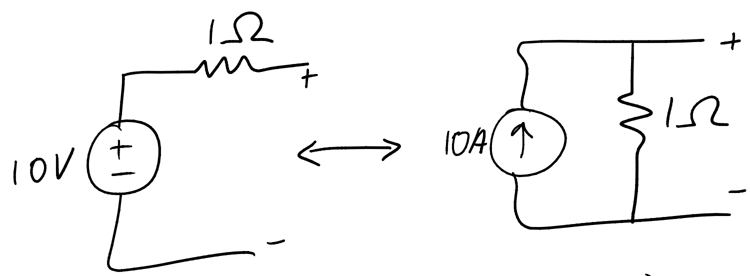
← $V_{OC} = V_{Th}$

$$R_{Th} = \frac{V_{Th}}{I_N} = 1\Omega$$



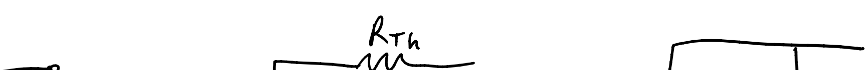
← $I_{sc} = I_N$

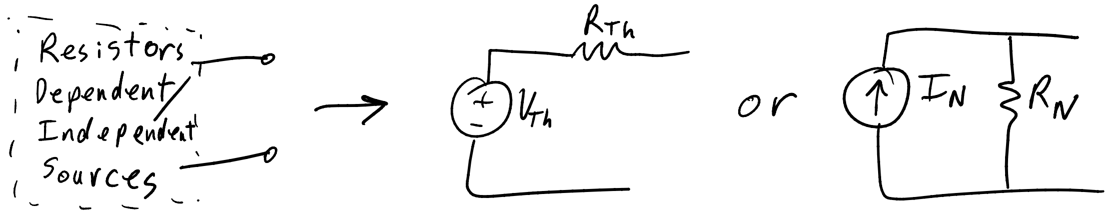




(Thevenin) (Norton)

Resistors



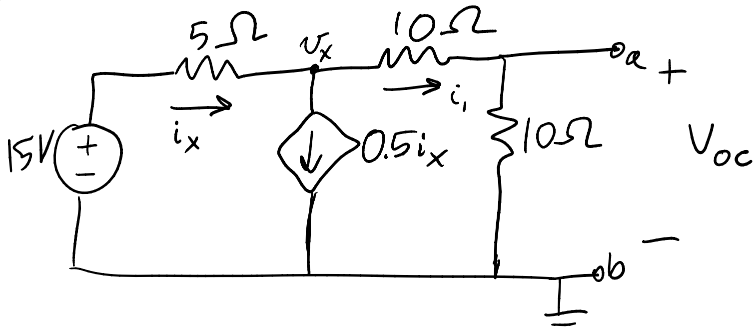


$$R_{Th} = R_N$$

$$V_{Th} = I_N R_N = I_N R_{Th}$$

$$V_{Th} = V_{oc} \qquad I_N = I_{sc}$$

P-Final Q1



$V_{oc} = 10 i_1$

$i_1 = \frac{V_{oc}}{10}$

$V_{oc} = 5V$

$i_x = i_1 + 0.5 i_x$

$0.5 i_x = i_1$

$i_1 = \frac{v_x}{20} = \frac{1}{2} A$

$i_x = \frac{15 - v_x}{5}$

$$0 = \frac{v_x}{20} - i_x + 0.5 i_x$$

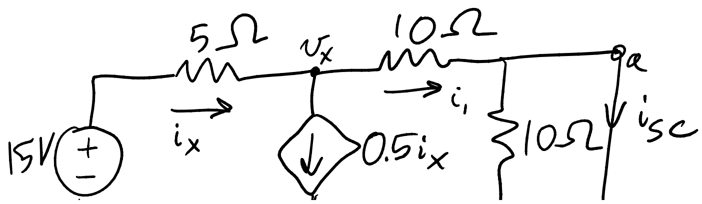
$$0 = \frac{v_x}{20} - 0.5\left(\frac{15 - v_x}{5}\right)$$

$$0 = \frac{v_x}{20} - \frac{15}{10} + \frac{v_x}{10}$$

$$\frac{15}{10} = \frac{3 v_x}{20}$$

$$30 = 3 v_x$$

$$v_x = 10V$$

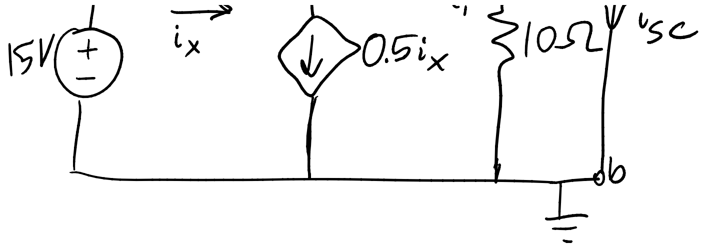


$i_x = \frac{15 - v_x}{5}$

$i_1 + 0.5 i_x - i_x = 0$

$\frac{v_x}{10} - 0.5 i_x = 0$

$\frac{v_x}{10} - 0.5\left(\frac{15 - v_x}{5}\right) = 0$



$$\frac{v_x}{10} - 0.5\left(\frac{15-v_x}{5}\right) = 0$$

$$\frac{v_x}{10} - \frac{15}{10} + \frac{v_x}{10} = 0$$

$$\frac{v_x}{5} = \frac{15}{10}$$

$$v_x = \frac{15}{2}$$

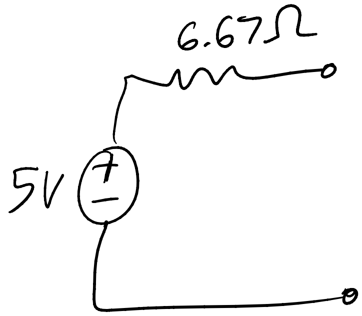
$$i_{sc} = i_1 = \frac{v_x}{10}$$

$$i_{sc} = \frac{3}{4} = 0.75A$$

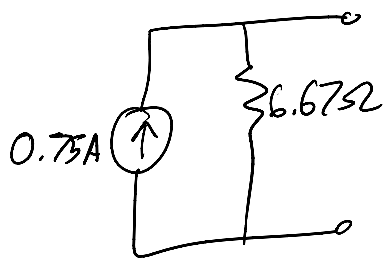
$V_{oc} = 5V$

$i_{sc} = 0.75A$

$R_{th} = \frac{V_{oc}}{i_{sc}} = 6.67\Omega$

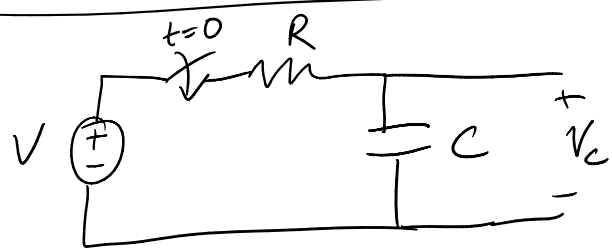


Thevenin



Norton

1st and 2nd Order



General Form

$$V_c(t) = V_\infty - (V_\infty - V_0)e^{-t/\tau}$$

$$V_c(t) = V - (V)e^{-t/\tau}$$

$V_0 = 0$

$V_\infty = V$

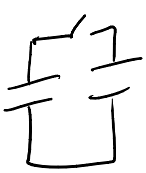
$\boxed{\begin{array}{l}\text{Cap } V \text{ cannot change instantly} \\ \text{Ind } I \text{ cannot change instantly}\end{array}}$

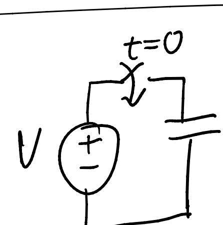
$I_c = C\frac{dV_c}{dt}$

$V_L = L\frac{di_L}{dt}$

$E_{L_1} = \frac{1}{2}L i_{L_1}^2$

$\boxed{i_{L_1}(0^-) = 1}$, $i_{L_2}(0^-) = 0$

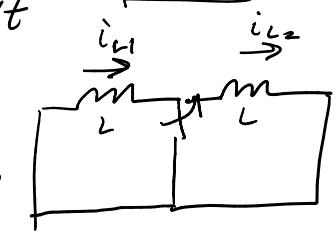




$V_c(0^-) = 0$

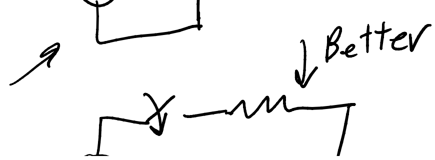
$V_c(0^+) = V$

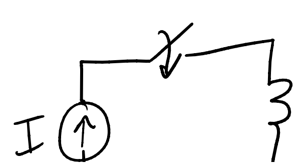
$I_c(0^+) = \infty$

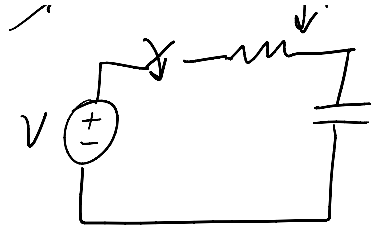


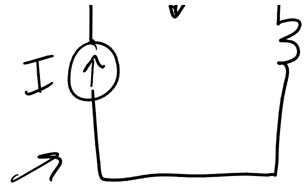
$L_{eq} = L + L = 2L$

$\frac{1}{2}L = E_{L_{eq}}(0^+) = \frac{1}{2}(2L)\, i^2$



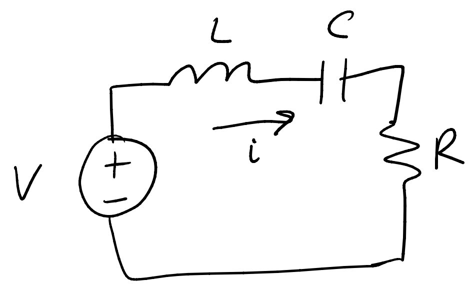


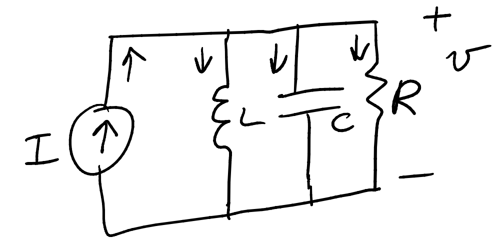




$\frac{1}{2}L = E_{L_{eq}}(0^+) = \frac{1}{2}(2L)\, i$

$i = \sqrt{\frac{1}{2}}$





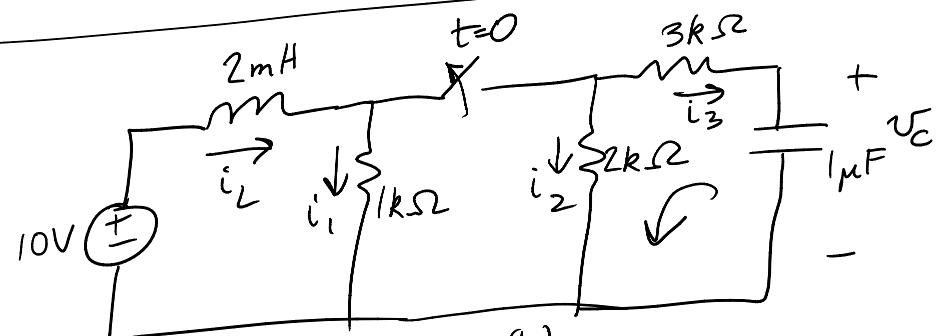
KVL: $V = L\frac{di}{dt} + \frac{1}{C}\int i\,dt + iR$

$0 = L\frac{d^2 i}{dt^2} + \frac{1}{C}i + R\frac{di}{dt}$

KCL: $I = \frac{1}{L}\int v\,dt + C\frac{dv}{dt} + \frac{v}{R}$

$0 = \frac{1}{L}v + C\frac{d^2v}{dt^2} + \frac{1}{R}\frac{dv}{dt}$

P-Final Q2



(a)

$i_L(0^-) = i_1(0^-) + i_2(0^-) = 15mA$

$i_1(0^-) = 10mA$

$i_2(0^-) = 5mA$

$i_3(0^-) = 0$

$v_c(0^-) = 10V$

(b)

$i_L(0^+) = 15mA$

$i_1(0^+) = 15mA$

$i_2(0^+) = \frac{10}{5000} = 2mA$

$i_3(0^+) = -2mA$

$v_c(0^+) = 10V$

(c) $i_L(t) = i_{L\infty} - (i_{L\infty} - i_{L0})e^{-t/\tau}$

$i_L(t) = 0.01 - (0.01 - 0.015)e^{-t/(2\times10^{-6})}$

$i_L(t) = 0.01 + 0.005e^{-t/(2\times10^{-6})}$

$i_{L\infty} = 10mA$

$i_{L0} = 15mA$

$\tau = \frac{L}{R} = 2\times10^{-6}\,s$

(d) $v_c(t) = v_{c\infty} - (v_{c\infty} - v_{c0})e^{-t/\tau}$

$v_c(t) = 0 - (0 - 10)e^{-t/(5\times10^{-3})}$

$-t/(5\times10^{-3})$

$v_{c\infty} = 0$

$v_{c0} = 10$

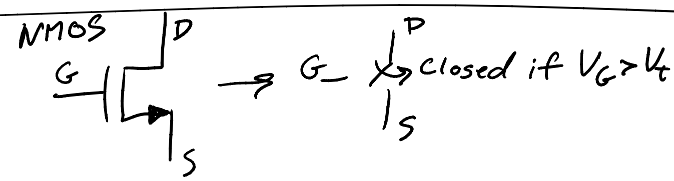
$\tau = RC = 5\times10^{-3}\,s$

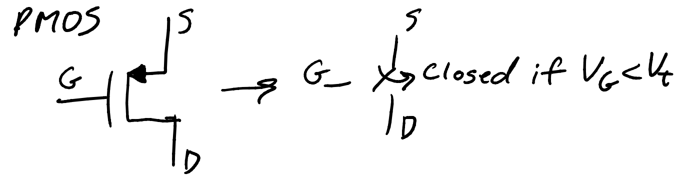
$v_c(t) = 0 - (0-10)e^{-t/(5\times10^{-3})}$

$v_c(t) = 10e^{-t/(5\times10^{-3})}$

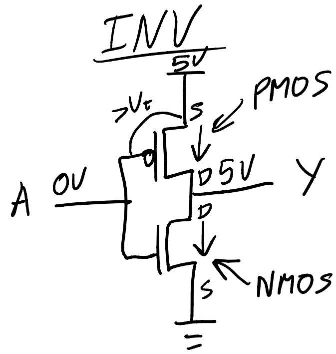
$\tau = RC = 5\times10^{-3}\,s$

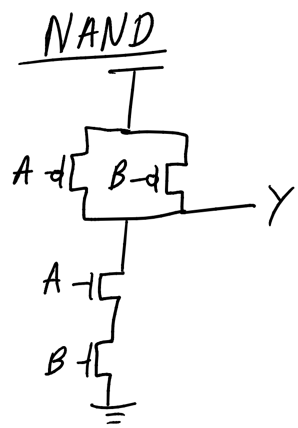
MOSFETs (Digital)

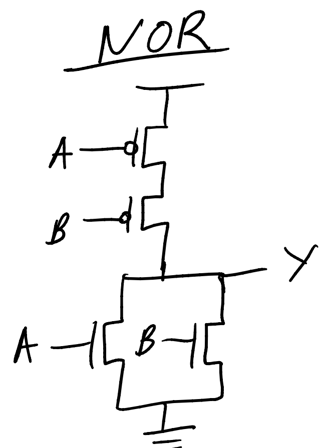




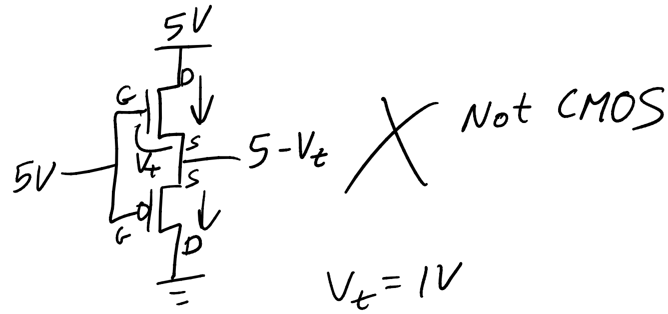
P-Final Q3



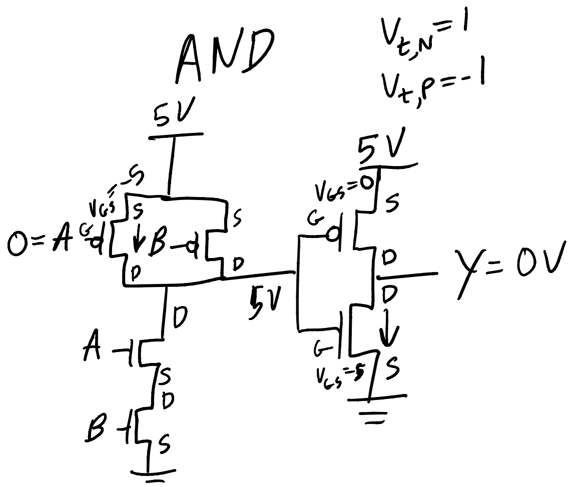


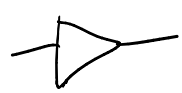


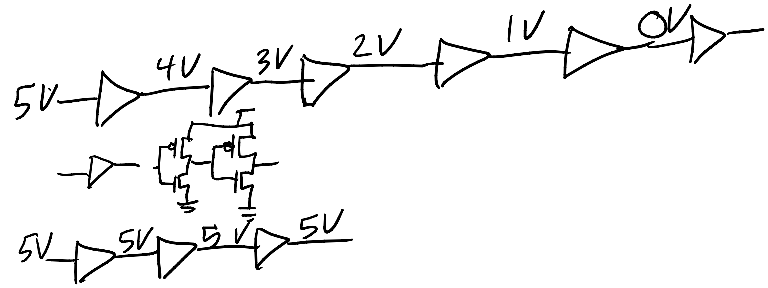
Why are PMOS pull-up?
NMOS pull-down?

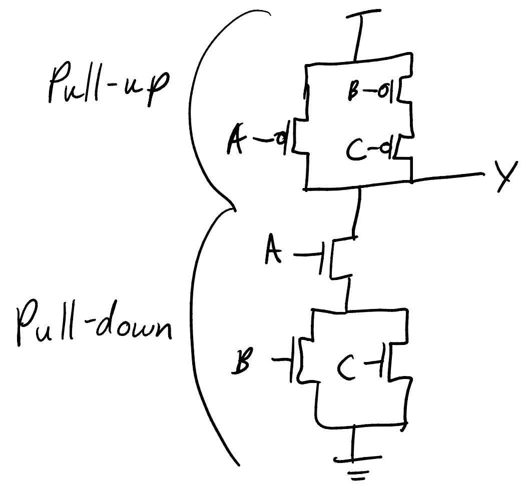


$V_t = 1V$

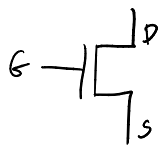






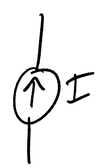


A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

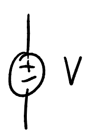


$V_{GS} > V_t$

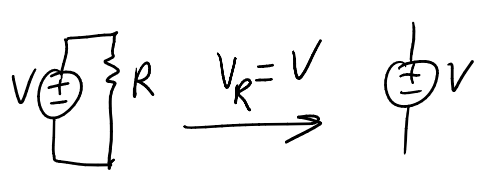
$V_S < V_G - V_t$ if MOSFET is on.

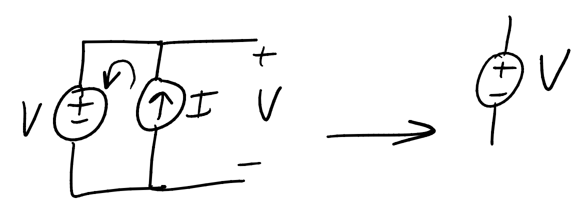


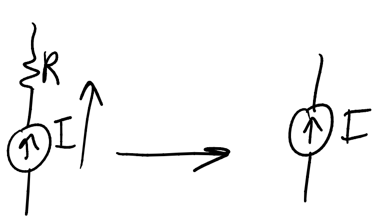
→ Constant Current

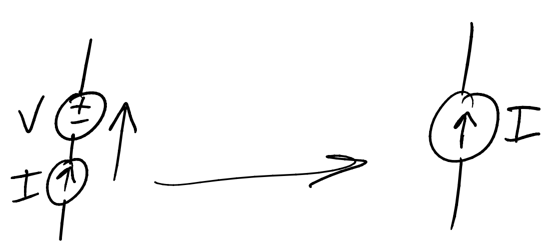


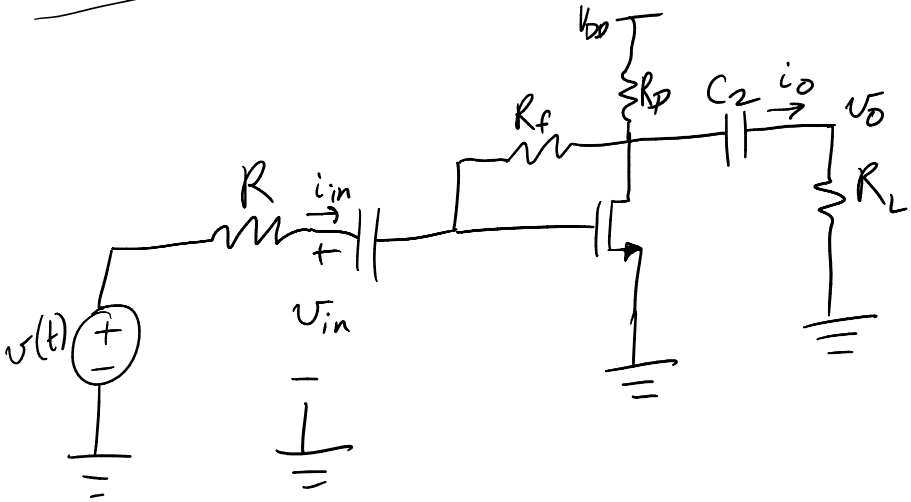
→ Constant Voltage











SSM