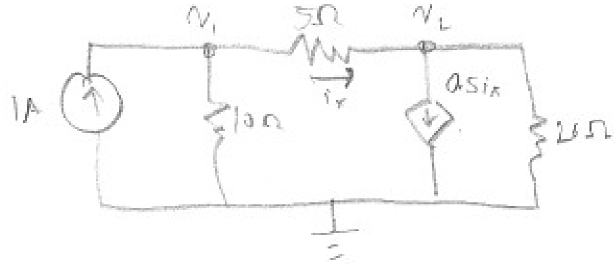
EE 40 HW 2 p1

P2.46



① $-1A + \frac{v_1}{10\Omega} + \frac{v_1 - v_2}{5\Omega} = 0$

i_x

② $\frac{v_2 - v_1}{5\Omega} + \frac{v_2}{20\Omega} + 0.5\left(\frac{v_1 - v_2}{5\Omega}\right) = 0$

Simplifying: $0.3v_1 - 0.2v_2 = 1$

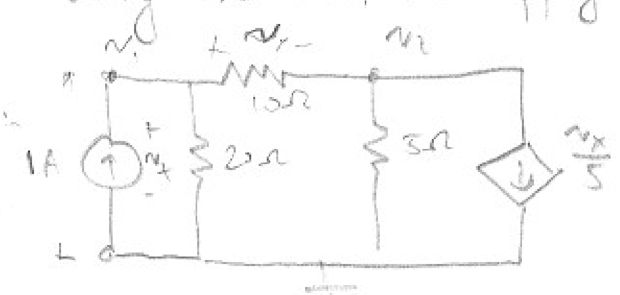
$-0.1v_1 + 0.15v_2 = 0$

Solving: $\boxed{v_1 = 6V, \quad v_2 = 4V}$

$i_x = \frac{v_1 - v_2}{5} = \boxed{0.4A}$

P2.49

Using the hint, we apply a test current:



① $-1A + \frac{v_1}{20\Omega} + \frac{v_1 - v_2}{10\Omega} = 0$

v_x

② $\frac{v_2 - v_1}{10\Omega} + \frac{v_2}{5\Omega} + \frac{1}{5}\left(\frac{v_1 - v_2}{10\Omega}\right) = 0$

Simplifying: $0.15v_1 - 0.1v_2 = 1$

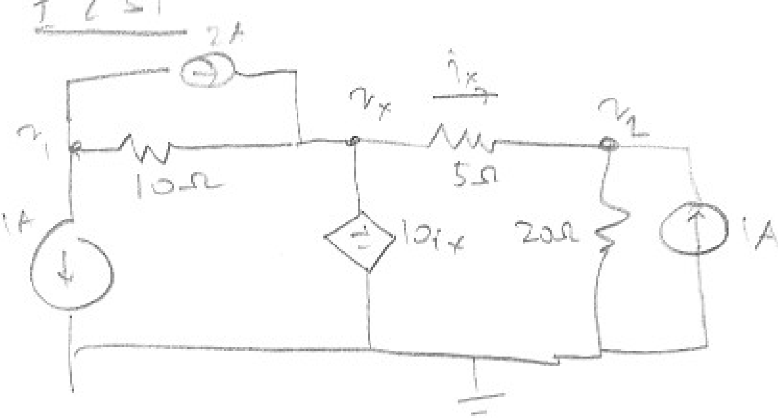
$v_1 + v_2 = 0 \rightarrow v_2 = -v_1$

Substituting: $0.15v + 0.1v_1 = 1$

$\rightarrow v_1 = 4 \rightarrow v_t = v_1 = 4V$

$R_{eq} = \frac{v_t}{i_t} = \frac{4V}{1A} = \boxed{4\Omega}$

P2.51



Ohms law on 5Ω:

$10i_x - v_2 = (i_x)(5\Omega) \rightarrow i_x = \frac{v_2}{5}$

$v_x - v_2 = \left(\frac{v_2}{5}\right)(5) \rightarrow v_x = 2v_2$

Now we can do Nodal:

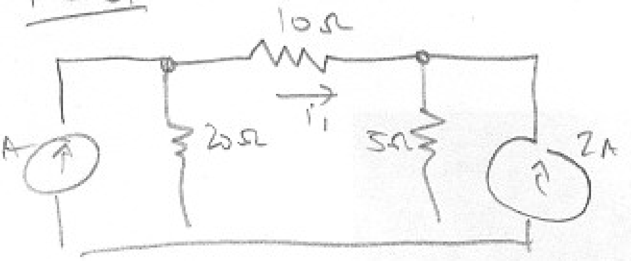
① $-3A + \frac{v_1 - 2v_2}{10\Omega} = 0$

② $\frac{v_2 - 2v_2}{5\Omega} + \frac{v_2}{20\Omega} - 1A = 0$

Solving: $\boxed{v_1 = -43.333V \quad v_2 = -6.667V}$

EE40 HW2 p2

P2.61

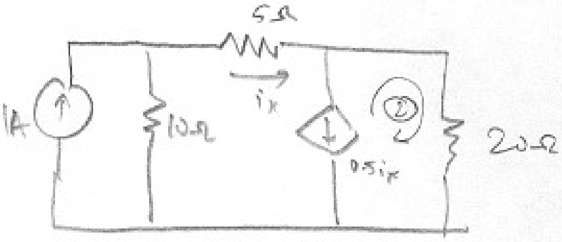


Because of the current sources there is only 1 unknown mesh current: i_1

Using KVL: $10i_1 + 5(i_1+2) + 20(i_1-1) = 0$

$$\boxed{i_1 = \frac{2}{7} = 0.286}$$

P2.46 (using mesh)



We know one mesh from the current source, we call the next i_x and the last, i_2.

Because we don't know the voltage across the dependent source we use a supermesh!

$$5i_x + 20i_2 + 10(i_x - 1) = 0$$

For our second equation, we use the dependent source:

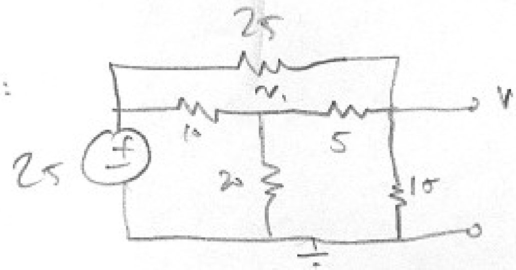
$$i_x - i_2 = 0.5i_x \rightarrow i_2 = \frac{1}{2}i_x$$

Substituting in:

$$5i_x + 10i_x + 10i_x - 10 = 0 \rightarrow \boxed{i_x = \frac{2}{5} = 0.4}$$

P2.66

First, V_{oc}:



Nodal: ① $\frac{v_1-25}{10} + \frac{v_1}{20} + \frac{v_1 - V_{th}}{5} = 0$

② $\frac{V_{th}-25}{25} + \frac{V_{th}-v_1}{5} + \frac{V_{th}}{15} = 0$

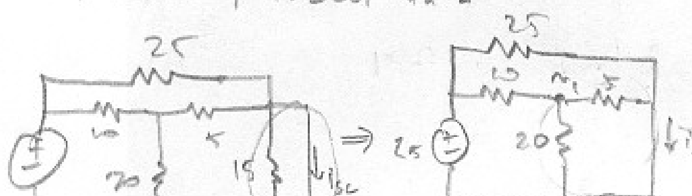
Simplifying: $0.35v_1 - 0.2V_{th} = 2.5$

$-0.2v_1 + 0.3067V_{th} = 1$

Solving: $v_1 = 14.356$

$V_{th} = \boxed{12.624}$

Then I_{sc}



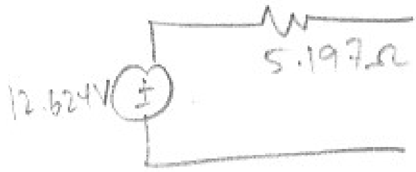
Nodal: $\frac{v_1-25}{10} + \frac{v_1}{5} + \frac{v_1}{20} = 0 \rightarrow v_1$

KCL: $I_N = i_{sc} = \frac{25V}{25\Omega} + \frac{v_1}{5\Omega} = \frac{17}{7} = \boxed{2.}$

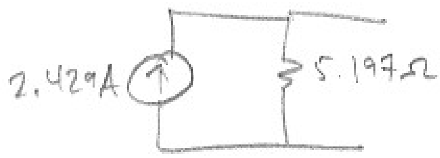
P 2.65 (cont'd)

$$R_{eq} = \frac{v_{oc}}{i_{sc}} = \frac{12.624}{2.429} = 5.197$$

Thevenin:

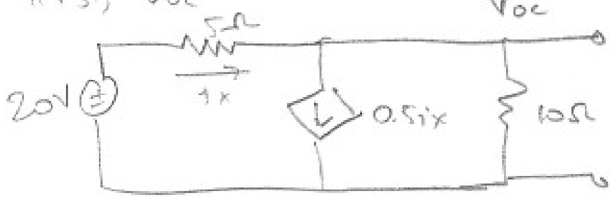


Norton:



P 2.77

First, v_{oc}:

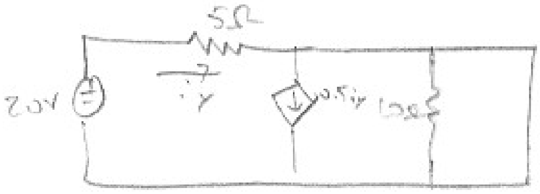


Nodal:

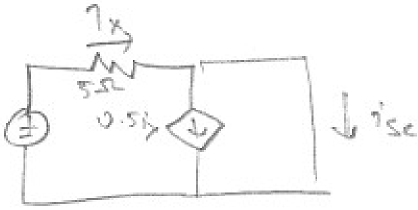
$$\frac{v_{oc}-20}{5} + 0.5\left(\overset{i_x}{\frac{20-v_{oc}}{5}}\right) + \frac{v_{oc}}{10} = 0$$

$$v_{oc} = 10V$$

Then i_{sc}:



$\rightarrow$

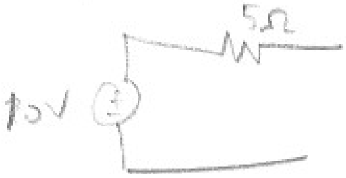


Ohm's: $i_x = \frac{20V}{5\Omega} = 4A$

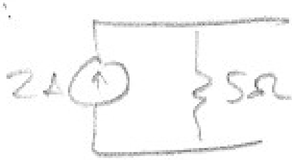
KCL $\quad i_{sc} = i_x - 0.5i_x = 2A$

$$R_{eq} = \frac{v_{oc}}{i_{sc}} = \frac{10V}{2A} = 5\Omega$$

Thevenin:



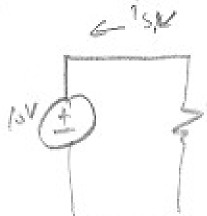
Norton:



P 2.81

From the voltage source:

$\Rightarrow$

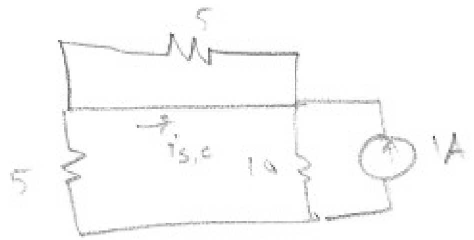


$$5 \| (10+5) = 3.75$$

$$i_{s,v} = \frac{-10}{3.75} = -2.667 A$$

P2.81 (con't)

from the current source:



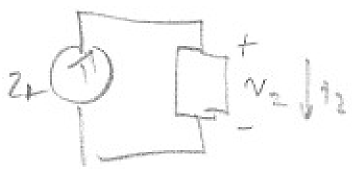
$\Rightarrow$

$$i_{sc} = \left(\frac{10}{5+10}\right)(1A) = -0.667A$$

$$i_s = i_{sv} + i_{sc} = -2.667A - 0.667A = \boxed{-3.333A}$$

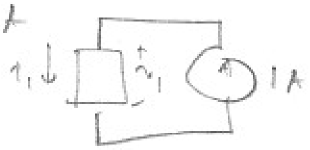
P2.85

(a) Zeroing the 1A:



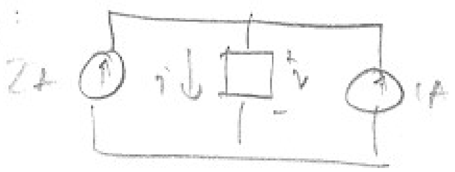
$i_2 = 2A, \quad v_2 = 2(2)^3 = 16V$

(b) Zeroing the 2A



$i_1 = 1A, \quad v_1 = 2(1)^3 = 2V$

(c) With both:



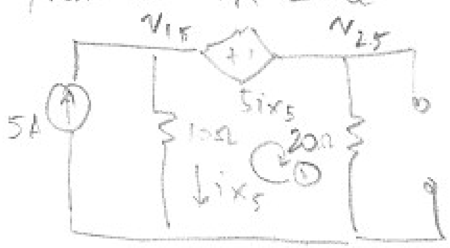
$i = 3A \quad v = 2(3)^3 = 54V$

$16V + 2V \neq 54V$

Superposition does not apply because A is nonlinear.

P2.47 (using superposition)

From the 5A source:



Using Mesh:

$5i_{x5} + 20i_1 + 10(i_1 - 5) = 0 \quad$ where $i_{x5} = 5 - i_1$

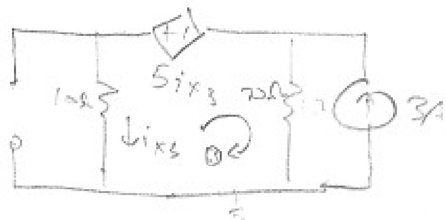
$25 - 5i_1 + 20i_1 + 10i_1 - 50 = 0$

$i_1 = 1A$

$v_{1,5} = (5 - i_1)10 = 40V$

$v_{2,5} = 20i_1 = 20V$

From the 3A source



Using Mesh:

$5i_{x3} + 20(i_1 + 3) + 10i_1 = 0 \quad$ where $i_{x3} = -i_1$

$-5i_1 + 20i_1 + 60 + 10i_1 = 0$

$i_1 = -2.4A$

$v_{1,3} = (-i_1)(10\Omega) = 24V$

$v_{2,3} = (i_1 + 3)20\Omega = 140V$

$v_1 = v_{13} + v_{15} = 64V$

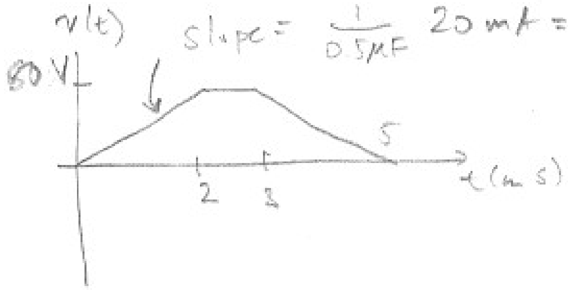
$v_2 = v_{23} + v_{25} = 160V$

~~EE40~~ HW2 p5

P3.10

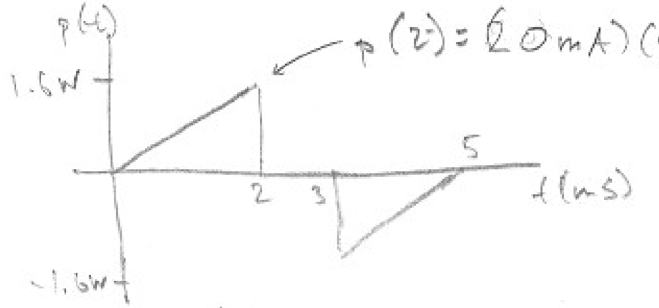
$v = \frac{1}{C}\int i\,dt + \cancel{v_0}^{\,0}$

slope $= \frac{1}{0.5\mu F}\, 20\,mA = 4\times10^{4}\,V/s = 40\,V/ms$



$p = i v$

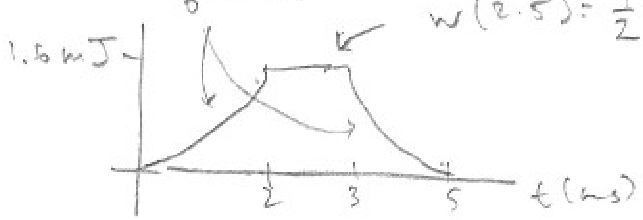
$p(2) = (20\,mA)(80\,V) = 1.6\,W$



$w = \frac{1}{2} C v^2$

quadratic

$w(2.5) = \frac{1}{2}\, 0.5\mu F\, (80V)^2 = 1.6\times10^{-3}\,J$
$= 1.6\,mJ$



P3.19

$p(0) = i(0)\,v(0) = (5mA)(-20V) = -100\,mW$ power is flowing out ($p<0$)

$v(t) = \frac{1}{C}\left[\int_0^t i(t)\,dt\right] - v(0) = \frac{1}{100\mu F}\left[\int_0^t 5mA\,dt\right] - 20V$

$= 50t - 20$

$p(1) = i(1)\,v(1) = (5mA)(50(1)-20) = 150\,mW$

power is flowing in ($p>0$)

P3.25

Because the charges are the same: $C_1 v_1 = C_2 v_2 \rightarrow v_1 = 2v_2$

and by KVL $v_1 + v_2 = 12V$

Solving: $\boxed{v_1 = 8V,\ v_2 = 4V}$

EE40 HW2 p6

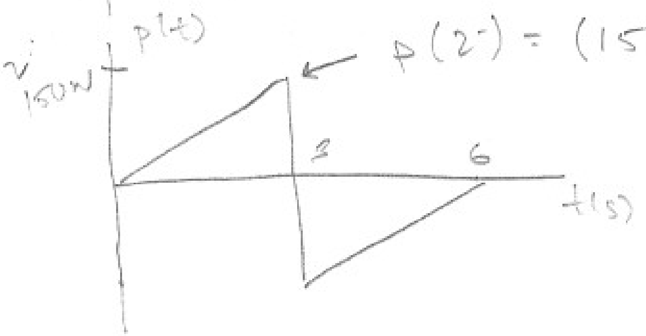
P3.43

$$i(t) = \frac{1}{L}\left[\int_0^t v(t)\,dt\right] + i(0) = \frac{1}{2H}\int_0^t v(t)\,dt$$

slope $= \frac{1}{2H} 10V = 5\,A/s$

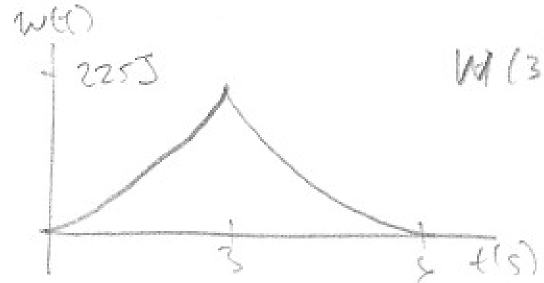
$p = i \cdot v$

$p(2^-) = (15A)(10V) = 150W$



$w = \frac{1}{2}Li^2$

$W(3) = \frac{1}{2}(2H)(15A)^2 = 225\,J$



P3.58

To find $i(t)$, we combine the inductors in parallel

$$i(t) = \frac{L_1+L_2}{L_1L_2}\int_0^t v(t)\,dt + \cancel{i_1(0)}^{0} + \cancel{i_2(0)}^{0} \rightarrow i(t)\frac{L_1L_2}{L_1+L_2} = \int_0^t v(t)\,dt$$

For L_1 alone, the voltage is also $v(t)$ making

$$i_1(t) = \frac{1}{L_1}\int_0^t v(t)\,dt + \cancel{i_1(0)}^{0} \longrightarrow i_1(t)\,L_1 = \int_0^t v(t)\,dt$$

setting these equal: $i(t)\frac{\cancel{L_1}L_2}{L_1+L_2} = i_1(t)\cancel{L_1}$

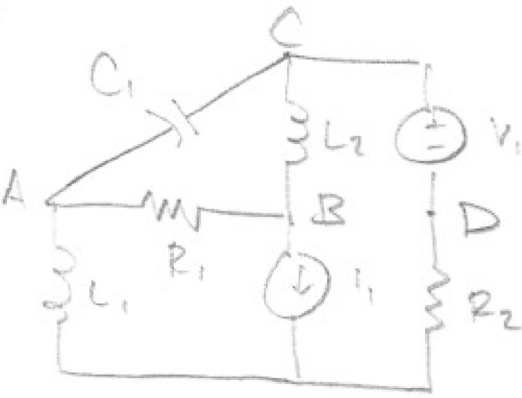
$$\boxed{i_1(t) = \frac{L_2}{L_1+L_2}\,i(t)}$$

The math is the same for $\boxed{i_2(t) = \frac{L_1}{L_1+L_2}\,i(t)}$

Notice this is a current divider just like with resistors!

EE40 HW2 P7

1)



We will use nodal analysis with a supernode combining C and D.

For the voltage source:

$$\boxed{C - D = V_1}$$

For the supernode:

$$C_1 \frac{d}{dt}(C-A) + \frac{1}{L}\int (C-B)\,dt + C_0 - B_0 + \frac{D}{R_2} = 0$$

Taking a derivative:

$$\boxed{C_1 \ddot{C} - C_1 \ddot{A} + \frac{1}{L}C - \frac{1}{L}B + \frac{1}{R_2}\dot{D} = 0}$$

For node A:

$$\frac{1}{L}\int A\,dt + A_0 + \frac{1}{R}(A-B) + C_1 \frac{d}{dt}(A-C) = 0$$

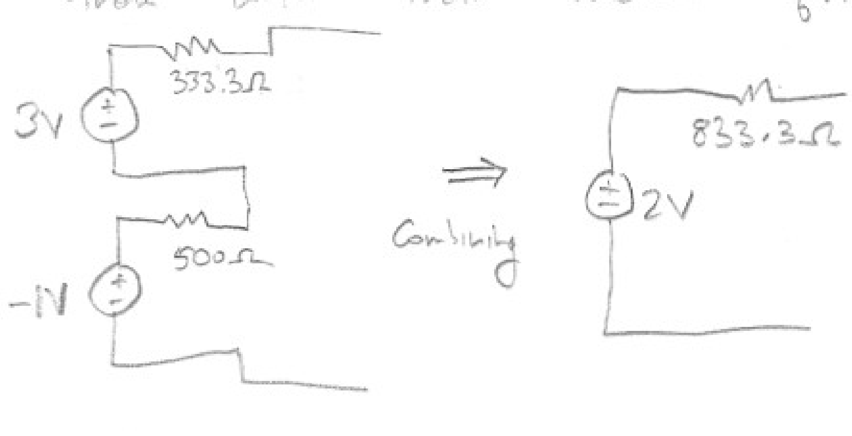
$$\boxed{\frac{1}{L}A + \frac{1}{R}\dot{A} - \frac{1}{R}\dot{B} + C_1\ddot{A} - C_1\ddot{C} = 0}$$

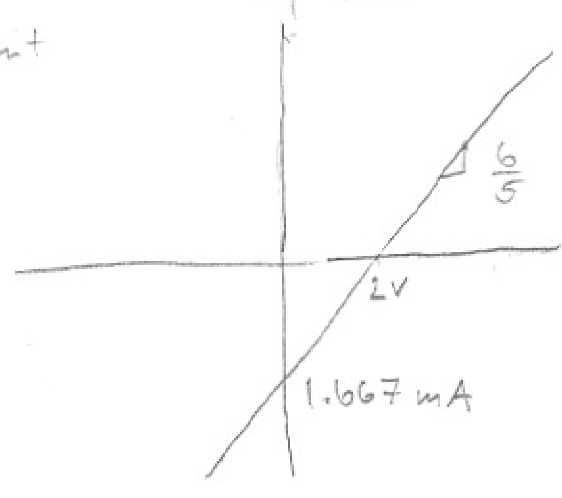
For node B:

$$\frac{1}{L}\int (B-C)\,dt + B_0 - C_0 + \frac{1}{R}(B-A) + I_1 = 0$$

$$\boxed{\frac{1}{L}B - \frac{1}{L}C + \frac{1}{R}\dot{B} - \frac{1}{R}\dot{A} + \dot{I}_1 = 0}$$

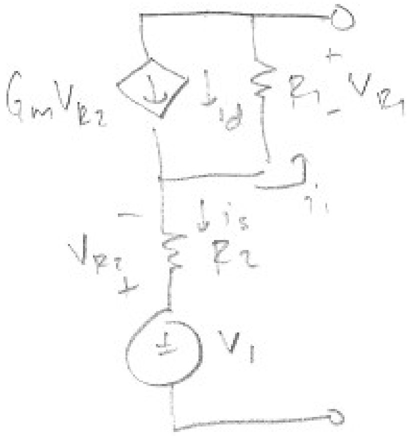
2) Since the networks are in series, we will represent them with their thevenin equivalent





EE40 HW2 p8

Finding v_{oc}



Since there can be no current through the bottom branch, $V_{R_2} = 0 \cdot R_2 = 0$

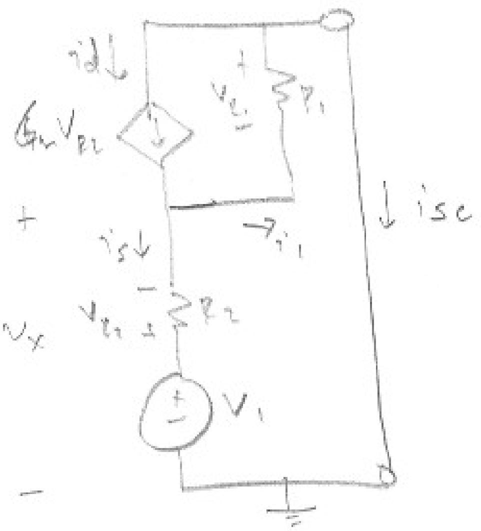
This means the dependent source will have $i_d = (G_m)(0) = 0$

By KCL $i_1 = i_d - i_s = 0$

So $V_{R_1} = 0 \cdot R_1 = 0$

Thus $\boxed{V_{th} = V_1}$

Finding i_{sc}



Nodal:

We have 1 unknown: v_x

KCL: $G_m V_{R2} = \frac{v_x}{R_1} + \frac{V_x - V_1}{R_2}$

But $V_{R2} = V_1 - v_x$, making this:

$$G_m V_1 - G_m v_x = \frac{v_x}{R_1} + \frac{v_x}{R_2} - \frac{V_1}{R_2}$$

$$\rightarrow v_x = \frac{\left(G_m V_1 + \frac{V_1}{R_1}\right)}{\left(\frac{1}{R_1} + \frac{1}{R_2} + G_m\right)}$$

$$i_{sc} = -i_s = \frac{V_1 - V_x}{R_2} = \boxed{\frac{V_1 - \left(\frac{G_m V_1 + \frac{V_1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2} + G_m}\right)}{R_2}} = I$$

$$R_{eq} = \frac{V_{th}}{I_n} = \boxed{\frac{V_1 R_2}{V_1 - \left(\frac{G_m V_1 + \frac{V_1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2} + G_m}\right)}} = R_{eq}$$