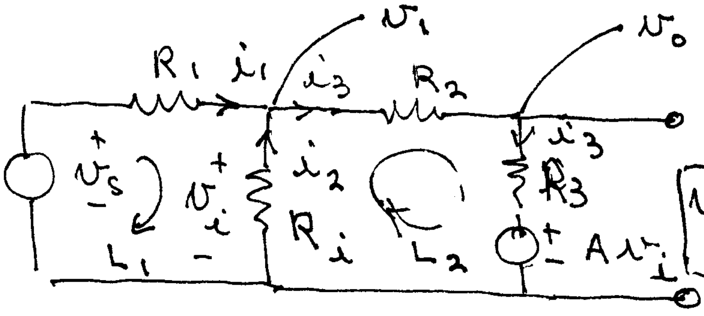
Example: 2-5 (Ulaby) → Can solve by KVL of course



$\boxed{v_o / v_s = \,?}$

KCL

① → $\dfrac{v_1 - v_s}{R_1} + \dfrac{v_1}{R_i} + \dfrac{v_1 - v_o}{R_2} = 0$

② → $\dfrac{v_o - v_1}{R_2} + \dfrac{v_o - A v_i}{R_3}$

③ → $v_i = v_1$

KVL solutions

④ $\boxed{v_s = R_1 i_1 - R_i i_2}$ Loop 1 (L_1)

⑤ $\boxed{R_i i_2 + R_2 i_3 + R_3 i_3 + A v_i = 0}$ Loop 2 (L_2)

⑥ $\boxed{v_o = A v_1 + R_3 i_3}$ → constraint gives v_o only

Solve for i_1, i_2 and i_3

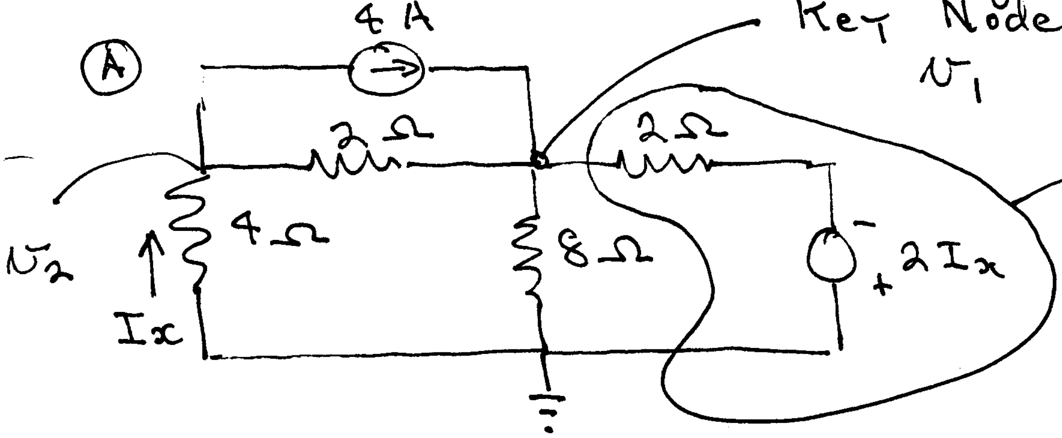
But $i_3 = i_1 + i_2$; $v_i = R_1 i_1$ → use these in ④ and ⑤ to obtain i_1 and i_2. Then use ⑥ to obtain v_o

Input resistance with dependent sources.

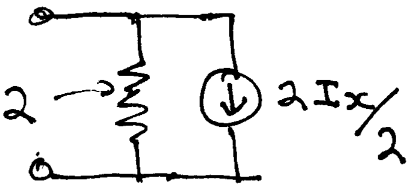
Cannot just set dependent sources equal to zero because a change in voltage causes a change in these sources which changes the slope of $i - v$

Alternative Ways of Analyzing | Ulaby + Maharbitz Example 2.10 ②

Key Node! v_1



Voltage Not Natural for KCL change to Norton



Note $I_x = -v_2/4$

KCL at ①

$$\frac{v_1}{8} + \underbrace{I_x}_{= v_2/4} + \frac{v_1}{2} - 4 + \frac{(v_1 - v_2)}{2} = 0$$

at ②

$$\frac{v_2}{4} + 4 + \frac{(v_2 - v_1)}{2} = 0 \Rightarrow \frac{3}{4} v_2 = \frac{v_1}{2} - 4$$

$$v_2 = \frac{2}{3} v_1 - \frac{16}{3}$$

$$v_1\left(\frac{1}{8} + \frac{1}{2} + \frac{1}{2}\right) + \left(\frac{2}{3} v_1 - \frac{16}{3}\right)\left(-\frac{1}{4} - \frac{1}{2}\right) - 4 = 0$$

$$v_1\left(\frac{9}{8} + \frac{2}{\cancel{3}}\left(-\frac{\cancel{3}}{4}\right)\right) + \frac{16}{\cancel{3}}\left(\frac{\cancel{3}}{4}\right) - 4 = 0$$

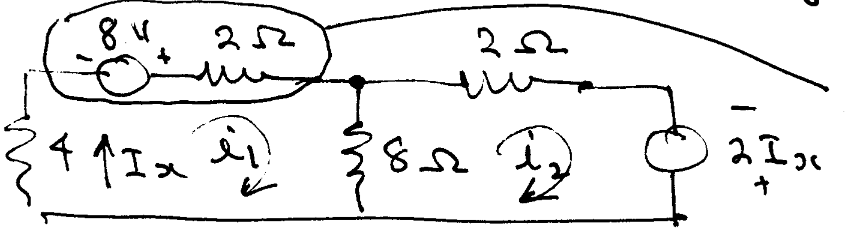
$$v_1\left(\frac{(9 - 4)}{8}\right) + 4 - 4 = 0$$

$$v_1\left(\frac{23}{\cancel{24}\ 8}\right) = 0 \qquad v_1 = 0$$

$$\therefore v_2 = -\frac{16}{3} \quad \therefore I_x = -\frac{v_2}{4} = +\frac{4}{3}$$

Alternative Ways of Analyzing Ulaby & Maharbitz Example 2.10 (3)

(B)



Norton to Thevenin

$8 = 2i_1 + 8(i_1 - i_2) + 4i_1$ (1) KVL

$2I_x = +8(i_2 - i_1) + 2i_2$ (2) KVL

$\uparrow$
i_1

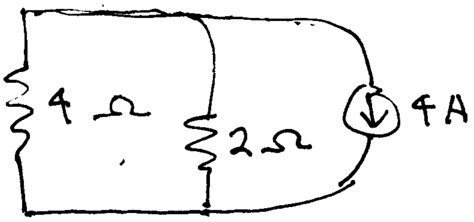
From (2) $10i_1 = 10i_2 \rightarrow i_1 = i_2 \quad \therefore v_1 = 0$

$8 = 2i_1 + 4i_1 \qquad i_1 = 8/6 = 4/3 = -I_x$

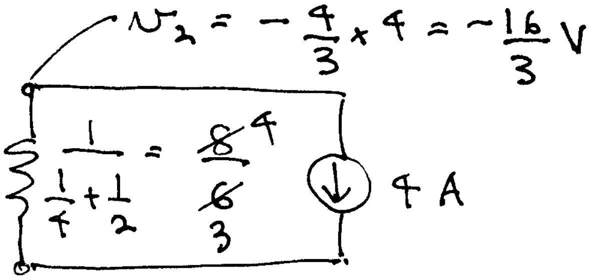
$\therefore v_2 = -16/3 \qquad \therefore I_x = +4/3$ Amps

(C)

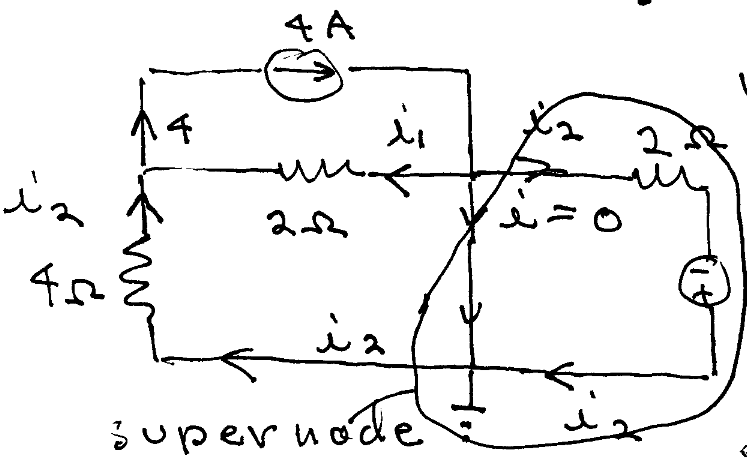
$v_1 = 0 \rightarrow$ This is a virtual short! (accidenental)



$\Rightarrow$



Why does it work?



We must have

$4 = i_1 + i_2$

Since $i = 0$

$2i_1 = 4i_2$

$\therefore 4 = 3i_2 \quad i_2 = 4/3$

$\therefore v_2 = -16/3$ Volts.

Note on

Coil → Flux = (Magnetic Field (Wb/m²)) Area

Faraday $v = \dfrac{d\,\text{Flux}}{dt}$

Flux = $L\,i$

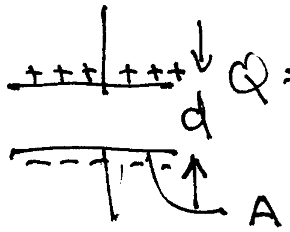
$$v = L\frac{di}{dt} = (pL)\,i$$

$$L \propto A\frac{N}{l} = \mu\frac{AN}{l}$$

μ: Magnetic Permeability; N: no of Turns

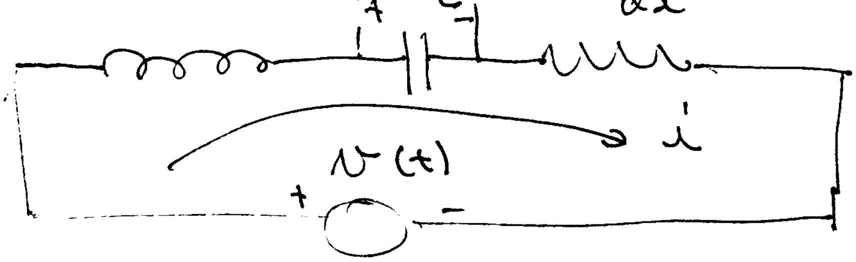
Note on

Capacitor →



$$Q = CV \qquad C \propto \frac{A}{d} = \epsilon\frac{A}{d}$$

Example Use of $\frac{d}{dx} = p$ operator



$$i = \frac{1}{pL + \frac{1}{pC} + R}\,v(t)$$

$$v_c = \frac{1}{pC}\,i = \frac{\frac{1}{pC}}{pL + \frac{1}{pC} + R}\,v(t)$$

$$= \frac{1}{p^2LC + 1 + pCR}\,v(t)$$

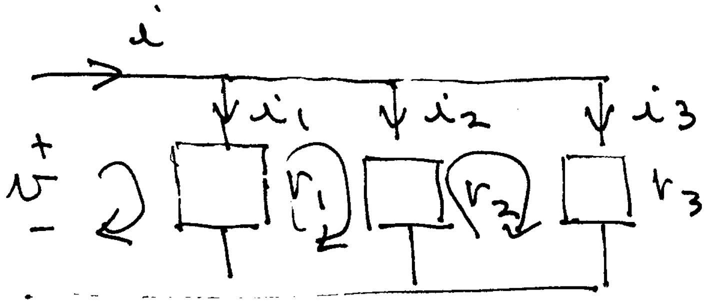
DE (Differential Equation)

$$(p^2LC + 1 + pCR)\,v_c(t) = v(t)$$

$$\left(\frac{d^2}{dt^2} + \frac{R}{L}\frac{d}{dt} + \frac{1}{LC}\right) v_c(t) = \frac{v(t)}{LC}$$

Current Divider }
Voltage Divider } Review

Current Divider as an exercise



want to replace r_1, r_2, r_3 by equivalent resistor

KCL $i = i_1 + i_2 + i_3$

Branch Relations

$$i = \frac{v_1}{r_1} + \frac{v_2}{r_2} + \frac{v_3}{r_3}$$

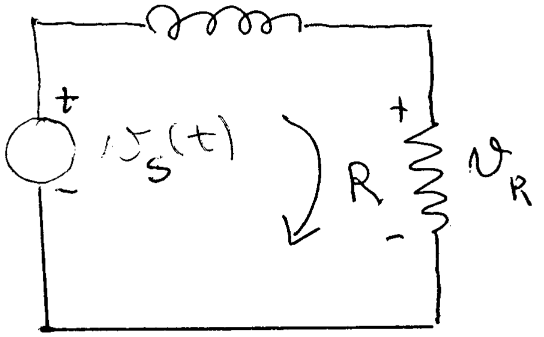
KVL around 3 Loops gives

$v = v_1$; $v_1 = v_2$, $v_2 = v_3$

$$\therefore i = v\left(\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}\right) = \frac{v}{r_{equiv.}}$$

$$\therefore \frac{1}{r_{equiv}} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}$$

L-R Circuit : Find the differential equation for $v_R(t)$ in terms of $v_S(t)$



KVL $\quad v_S(t) = (Lp)\, i + R i$

$$v_R = R i$$

$$= \frac{R}{(R+pL)} v_S(t)$$

$$\therefore (R+pL)\, v_R = R\, v_S(t)$$

$$\left(\frac{R}{L} + \frac{d}{dt}\right) v_R = v_S(t)$$

is the differential Equation to solve