P1: $P = i \cdot V$

$= \frac{dQ}{dt} \cdot V$

$= \frac{d(VC)}{dt} \cdot V$

$= \left(C\frac{dV}{dt} + V\frac{dC}{dt}\right)V$

$P\,dt = (6V - 4V^2)\,dV + V^2 d(6 - 4V)$

$W = \int_2^4 (6V - 4V^2)\,dV + \int_2^4 (-4V^2)\,dV$

$= \left(\frac{1}{2}6V^2 - \frac{2}{3}4V^3\right)\Big|_2^4$

$= \frac{136}{3}\ J$

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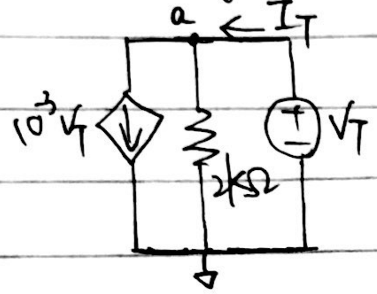
P2: find V_{oc}: leave port 11' open $\Rightarrow V_x = 0 \Rightarrow V_{oc} = 2\times10^3 \times 10^{-3} V_x = 0\ V$

find R_{TH}: apply test V_T, I_T

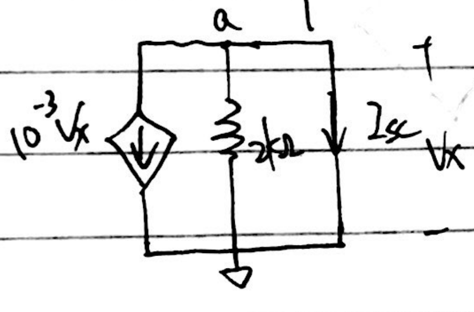


KCL @ node a: $I_T = 10^{-3} V_T + \frac{V_T}{2\times10^3}$

$I_T = \frac{3}{2000} V_T$

$R_{TH} = \frac{V_T}{I_T} = \frac{2000}{3}\ \Omega$

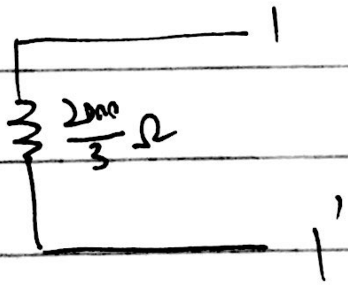
find I_{sc}: leave port 11' short $\Rightarrow V_x = 0$



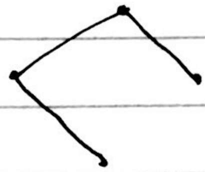
KCL @ node a:

$I_{sc} = -10^{-3} V_x - \frac{V_x}{2\times10^3} = 0\ A$

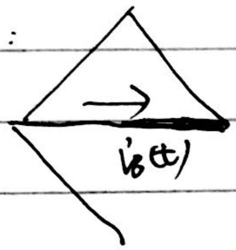
Norton's equivalent circuit:



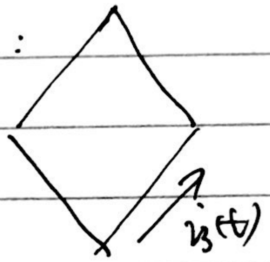
P3: a. spanning three



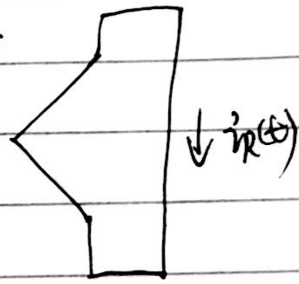
b. loop 1:

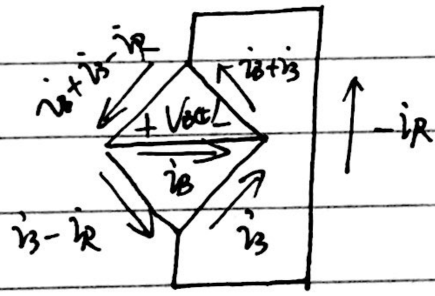


loop2:



loop3:





current in each branch

(we also define the voltage across the current source as $V_B(t)$)

KVL for loop1: $\frac{1}{C_1}\int_{-\infty}^{t}[i_B(\tau)+i_3(\tau)]d\tau+[i_B(t)+i_3(t)-i_R(t)]R_1+V_B(t)=0$

KVL for loop2: $\frac{1}{C_1}\int_{-\infty}^{t}[i_B(\tau)+i_3(\tau)]d\tau+[i_B(t)+i_3(t)-i_R(t)]R_1$

$+[i_3(t)-i_R(t)]R_2+i_3(t)R_3=0$

KVL for loop3: $-i_R(t)R+[i_B(t)+i_3(t)-i_R(t)]R_1+[i_3(t)-i_R(t)]R_2=0$

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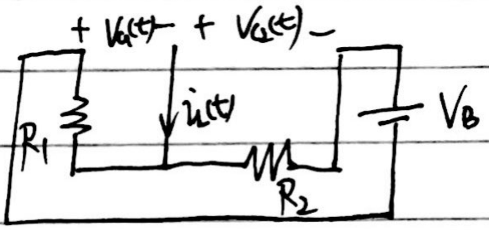
P4: In steady state, C_1, C_2 behave like open circuit and L behaves like short circuit. So circuit can be simplified.



$i_L(t) = 0\ A$

$V_{c1}(t) = -V_B \dfrac{R_1}{R_1+R_2} = -3 \cdot \dfrac{1\times10^3}{1\times10^3+2\times10^3} = -0.6\ V$

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P5. a. KVL: $L\frac{di_L(t)}{dt} + \frac{1}{C}\int_{-\infty}^{t} i_L(\tau)\,d\tau = 0$

$$\frac{d^2 i_L(t)}{dt^2} + \frac{1}{LC} i_L(t) = 0$$

b. $i_L(0+) = i_L(0-) = 1A$

$$\left.\frac{di_L(t)}{dt}\right|_{t=0+} = \frac{V_L(0+)}{L} = \frac{V_L(0-)}{L} = \frac{1}{0.25} = 4 \ A/s$$

c. $$\left.\frac{d^2 i_L(t)}{dt^2}\right|_{t=0+} = -\frac{1}{LC} i_L(t)\Big|_{t=0+} = -\frac{1}{LC} i_L(0+) = -\frac{1}{0.25\times 1}\times 1 = -4 \ A/s^2$$

d. $s^2+4=0$

$s=\pm 2j \Rightarrow \sigma=0,\ \omega=2 \Rightarrow i_g(t) = 2|K|\cos(2t+\angle K)$

$i_p(t)=0 \Rightarrow i_L(t) = i_g(t)+i_p(t) = 2|K|\cos(2t+\angle K)$ — ①

$\frac{di_L(t)}{dt} = -4|K|\sin(2t+\angle K)$ — ②

use boundary values:

plug $t=0+$ to ①: $2|K|\cos\angle K = 1$

plug $t=0+$ to ②: $-4|K|\sin\angle K = 4$

$$\Rightarrow \begin{cases} \angle K = -\tan^{-1}2 = -63^\circ \\ |K| = \frac{\sqrt{5}}{2} \end{cases}$$

$\Rightarrow i_L(t) = \sqrt{5}\cos(2t-63^\circ)$

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