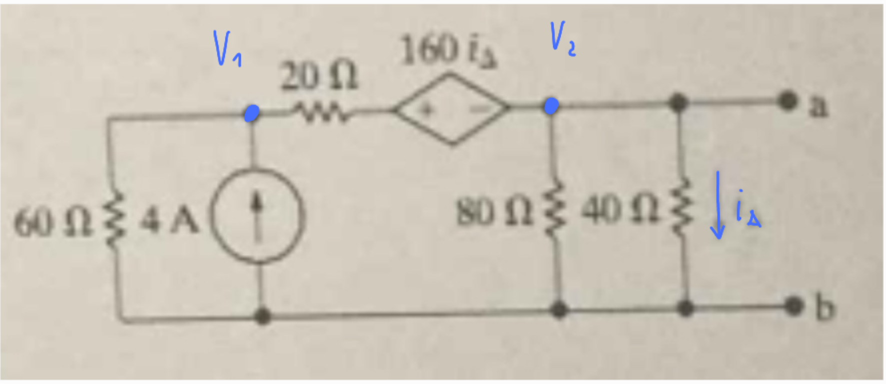
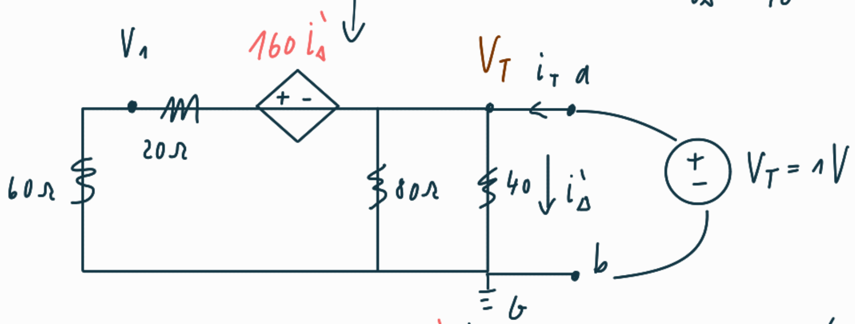


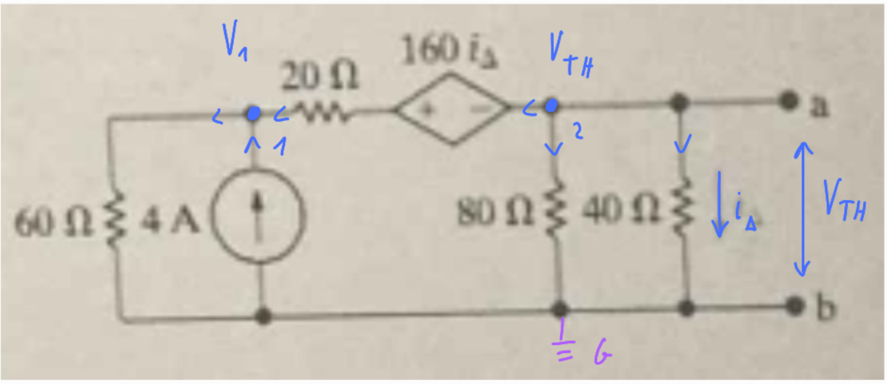
step 1)

$i_\Delta' = \frac{1}{40}$



$$i_T - \frac{1}{40} - \frac{1}{80} - \left(\frac{V_T - (-160 i_\Delta')}{60+20}\right) \Rightarrow i_T - \frac{3}{80} - \left(\frac{1 + \frac{160}{40}}{80}\right) \Rightarrow i_T = \frac{3}{80} + \frac{1+4}{80} = \frac{1}{10}$$

$$R_{TH} = \frac{V_T}{i_T} = \frac{1}{\frac{1}{10}} = 10\,\Omega$$

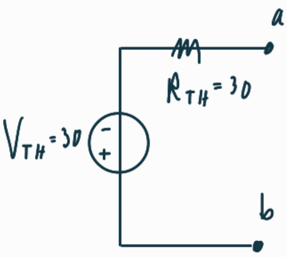


$$i_\Delta = \frac{V_{TH}}{40}$$

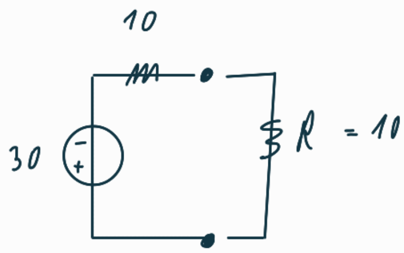
node 1: $\frac{V_{TH} + 160 i_\Delta - V_1}{20} + 4 - \frac{V_1}{60} = 0$

$\Rightarrow V_{TH} = 30$

node 2: $\frac{V_{TH}}{40} + \frac{V_{TH}}{80} + \frac{V_{TH} + 160 i_\Delta - V_1}{20} = 0$

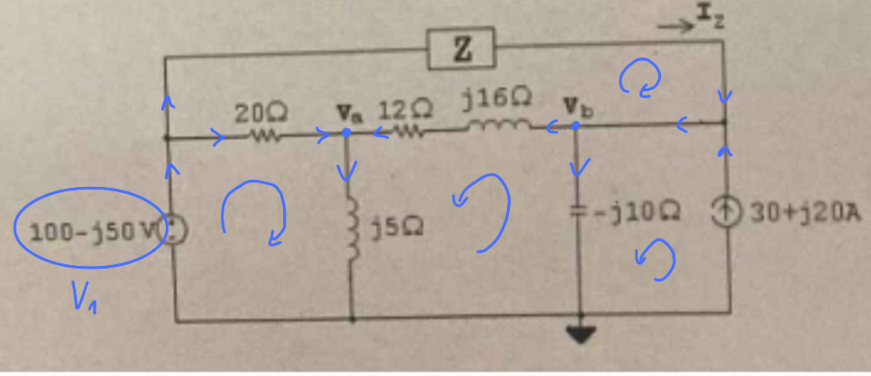


, for max power:



$$p = \frac{V_{TH}^2}{4R_{TH}} = \frac{900}{40} = \frac{90}{4} = \frac{45}{2} = 22.5\ W$$

Problem 3. (2.5 Pts) Find the value of Z in the circuit, if $V_b = 140+j30$ V

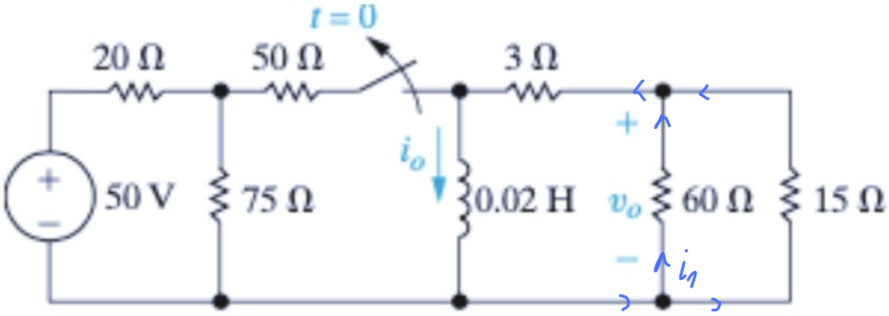


$$\text{node } a: \frac{V_1 - V_a}{20} + \frac{V_b - V_a}{12+16j} - \frac{V_a}{5j} = 0$$

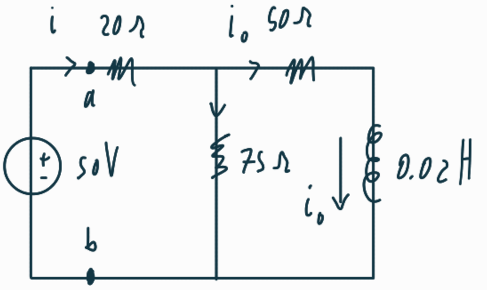
$$\Rightarrow Z = 2 + 2j$$

$$\text{node } b: 30 + 20j + \frac{V_1 - V_b}{Z} - \frac{V_b}{-10j} - \frac{V_b - V_a}{12+16j} = 0$$

1. The switch has been closed for a long time. At t = 0 the switch is opened.
a. Determine $i_o(0)$ for $t \geq 0$.
b. Determine $v_o(t)$ for $t \geq 0+$.



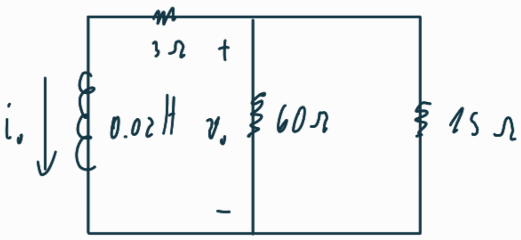
for $t < 0$:



$$R_{eq} = \frac{50 \cdot 75}{50 + 75} + 20 = 30 + 20 = 50 \Rightarrow i = \frac{U}{R} = \frac{50}{50} = 1$$

$$i_o = i \cdot \frac{75}{125} = 1 \cdot \frac{3}{5} = \frac{3}{5}$$

for $t \geq 0$:



$$\tau = \frac{L}{R'_{eq}} = \frac{0.02}{15} = \frac{2}{1500} = \frac{1}{750}$$

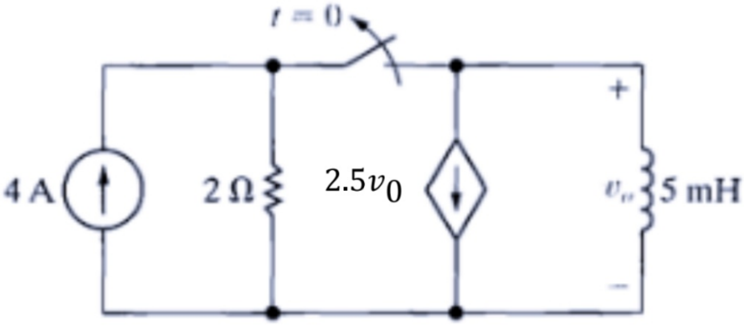
$$R'_{eq} = 3 + \frac{4 \cdot 15 \cdot 15}{5 \cdot 15} = 3 + 12 = 15\,\Omega$$

$$i(t) = i_o \cdot e^{-\frac{t}{\tau}} = \frac{3}{5} \cdot e^{-750t}$$

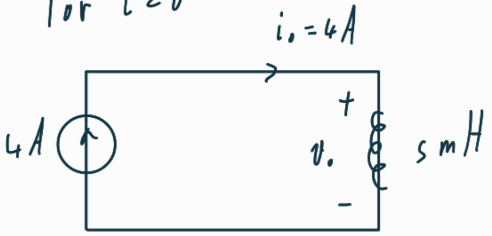
$$i_1(t) = i(t)\cdot\frac{15}{75} = \frac{3}{5}\cdot e^{-750t}\cdot\frac{1}{5} = \frac{3}{25}\cdot e^{-750t}$$

$$v_o(t) = L\cdot\frac{di_1(t)}{dt} = 0.02\cdot\left(\frac{3}{25}\cdot e^{-750t}\right)' = \frac{2}{100}\cdot\frac{3}{25}\cdot(-750)\cdot e^{-750t} = \frac{-3\cdot 750}{1250}\,e^{-750t} = -\frac{9}{5}\,e^{-750t}$$

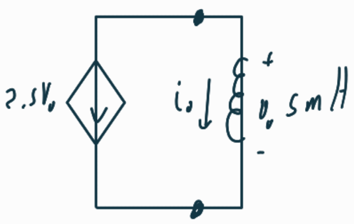
2. The switch in the circuit below has been closed for a long time before opening at $t = 0$. Find $v_0(t)$ for $t \geq 0^+$.



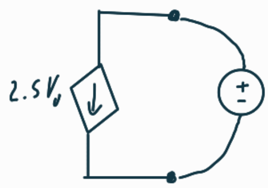
for $t<0$



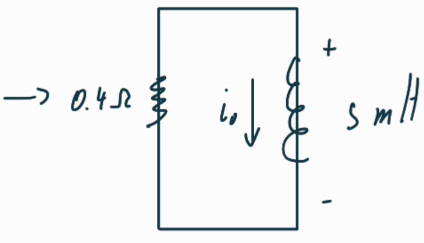
for $t \geq 0^+$:



TH. $\longrightarrow$



$V_T = 1V \Rightarrow i_T = 2.5\,V_T \Rightarrow R_{TH} = \frac{V_T}{i_T} = \frac{1}{2.5} = 0.4\,\Omega$

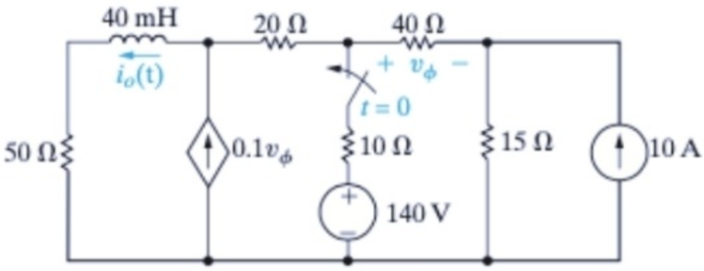


$$\tau = \frac{L}{R} = \frac{5\cdot 10^{-3}}{4\cdot 10^{-1}} = \frac{5}{4}\cdot 10^{-2} = \frac{125}{100}\cdot 10^{-2} = 125\cdot 10^{-4} = 0.0125$$

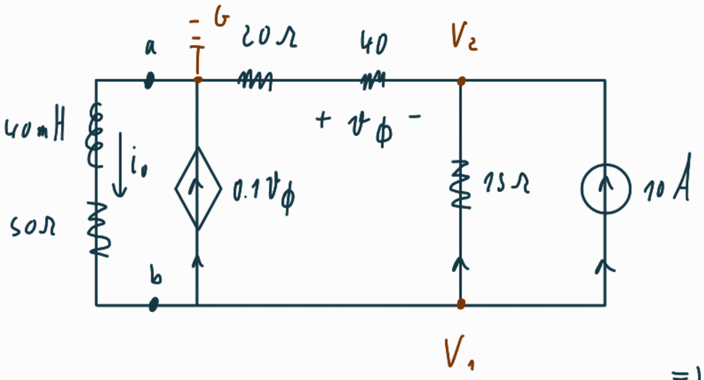
$$i(t) = i_0\,e^{-\frac{t}{\tau}} = 4\cdot e^{-\frac{1000\cdot t}{125}} = 4\cdot e^{-80t}$$

$$v_0(t) = L\,\frac{di(t)}{dt} = 5\cdot 10^{-3}\cdot 4\cdot(-80)\cdot e^{-80t} = -1.6\cdot e^{-80t}$$

3. The switch in the circuit has been opened a long time before closing at t = 0. Find $i_o(t)$ for t ≥ 0



for $t < 0$:



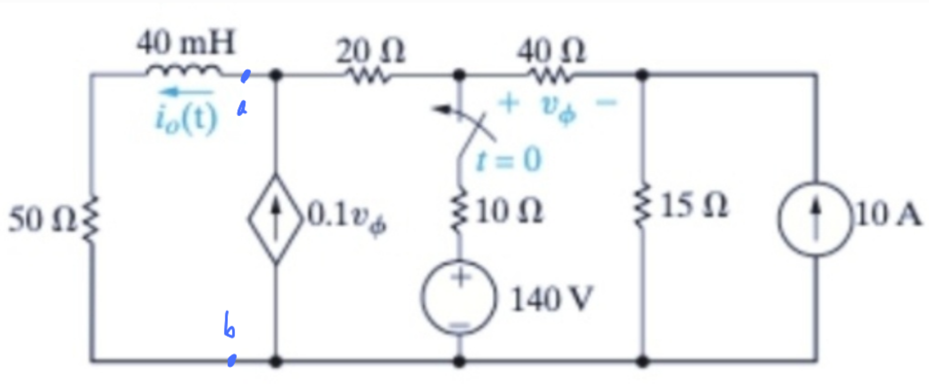
$$1: \frac{-V_1}{50} - 0.1 v_\phi - \frac{V_1 - V_2}{15} - 10 = 0$$

$$2: 10 + \frac{V_1 - V_2}{15} - \frac{V_2}{60} = 0$$

$$v_\phi = -V_2 \cdot \frac{40}{60}$$

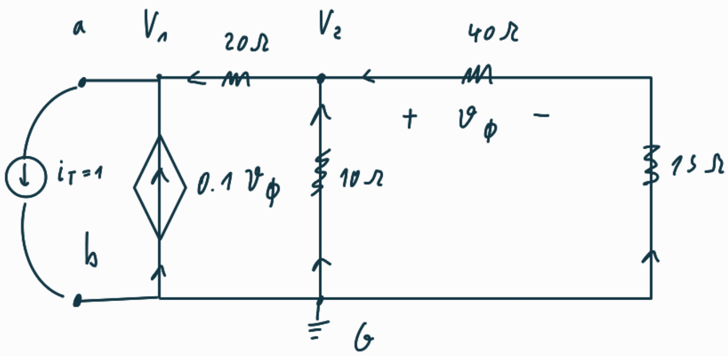
$$\Rightarrow V_1 = -300\ V \Rightarrow i_0 = \frac{-(-300)}{50} = 6\ A$$

for $t \geq 0^+$



TH. ⇒

$V_1 = V_T$



$$0.1 v_\phi + \frac{V_2 - V_1}{20} - 1 = 0$$

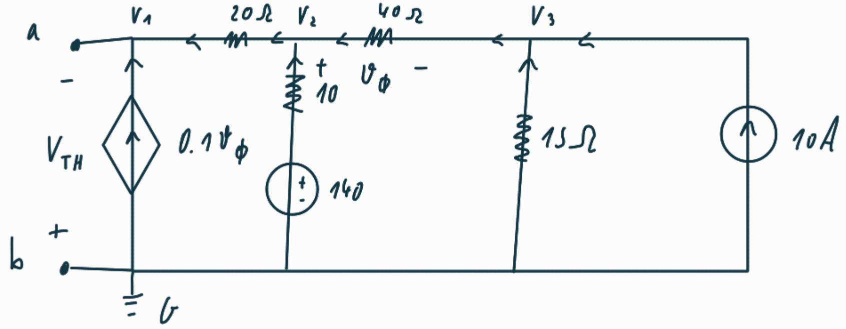
$$-\frac{V_2}{10} - \frac{V_2}{55} - \frac{V_2 - V_1}{20} = 0$$

$$v_\phi = -\left(-V_2 \cdot \frac{40}{55}\right)$$

$$V_1 = -74$$

$$V_T = -V_1 = 74$$

$$R_{TH} = \frac{V_T}{i_T} = 74\ \Omega$$



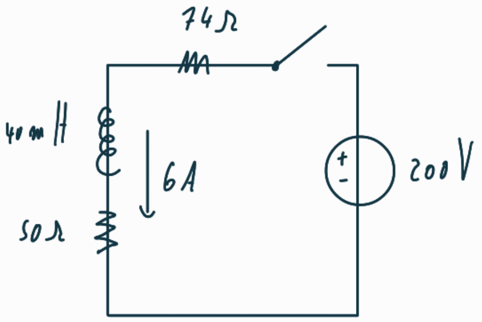
$$\frac{V_3 - V_2}{10} + \frac{V_2 - V_1}{20} = 0$$

$$\frac{V_2 - V_1}{20} = \frac{V_3 - V_2}{40} + \frac{V_2 - 140}{10}$$

$$-\frac{V_3}{15} + 10 = \frac{V_3 - V_2}{40}$$

$V_{TH} = 200$

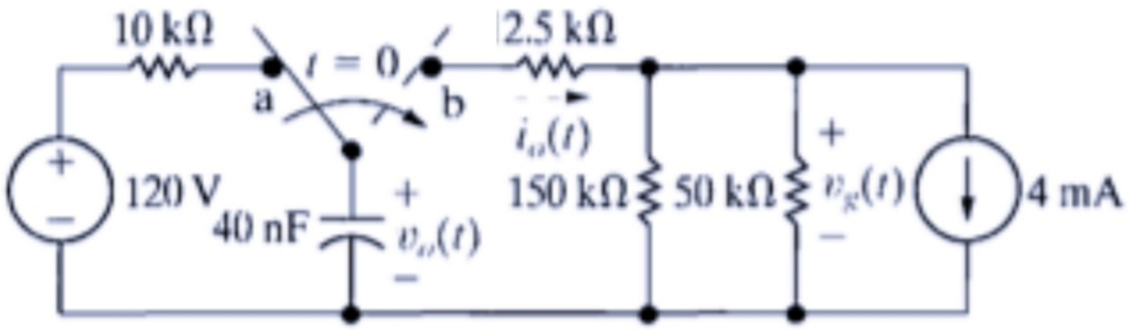
$$\tau = \frac{L}{R} = \frac{40 \cdot 10^{-3}}{124} = \frac{10^{-2}}{31} = \frac{1}{3100}$$



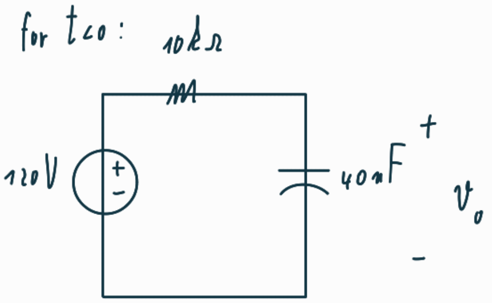
$$i(t) = \frac{V_s}{R_{eq}} + \left(i_0 - \frac{V_s}{R_{eq}}\right) e^{-\frac{t}{\tau}} = \frac{200}{124} + \left(6 - \frac{200}{124}\right) e^{-3100t} =$$

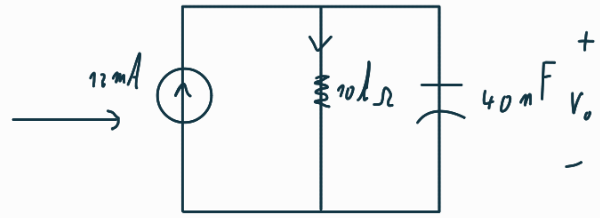
$$= \frac{50}{31} + \left(i_0 - \frac{50}{31}\right) e^{-3100t}$$

5. The switch in the circuit has been in position *a* for a long time. At t = 0, the switch moves instantaneously to position *b*. For $t \geq 0^+$, find
   a. $v_o(t)$
   b. $i_o(t)$
   c. $v_g(t)$
   d. $v_g(0^+)$



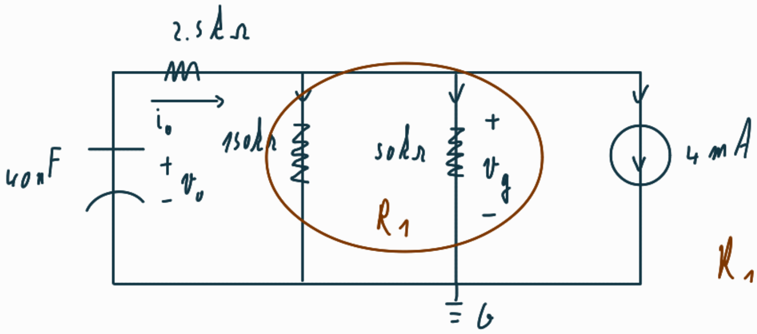
for $t < 0$:





for $t \geq 0^+$:

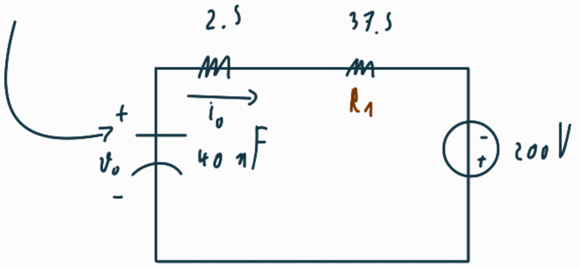
$V_0 = I \cdot R = 120\,V$



$$R_{eq} = 2.5 + \frac{3 \cdot 50 \cdot 50}{4 \cdot 50} = 2.5 + 37.5 = 40k\Omega$$

$$\tau = RC = 40 \cdot 1000 \cdot 40 \cdot 10^{-9} = 1600 \cdot 10^{-6} = 1.6 \cdot 10^{-3} = \frac{8}{5000}$$

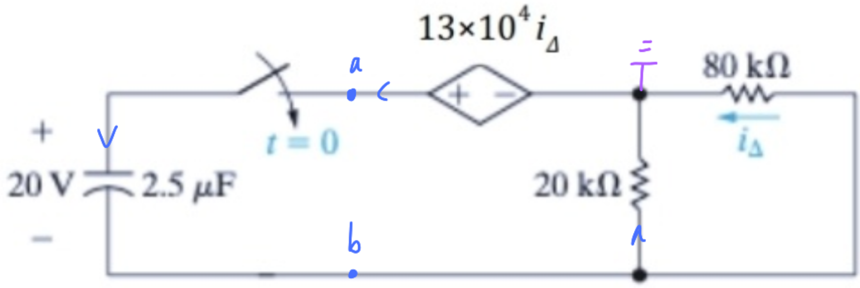
$R_1 = 37.5$

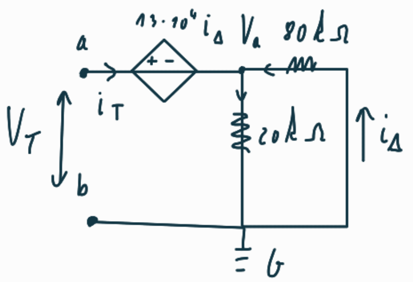


$v_o(t) = 200 - 80\,e^{-\frac{5t}{8}}$ $i_s = \frac{200}{40} = 5\ mA$

$i_o(t) = \left(5\cdot10^{-3} - \frac{150}{40\cdot1000}\right) e^{-\frac{5000t}{8}} = (0.005 - 0.00375)\,e^{-625t} = 0.00125\,e^{-625t}$

6. a. The capacitor in the circuit below is charged to 20 V at the time the switch is closed. If the capacitor ruptures when its terminal voltage equals or exceeds 20 kV, how long does it take to rupture the capacitor?





$V_A = 130\cdot10^3 i_\Delta + V_T = 130\cdot10^3\,\frac{V_A}{80\cdot10^3} + V_T \Rightarrow V_A = \frac{V_T}{1-\frac{13}{8}} = \frac{V_T}{-\frac{5}{8}}$

$i_\Delta = \frac{V_A}{80\cdot10^3}$

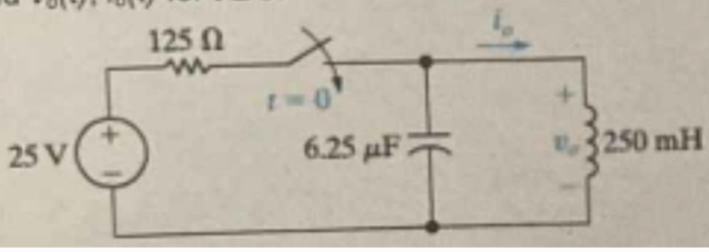
$i_T = \frac{V_A}{20k} - \frac{V_A}{80k} = V_A\left(\frac{3}{8}\right) = -\frac{8}{5}\cdot\frac{3}{8k}\cdot V_T = -\frac{3}{5k}V_T$

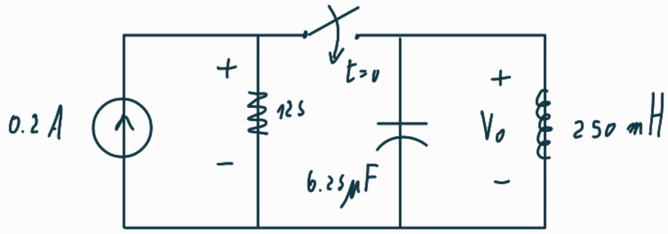
$\Rightarrow R_{TH} = \frac{V_T}{i_T} = \frac{V_T}{-\frac{3}{5}V_T} = -\frac{5000}{3}\ \Omega$

$v(t) = 20\cdot e^{-\frac{t}{\tau}} = 20\cdot e^{\frac{-t}{-2.5\cdot10^{-3}\cdot\frac{5}{3}\cdot10^3}} = 20\cdot e^{\frac{t}{\frac{125}{100}}} = 20\,e^{\frac{12t}{5}}$

$20\,e^{\frac{12t}{5}} = 20000 \Rightarrow e^{\frac{12t}{5}} = 1000 \Rightarrow \frac{12t}{5} = \ln 10^3 \Rightarrow t = \frac{3\cdot5\ln10}{12} = \frac{5}{4}\ln10$

Problem 2. (2.5 Pts) There is no energy stored in the circuit below when the switch is closed at $t = 0$. Find $v_o(t)$, $i_o(t)$ for $t \geq 0$.





$V_0(0^+) = ?$

$$w_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{250\cdot10^{-3}\cdot 6.25\cdot10^{-6}}} = \frac{1}{\sqrt{25\cdot625\cdot10^{-10}}} =$$

$$= \frac{10^5}{5^3} = 5^2\cdot2^4 = 800$$

$$\alpha = \frac{1}{2RC} = \frac{1}{2\cdot125\cdot625\cdot10^{-8}} = \frac{10^8}{2\cdot5^7} = 5\cdot2^7 = 640$$

$$w_d = \sqrt{w_0^2-\alpha^2} = 480$$

$w_0 > \alpha \Rightarrow$ underdamp

$$i(t) = i_s + (B_1 \cos t w_d + B_2 \sin t\, w_d)\, e^{-\alpha t}$$

$$i(0) = i_s + B_1 \Rightarrow 0 = 0.2 + B_1 \Rightarrow B_1 = -0.2$$

$$i'(0) = -\alpha B_1 + w_d B_2 \Rightarrow 128 + 480 B_2 = 0 \Rightarrow$$

$$\Rightarrow B_2 = -\frac{2^7}{2^4\cdot2\cdot5\cdot3} = \frac{-4}{15} = -0.2(6)$$

$$i_o(t) = 0.2 - (0.2\cos 480t + 0.26\sin 480t)\,e^{-640t}$$

$$v_o(t) = L\frac{di_o}{dt} = 250\cdot10^{-3}\cdot\left((128\sin 480t - 128\cos 480t)\,e^{-640t} - 640\left(-0.2\cos 480t - \frac{4}{15}\sin 480t\right)e^{-640t}\right)$$

$$\left(i_s + (B_1\cos t w_d + B_2 \sin t w_d)\,e^{-\alpha t}\right)' = (-w_d B_1 \sin t w_d + w_d B_2 \cos t w_d)\,e^{-\alpha t} + (B_1 \cos t w_d + B_2 \sin t w_d)\,e^{-\alpha t}$$