Name: _____ (please print)

Signature: _____

ECE 2202 – Midterm Exam
July 22, 2020

Online

1. This quiz is open book, open notes.
2. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit. A solution which is not given in a reasonable order will lose credit.
3. Show all units in solutions, intermediate results, and figures. Units in the quiz will be included between square brackets.
4. If the grader has difficulty following your work because it is messy or disorganized, you will lose credit.
5. Do not use red ink. Do not use red pencil.
6. You will have 25 minutes to work on this quiz, and 15 minutes to download/print, scan and submit.

_____/25

_____/45

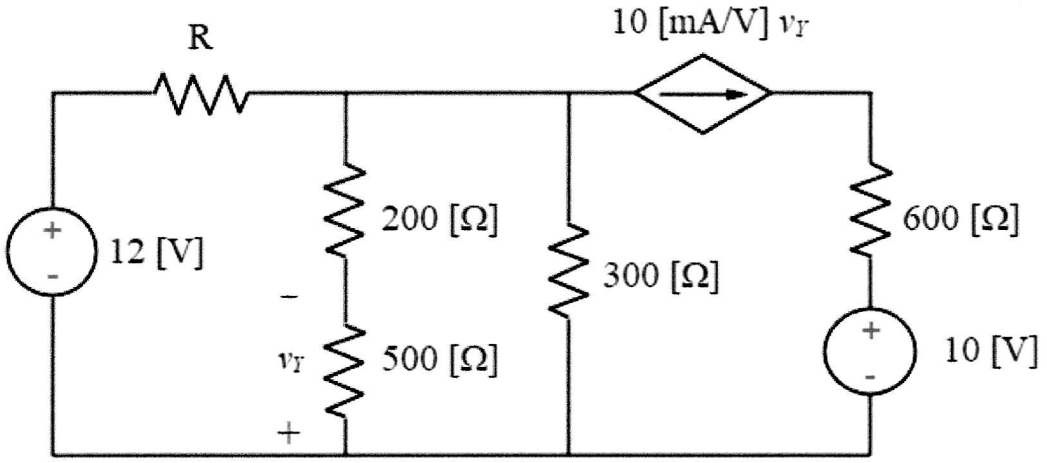
_____/30

_____/100

Room for extra work

1. [25 points] The Thevenin resistance seen by the 200 [Ω] resistor in the circuit shown below is known to be - 67.65 [Ω].

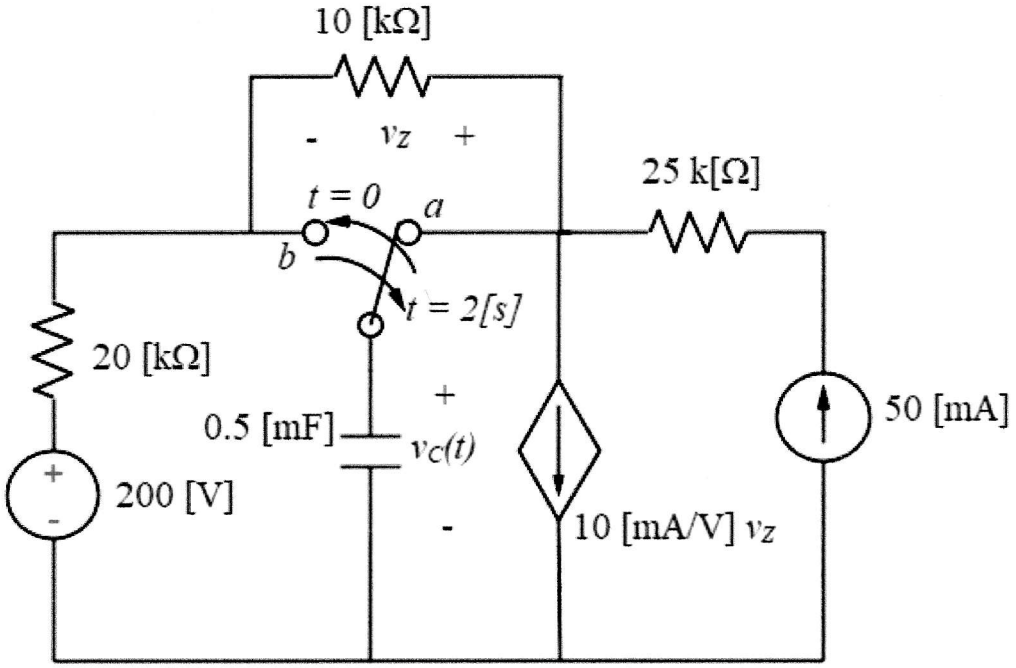
a. Find the value of the resistor R.
b. Find the Thevenin voltage v_{TH} seen by the 200 [Ω] resistor.
c. Draw the complete Thevenin equivalent seen by the 200 [Ω] resistor. Be sure to label terminals clearly.



Room for extra work

2. [45 points] In the circuit below, the switch was in position 'a' for a long time. At t = 0, it moved to position 'b'. After 2 [s], it moved back to position 'a'.

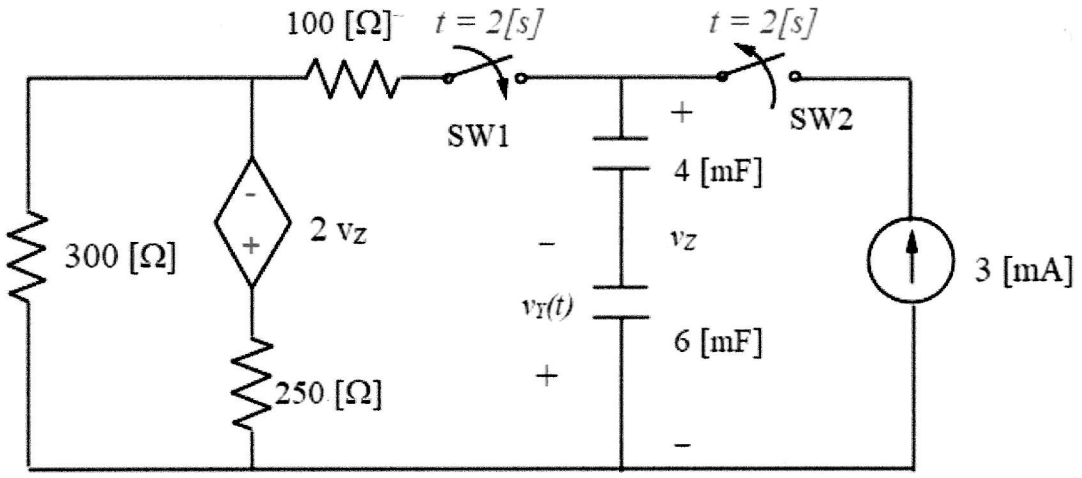
a. Find $v_C(t)$ for $0 \le t \le 2$ [s].
b. Find $v_C(t=2[s]^+)$.
c. Find $v_C(t)$ for $t \to \infty$.



Room for extra work

3. [30 points] In the circuit below, the energy stored in the capacitors at $t = 0^-$ was 0. Switch SW 1 was open for a long time and closed at t = 2 [s]. SW 2 was closed for a long time and opened at t = 2 [s].

Find $v_Y(t)$ for t > 2 [s].



Room for extra work

Name: SOLUTIONS (please print)

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_____/25

_____/45

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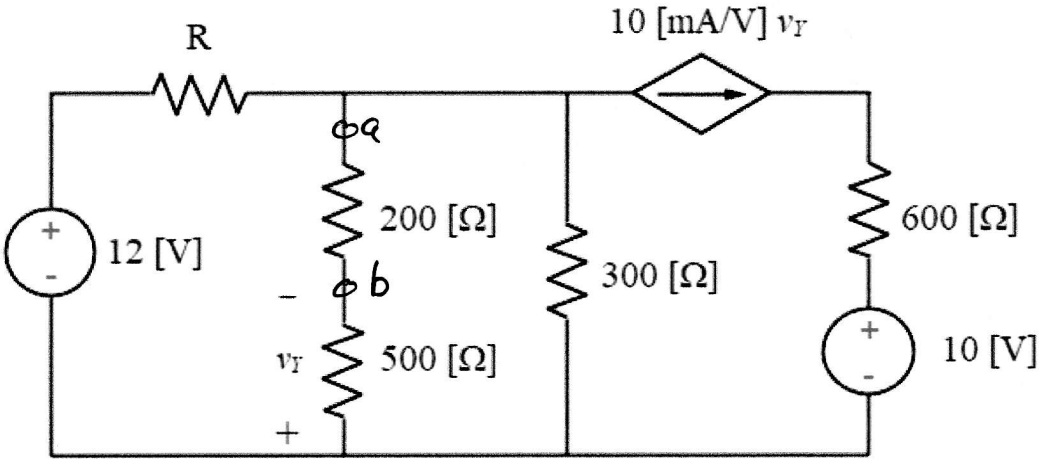
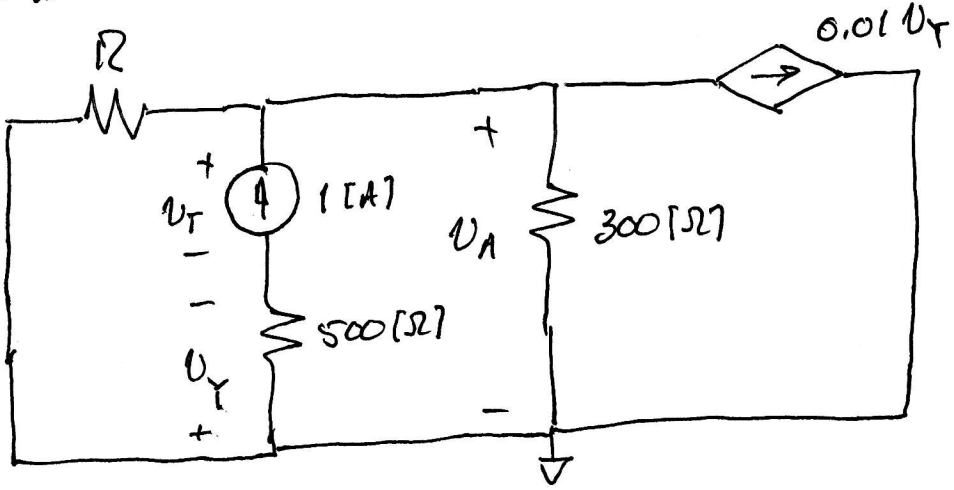
1. [25 points] The Thevenin resistance seen by the 200 [Ω] resistor in the circuit shown below is known to be - 67.65 [Ω].

+15 a. Find the value of the resistor R.
+6 b. Find the Thevenin voltage v_{TH} seen by the 200 [Ω] resistor.
+4 c. Draw the complete Thevenin equivalent seen by the 200 [Ω] resistor. Be sure to label terminals clearly.



a) If we were looking for R_{TH}, we might use a test source. Here we'll use a current source, but a voltage source also works.



600 [Ω] and 10 [V] are in series with a current source.

Since $R_{TH} = -67.65$ [Ω], we know $v_T = -67.65$ [V].

Then $v_A = v_T - v_Y = -567.65$ [V].

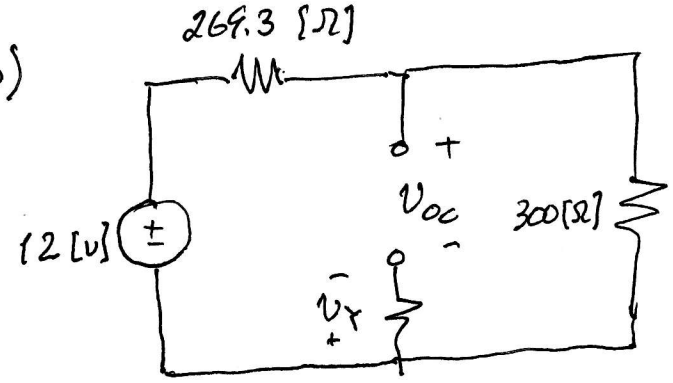
Room for extra work

$V_A = -567.65\ [V]$

$$\frac{-567.65}{R} - \frac{567.65}{300} - 1 + 5 = 0$$

$$\Rightarrow R = 269.3\ [\Omega]$$

b)

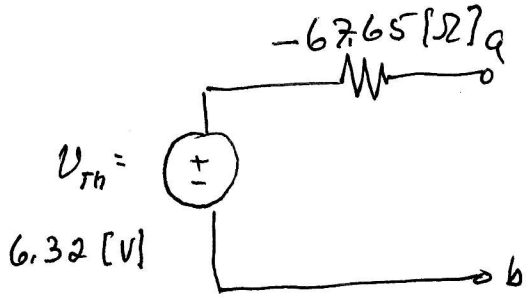


$V_x = 0$

$$V_{oc} = 12 \cdot \frac{300}{300 + 269.3}$$

$$V_{oc} = 6.32\ [V]$$

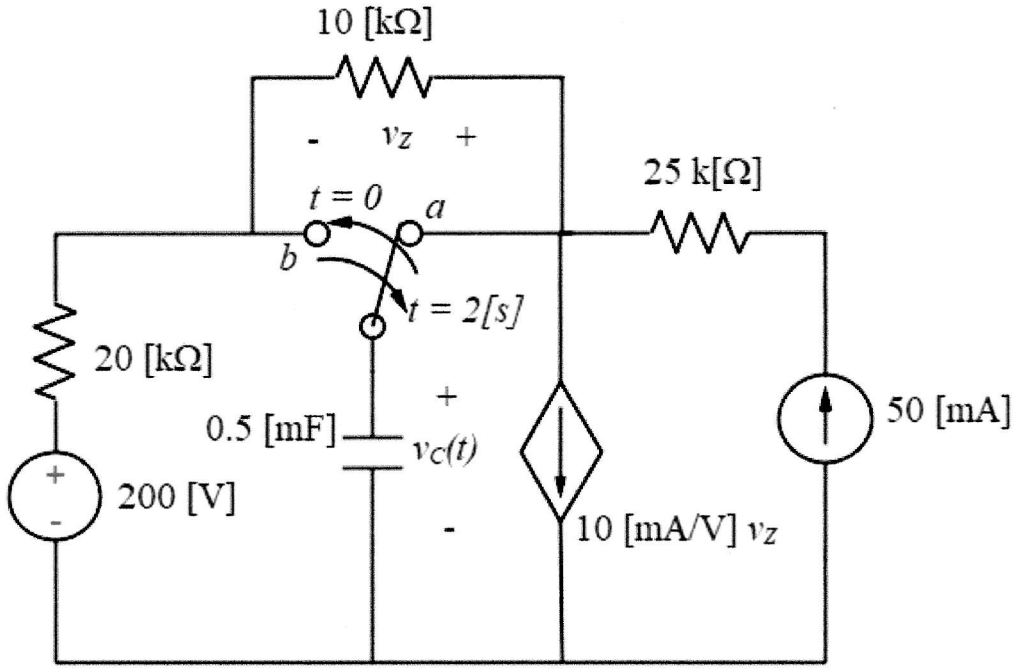
c) A Thevenin equivalent has no meaning if terminals are not labeled on both the original circuit and the Thevenin equivalent.



2. [45 points] In the circuit below, the switch was in position 'a' for a long time. At t = 0, it moved to position 'b'. After 2 [s], it moved back to position 'a'.

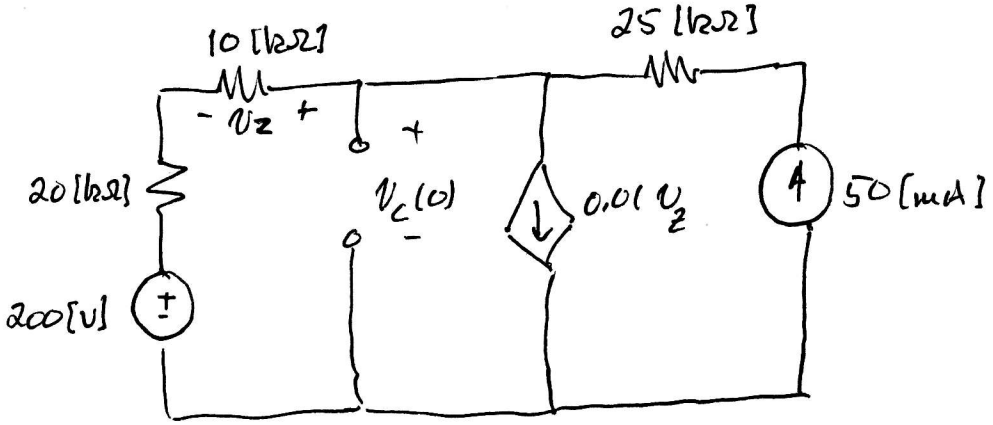
a. Find $v_C(t)$ for $0 \le t \le 2$ [s].
b. Find $v_C(t=2[s]^+)$.
c. Find $v_C(t)$ for $t \to \infty$.

$v_c(0)$ 8 v_{cf} 8 ε 6 v_c 10
$v_c(2)$ +8
v_{cf} +5



a)

Re-draw for $t<0$, and set C → open circuit to find $v_c(0)$.



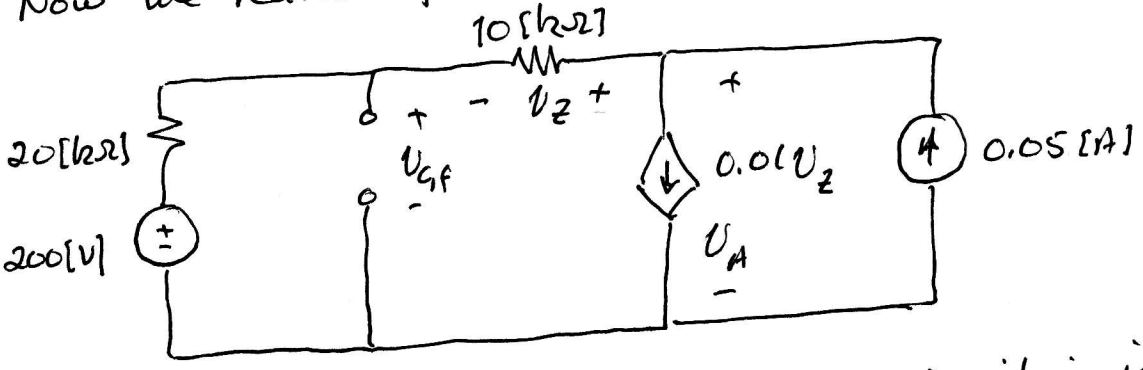
+ 8

$$\frac{v_c(0)-200}{30000} + 0.01\,v_z - 0.05 = 0 \qquad v_z = \frac{v_c(0)-200}{30000}\cdot 10000$$

$v_c(0) = 214.8$ [V]
$v_z = 4.950$ [V]

Room for extra work

Now we redraw for $t>0$ and set $C \rightarrow$ open to find $v_{c,f}$.

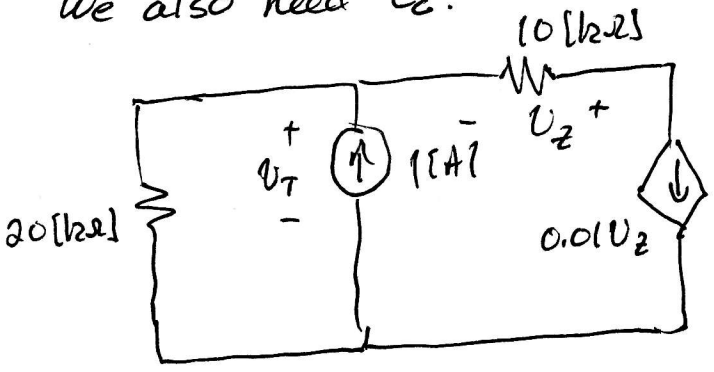


In terms of circuit analysis, this circuit is identical to the previous ($t<0$) circuit, but the capacitor is in a different place. So v_A as defined above, and v_z, are the same as before!

$v_A = 214.8$ [V] $\quad v_z = 4.950$ [V]

KVL: $v_{c,f} - v_A + v_z = 0 \Rightarrow v_{c,f} = 209.9$ [V] +8

We also need τ_c:



$v_z = -10000 \cdot (0.01 v_z)$

$\Rightarrow v_z = 0$!

$\therefore v_T = 20000$ [V]

$R_{TH} = 20000$ [Ω] +6

$\tau_c = (20 \times 10^3)(5 \times 10^{-4}) = 10$ [s].

So... $\boxed{v_c(t) = 209.9 + (214.8 - 209.9)\, e^{-t/10[s]}}$ [V] $\quad 0 \le t \le 2$[s]

+5 +2 +3 p2

Room for extra work

Problem 2 con't ...

b) The switch moves back to 'a' at $t = 2[s]$ so

$$v_c(2[s]^+) = v_c(2[s]) = 209.9 + (214.8 - 209.9)e^{-2/10}$$

+ 8

$$\boxed{v_c(2[s]^+) = 213.9\ [V]}$$

c) $t \to \infty$ is the final value, for which C is an open circuit. But this is the same circuit we encountered to find $v_c(0)$, so...

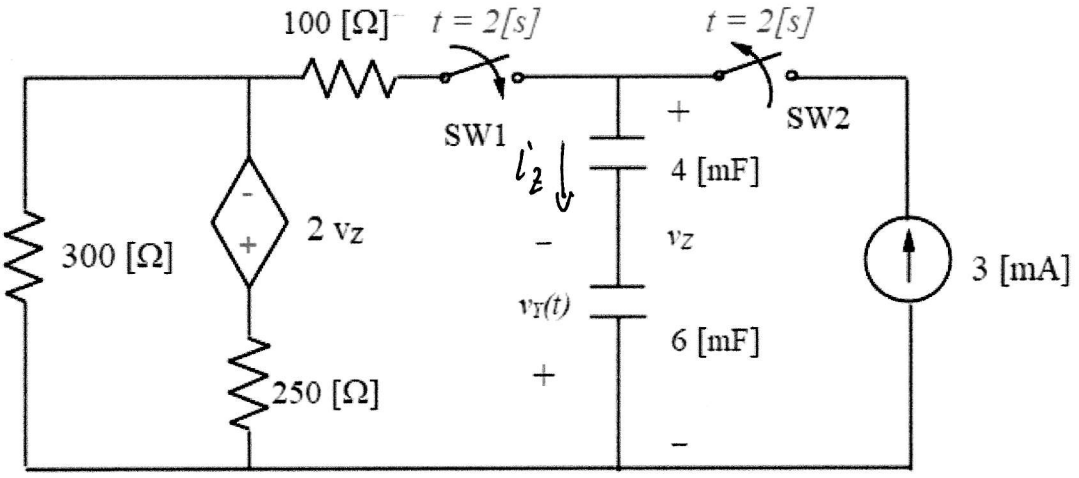
$$\boxed{v_{c,f} = 214.8\ [V]}$$

+ 5

v_z

3. [30 points] In the circuit below, the energy stored in the capacitors at $t = 0^-$ was 0. Switch SW 1 was open for a long time and closed at t = 2 [s]. SW 2 was closed for a long time and opened at t = 2 [s].

Find $v_Y(t)$ for t > 2 [s].



For $t < 2$ [s] we have a current source in series with an equivalent capacitance $C_{eq} = \frac{C_1 \cdot C_2}{C_1 + C_2} = 2.4$ [mF]. +1

So we have $v_z(t) = \frac{1}{2.4 \times 10^{-3}} \int_0^t 0.003\,dt + 0 = 1.25\left[\frac{V}{s}\right] t$

+4 At $t = 2$ [s], $\underline{v_z(2\text{[s]}) = 2.50\ [V].}$

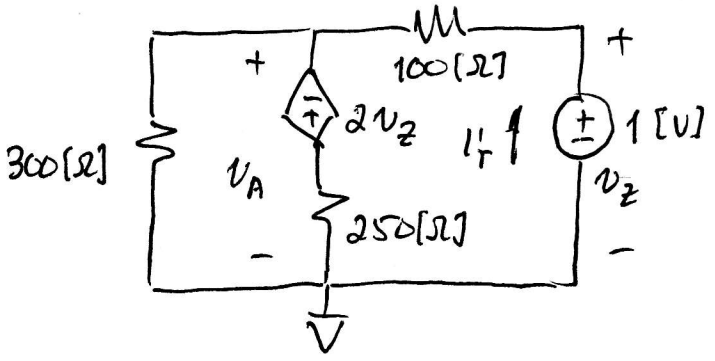
We will also need an initial condition on v_Y:

$$v_Y(t) = \frac{-1}{0.006} \int_0^2 0.003\,dt + 0 = -0.5\left[\frac{V}{s}\right] t$$ +4

So $\underline{v_Y(2\text{[s]}) = -1\ [V].}$

Now we look at $t > 2$ [s] ...

Room for extra work



We need R_{TH}:

$$\frac{v_A}{300} + \frac{v_A + 2v_z}{250} + \frac{v_A - 1}{100} = 0$$

$v_z = 1\,[V] \Rightarrow v_A = 0.1154\,[V]$

$$\Rightarrow i_T' = -\frac{v_A - 1}{100} = 8.846\,[mA]$$

$R_{TH} = 113\,[\Omega] \Rightarrow \tau_c = (2.4\times10^{-3})(113) = 271.3\,[ms]$ +5

This is a natural response problem so... $v_{c,f} = 0$ +2

$$v_z(t) = 2.5\,e^{-(t-2[s])/0.2713[s]}\ [V] \quad 0 \le t \le 2\,[s]$$ +7 (+2, +3, +1, +1)

$v_y(t)$ is going to have the same time constant, and we know $v_y(2[s]) = -1\,[V]$. So we have

$$\boxed{v_y(t) = -1\,e^{-(t-2[s])/0.2713[s]}\ [V] \quad t \ge 2\,[s]}$$ +7

This is the answer, but let's verify by finding $i_z'(t)$ and then integrating to find $v_y(t)$. We should get the same thing.

$$i_z'(t) = C_{eq}\frac{d}{dt}[v_z(t)] = (2.4\times10^{-3})(2.5)\left(\frac{-1}{0.2713}\right)e^{-(t-2)/0.2713}$$

$$i_z'(t) = -22.12\,e^{-(t-2[s])/0.2713[s]}\ [mA] \quad t \ge 2\,[s]$$ +3

$$v_y(t) = -\frac{1}{0.006}\int_{2[s]}^{t} i_z'(t)\,dt + (-1)\ [V]$$ ← initial condition from previous page

$$= \frac{22.12\times10^{-3}}{0.006}(-0.2713)\,e^{-(t-2[s])/0.2713[s]}\Big|_{2[s]}^{t} - 1$$

$$= -1.00\,e^{-(t-2[s])/0.2713[s]}\ [V] \quad t > 2\,[s]$$ +4

So this checks!