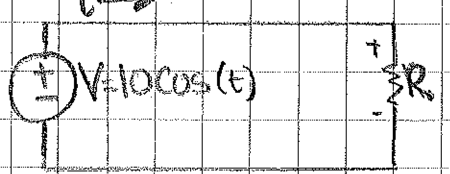
Engr M20 - HW set 1 for Ch. 1 and Ch. 2

19/20

Jared Fowler
Jan 17, 2018

1) A resistor absorbs an instantaneous power of $20\cos^2(t)$ mW when connected across $V = 10\cos(t)$ V, voltage source. Find i and R.



$$P = Vi$$

$$20\cos^2(t)\,\text{mW} = 10\cos(t)\,\text{V} \cdot i$$

$$i = \frac{0.02\cos^2(t)}{10\cos(t)}$$

$$i = 0.002\cos(t)\ \text{A} = \boxed{2\cos(t)\ \text{mA}}$$

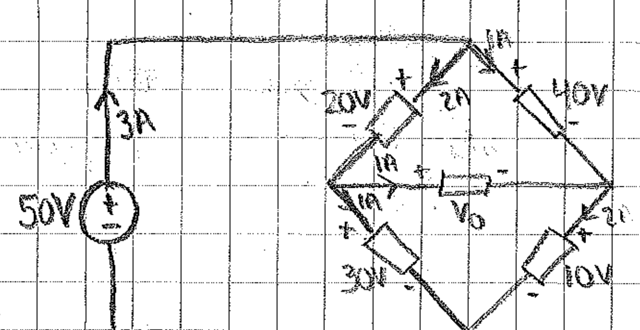
$$V = iR$$

$$10\cos(t)\,\text{V} = 0.002\cos(t)\,R$$

$$R = \frac{10\cos(t)}{0.002\cos(t)}$$

$$R = 5000\,\Omega = \boxed{5\,\text{k}\Omega}$$

2) Find V_o for the circuit below:



Use KVL : $\sum_{m=1}^{M} V_m = 0$ (for any closed loop)

...so... $-50\text{V} + 20\text{V} + V_o + 10\text{V} = 0$

$$V_o = \boxed{20\text{V}}$$

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3) If the current flowing through an element is given by:

$$i(t) = \begin{cases} 3t\,A, & 0 < t < 6s \\ 18\,A, & 6 < t < 10s \\ -12\,A, & 10 < t < 15s \\ 0, & t > 15s \end{cases} \qquad \text{Given: } q(0) = 0$$

Plot the charge stored in the element over $0 < t < 20s$.

Note:

$q(t) = i\,dt$, $\Longrightarrow$

$Q = \int_{t_1}^{t_2} i\,dt$

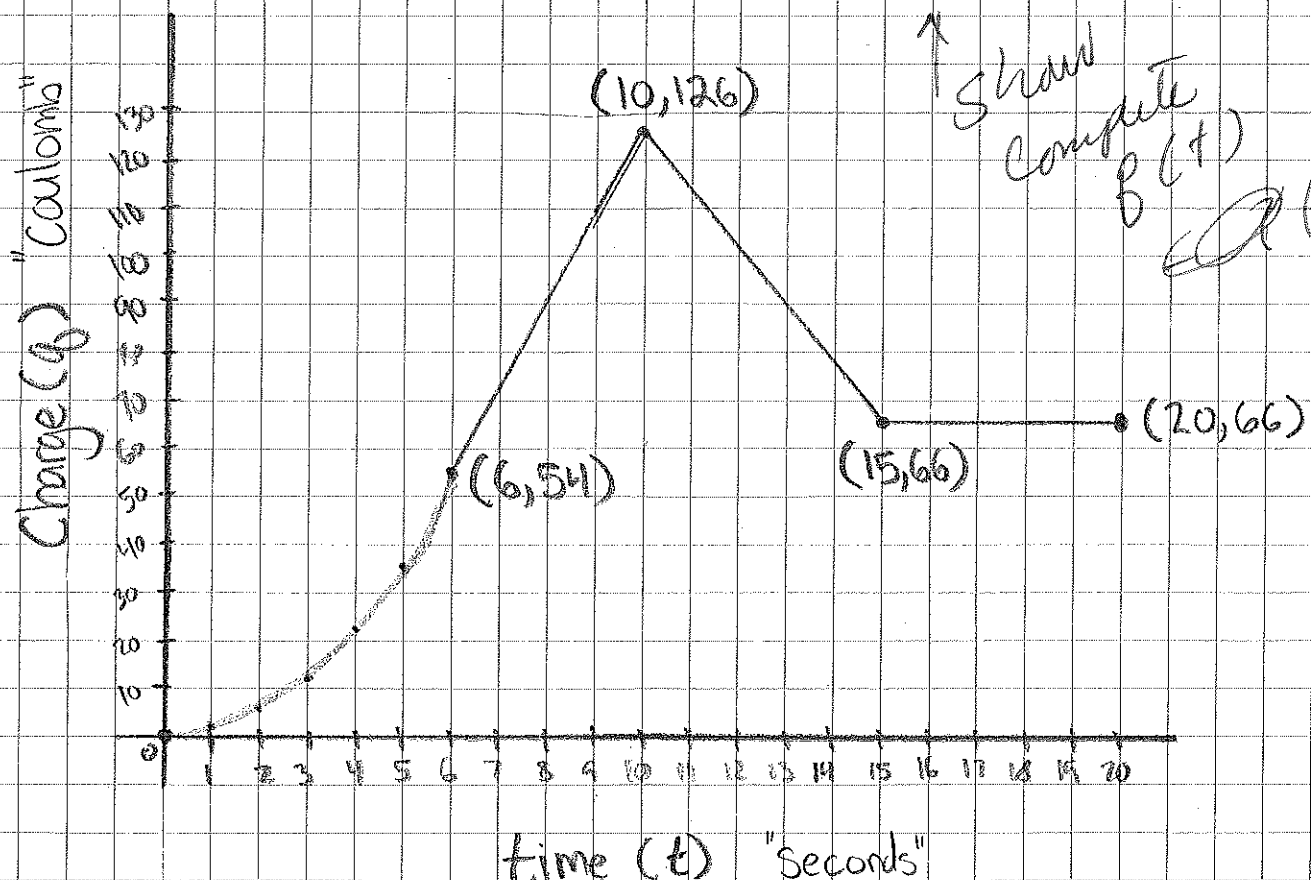
$\int_0^6 3t\,A\,dt = \frac{3}{2}t^2\Big]_0^6 \longrightarrow$ @ $t=6$, $q=54$

$\int_6^{10} 18\,A\,dt = 18t\Big]_6^{10} \longrightarrow$ @ $t=10$, $q = 54+72 = 126$

$\int_{10}^{15} -12\,A\,dt = -12t\Big]_{10}^{15} \longrightarrow$ @ $t=15$, $q = 126-60 = 66$

↑ Show complete $q(t)$

-1



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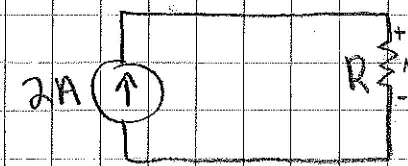
4) Specify the resistance R in Figure below so that both of the following Conditions are satisfied:

1. $V > 10V$
2. The power absorbed by the resistor is less than 25 W



Use the resistor table to just choose resistor(s) nominal values that satisfy the design.

Note:

$V = iR$

$V = 2R \;,\; V > 10 \rightarrow R > 5\Omega$

$P = Vi = i^2 R, \; P < 25W$

$25 > (2^2)R \rightarrow R < 6.25\Omega$

$\left.\right\} \; 5 < R < 6.25$

∴ so, we can use one of the following: $\boxed{5.1\Omega, 5.6\Omega, 6.2\Omega}$

5) In a household, a 120-W PC is run for 4 hours/day, while a 60-W bulb burns for 8 hours/day. If the utility company charges \$0.12/KWh, Calculate how much the household pays per year on the PC and the bulb.

Note:

* 1 year = 365 days = 8760 hours = 525600 min = 31536000 s

$120W \cdot (60 \cdot 60 \cdot 4 \cdot 365)s = 630720000 \; W\text{-}S$

$60W \cdot (60 \cdot 60 \cdot 8 \cdot 365)s = 630720000 \; W\text{-}S$

$\frac{\$0.12}{KW\text{-}H} \cdot 2(630720 \, KW\text{-}S) \cdot \frac{1 \, KW\text{-}H}{(60 \cdot 60) KW\text{-}S} = \boxed{\$42.05}$

... and on leap year: \$42.16

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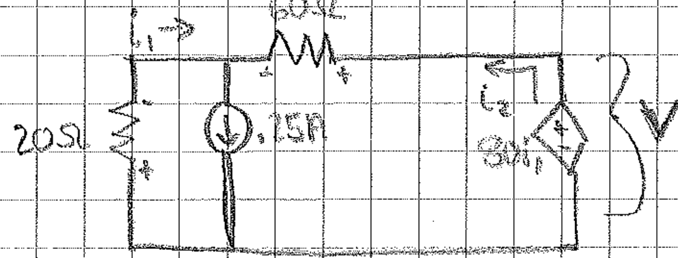
20/20

1) Determine the value of the voltage that is measured by the meter in the circuit below:



Note: KCL → $.25A = i_1 + i_2$ (1)

KVL → $-80i_1 + 60i_2 - 20i_1 = 0$

$60i_2 = 100i_1$

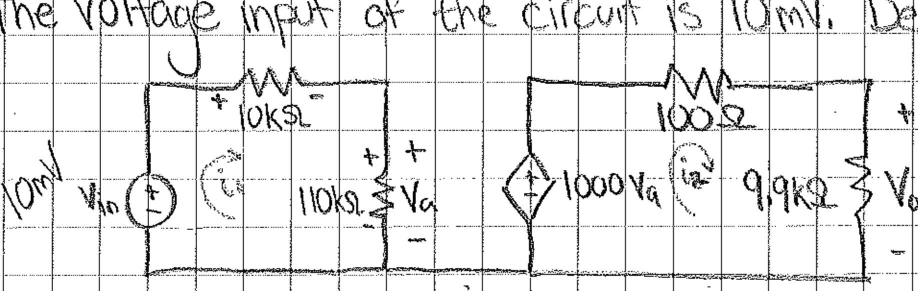
$i_1 = \frac{3}{5} i_2$ (2)

$.25 = \frac{3}{5} i_2 + i_2$ (1,2)

$.25 = \frac{8}{5} i_2$

$i_2 = .156 \rightarrow i_1 = .09375 \rightarrow V = \boxed{7.5V}$

2) The voltage input of the circuit is 10mV. Determine $V_o(t)$.



Note: KVL → $10mV = 10Ki_1 + 110Ki_1$

$10mV = 120Ki_1$

$\therefore i_1 = .0000000833A$ (1)

$\therefore V_a = i_1(110K) = 9.167\ mV$ (2)

KVL → $1000(9.167mV) = 100i_2 + 9.9Ki_2$

$9.17 = 10Ki_2$

$\therefore i_2 = 0.917\ mA$ (3)

$V_o = (i_2)(9.9K) = (0.917)(9.9) = \boxed{9.075V}$

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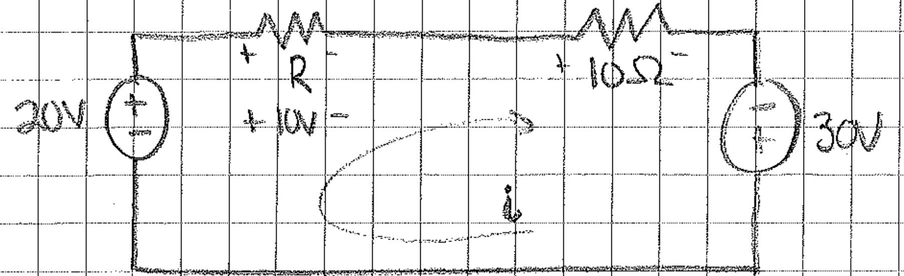
3) Find R in the circuit below:



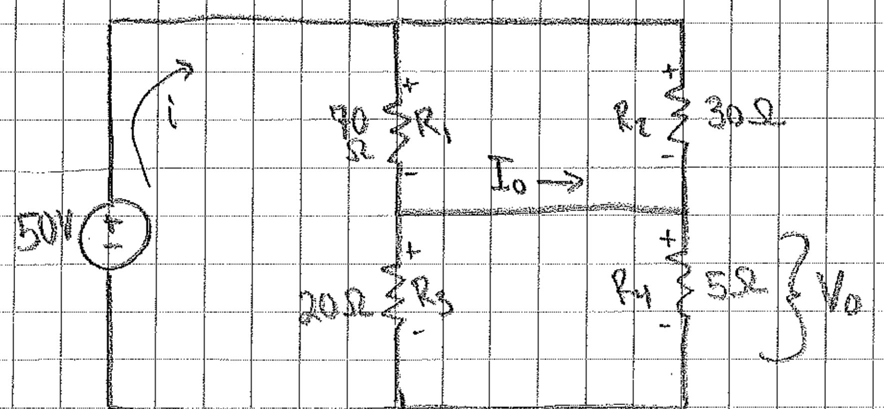
Note: KVL → $-20V + 10V + 10i - 30V = 0$ Ohm's → $R = \frac{V_R}{i}$ (2)

$10i = 40V$

$i = 4A$ (1)

$\therefore R = \frac{V_R}{i} = \frac{10}{4} = \boxed{2.5\Omega}$

4) Calculate V_o and I_o in the circuit below:



Note: $V_{R_1,R_2} \Rightarrow R_{12} = \left(\frac{1}{70} + \frac{1}{30}\right)^{-1} = 21\Omega$ (1)

$V_{R_3,R_4} \rightarrow R_{34} = \left(\frac{1}{20} + \frac{1}{5}\right)^{-1} = 4\Omega$ (2)

KVL → $50V = 21i + 4i \rightarrow i = 2A \rightarrow V_0 = V_{34} = (4)(2) = \boxed{8V}$ (3)

b/c $V_0 = 8V$, this means that $i_3 = \frac{8}{20} = \frac{2}{5}$, (4)

and using KVL $50 = V_{R_1} + 8 \rightarrow V_{12} = 42V \rightarrow i_1 = \frac{42}{70} = \frac{3}{5}$ (5)

KCL → $i_1 = I_0 + i_3 \rightarrow \frac{3}{5} = I_0 + \frac{2}{5} \rightarrow I_0 = \boxed{0.2A}$

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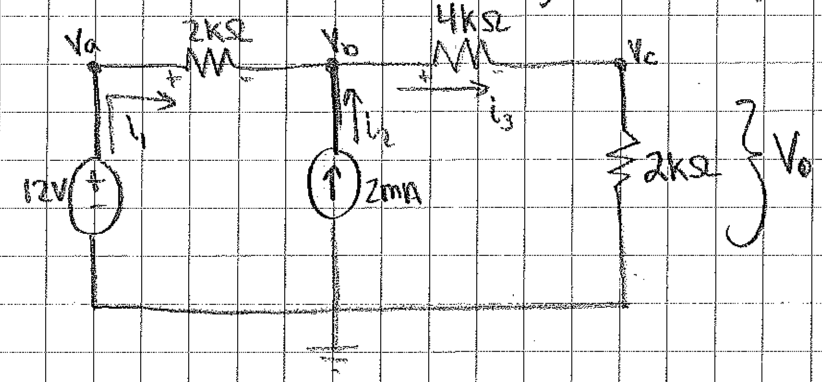
19/20

1) Find V_o across the 2k resistor, using nodal analysis.



KCL @ $V_b \rightarrow$ $i_3 = i_1 + 2mA$

$$\frac{V_b - V_c}{4K} = \frac{V_a - V_b}{2K} + 2mA$$

$$\frac{V_b}{4k} - \frac{V_c}{4k} = \frac{V_a}{2k} - \frac{V_b}{2k} + 2mA$$

$$V_b - V_c = 2V_a - 2V_b + 8$$

$$2V_a - 3V_b + V_c = -8 \quad (1)$$

KCL @ $V_c \rightarrow$ $i_3 = i_3$

$$\frac{V_b - V_c}{4K} = \frac{V_c - 0}{2K}$$

$$\frac{V_b}{4k} - \frac{V_c}{4k} = \frac{V_c}{2K}$$

$$V_b - V_c = 2V_c$$

$$V_b = 3V_c \quad (2)$$

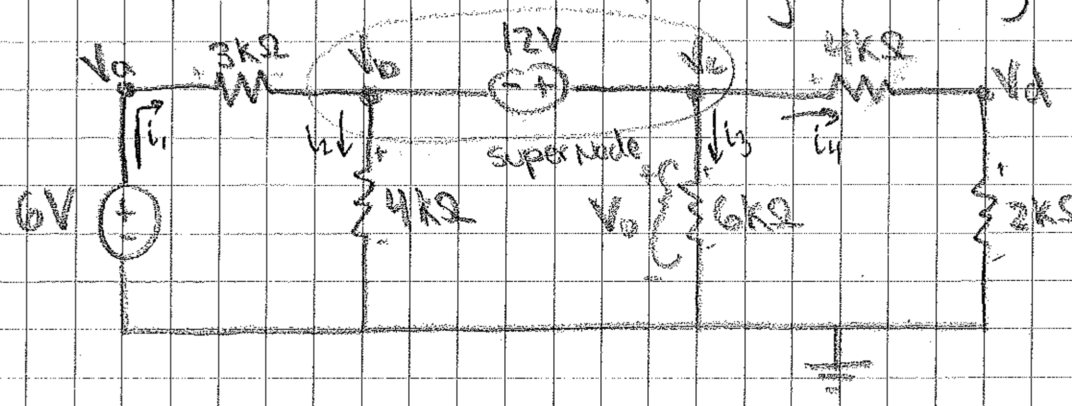
Note: $V_a = 12V$ (3)

$$\rightarrow \quad 2(12) - 9V_c + V_c = -8$$

$$8V_c = 32$$

$$V_c = 4V \quad \& \; V_c = V_o \; \therefore \; V_o = \boxed{4V}$$

2) Find V_o across the 6k resistor, using nodal analysis.



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Note: $V_a = 6V$ (1) & $V_c - V_b = 12V$ (2)

KCL @ Super Node: $i_1 = i_2 + i_3 + i_4$

$$\frac{V_a - V_b}{3K} = \frac{V_b - 0}{4K} + \frac{V_c - 0}{6K} + \frac{V_c - V_d}{4K}$$

$$\frac{V_a}{3K} - \frac{V_b}{3K} = \frac{V_b}{4K} + \frac{V_c}{6K} + \frac{V_c}{4K} - \frac{V_d}{4K}$$

$$4V_a - 4V_b = 3V_b + 2V_c + 3V_c - 3V_d$$

$$4(6) - 7V_b = 5V_c - 3V_d$$

$$24 = 7V_b + 5V_c - 3V_d \quad (3)$$

KCL @ V_d: $i_4 = i_4$

$$\frac{V_c - V_d}{4K} = \frac{V_d - 0}{2K}$$

$$\frac{V_c}{4K} - \frac{V_d}{4K} = \frac{V_d}{2K}$$

$$V_c - V_d = 2V_d$$

$$V_c = 3V_d \quad (4)$$

$$\rightarrow \quad 24 = 7(V_c - 12) + 5V_c - 3\left(\frac{V_c}{3}\right)$$

$$24 = 7V_c - 84 + 5V_c - V_c$$

$$108 = 11V_c \rightarrow V_c = 9.82 \quad \& \quad V_c = V_o = \boxed{9.82V}$$

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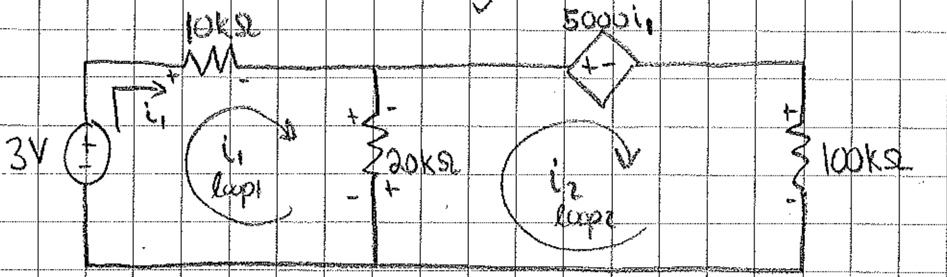
3) Find the energy delivered to the cathode during a 24 hour period. (The cathode is represented by the dependent voltage source and the 100 kΩ resistor. Use Mesh analysis to solve this problem.



KVL @ loop1: $-3V + 10Ki_1 + 20K(i_1 - i_2) = 0$

$-3V + 30Ki_1 - 20Ki_2 = 0$ (1)

KVL @ loop2: $5000i_1 + 100Ki_2 + 20K(i_2 - i_1) = 0$

$120Ki_2 - 15Ki_1 = 0$

$8 i_2 = i_1$ (2)

$\longrightarrow -3V + 30K(8i_2) - 20Ki_2 = 0$

$220Ki_2 = 3V$

$\underline{i_2 = 0.0136\,mA}$ (3)

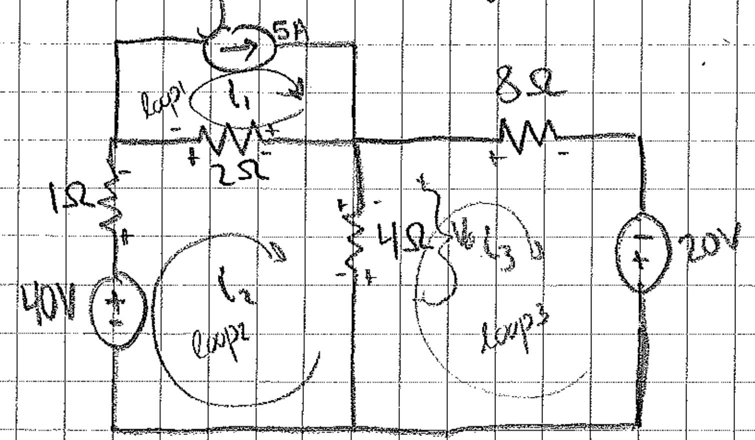
$P = Vi = i^2R = (100k)(.0000136)^2 = 0.018\,mW\text{-}S$ (4)

$\int_0^{(24\cdot 60\cdot 60)} 0.000018\,dt = \left[0.000018t + C\right]_0^{86400} = \boxed{1.6W}$

-1

~~Note: $i_1 = 0.000109A \rightarrow 3(i_1) = .326mW \rightarrow 28.20W$~~

4) Apply mesh analysis to find V_o across 4Ω in the circuit below:



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KVL@loop2: $-40V + i_2 + 2(i_2-5) + 4(i_2-i_3) = 0$

$-40 + i_2 + 2i_2 - 10 + 4i_2 - 4i_3 = 0$

$50 = -4i_3 + 7i_2 \quad (1)$

KVL @ loop 3: $-20 + 4(i_3 - i_2) + 8i_3 = 0$

$-20 + 4i_3 - 4i_2 + 8i_3 = 0$

$20 = -4i_2 + 12i_3$

$5 = -i_2 + 3i_3 \quad (2)$

$\longrightarrow \quad 50 = 7(3i_3 - 5) - 4i_3$

$50 = 21i_3 - 35 - 4i_3$

$85 = 17i_3$

$i_3 = 5A \quad (3)$

$\therefore V_0 = Ri = 4(5) = \boxed{20V}$

$9 \cdot 9$

3^4

$(3^2)^2$

$3^2 3^2$

$3 \cdot 3 \cdot 3 \cdot 3$

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Engr. M20 HW #4

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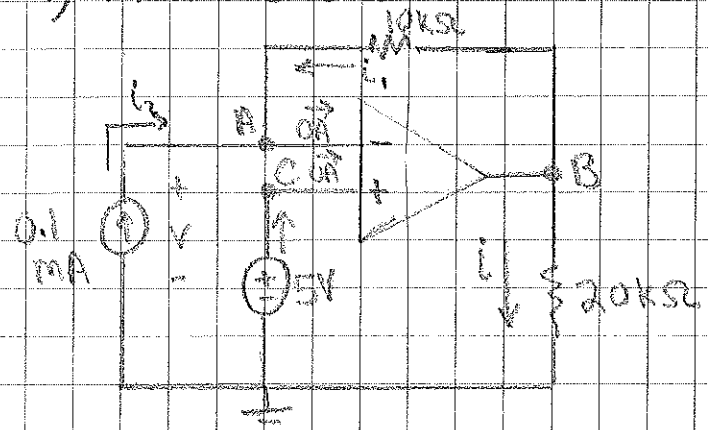
1) Find v and i in the circuit below:



KCL @ (-) opAmp:

$i_1 + i_2 = 0A$

$\frac{V_B - V_A}{10K} + 0.1mA = 0A$

$\frac{V_B}{10K} - \frac{V_A}{10K} + 0.1mA = 0$

$V_B - V_A + 1V = 0$ (Eq 1)

Note: Principle of Short $\Rightarrow V_A = V_C$

Note: $V_C = 5V \Rightarrow \underline{V_A = 5V}$ (Eq 2)

(Eq 1, Eq 2) $\rightarrow V_B - 5 + 1 = 0$

$V_B = 4V$ (Eq 3)

Note: $V = iR \Rightarrow 4 = i(20K)$

$\boxed{i = 200 \mu A}$

Note: $V = V_A \Rightarrow \boxed{V = 5V}$

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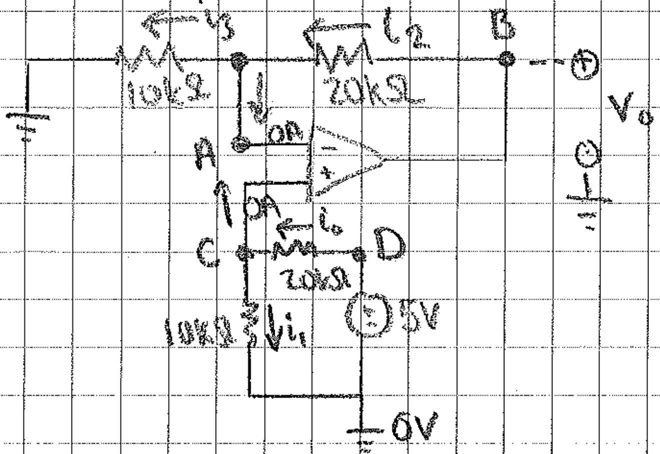
2) Find V_o and i_o in the CKT below:



KCL @ C:

$i_o = i_1 + 0A$

$$\frac{V_D - V_C}{20K} = \frac{V_c - 0}{10K}$$

$$\frac{V_D}{\cancel{20K}} - \frac{V_c}{\cancel{20K}} = \frac{2V_c}{\cancel{20K}}$$

Note: $V_D = 5V$

$5 - V_c = 2V_c$

$3V_c = 5$

$V_c = 5/3\,V$ (Eq 1)

Note: Principle of Short $\rightarrow V_A = \cancel{V_C}^{5/3V} \Rightarrow V_A = 5/3\,V$ (Eq 2)

KCL @ A:

$i_2 = i_3 + 0A$

$$\frac{V_B - V_A}{20k\Omega} = \frac{V_A - 0}{10k\Omega}$$

$$\frac{V_B}{\cancel{20K}} - \frac{V_A}{\cancel{20K}} = \frac{2V_A}{\cancel{20K}}$$

$V_B = 3V_A = 3(5/3)$

$\therefore V_B = 5V$ (Eq 3)

Note: $V_B = V_o \rightarrow \boxed{V_o = 5V}$

Note: $V = i_oR = (V_D - V_c) = i_o(20K)$

$$\frac{5 - 1.667}{20K} = i_o \Rightarrow \boxed{i_o = 166.7\,\mu A}$$

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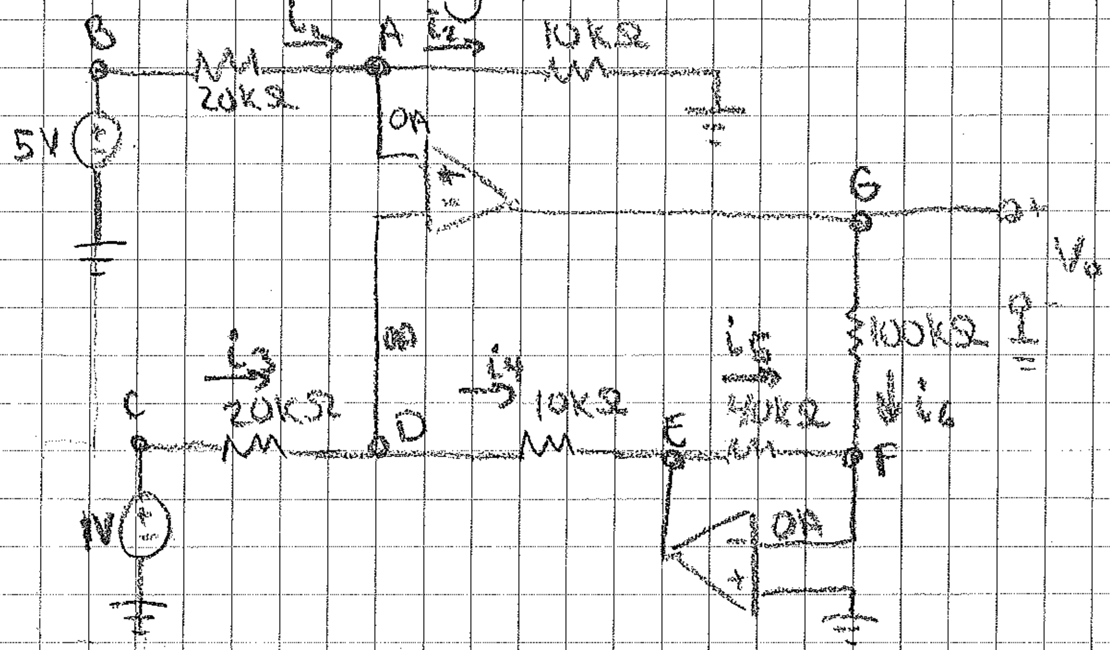
3) Find V_0 in the following Circuit:



Note: $V_B = 5V$; $V_C = 1V$; $V_F = 0V$ (Principle of short)

KCL @ A:

$i_1 = i_2 + 0A$

$$\frac{V_B - V_A}{20K} = \frac{V_A - 0}{10K}$$

$$-\frac{V_A}{\cancel{20K}} + \frac{V_B}{\cancel{20K}} = \frac{2V_A}{\cancel{20K}}$$

$+V_B = 3V_A \Rightarrow V_A = 5/3 = 1.667V$ (Eq1)

$\therefore V_D = 1.667V$ (Principle of short)

KCL @ D

$i_3 = i_4 + 0A$

$$\frac{V_C - V_D}{20K} = \frac{V_D - V_E}{10K}$$

$$\frac{\cancel{V_C}^{1}}{\cancel{20K}} - \frac{V_D}{\cancel{20K}} = \frac{2V_D}{\cancel{20K}} - \frac{2V_E}{\cancel{20K}}$$

$3\cancel{V_D}^{5/3} = 1 + 2V_E$

$4 = 2V_E$

$V_E = 2V$ (Eq2)

KCL @ F

$i_5 + i_6 = 0A$

$$\frac{V_E - V_F}{40K} + \frac{V_G - V_F}{100K}$$

$$\Rightarrow \frac{5\cancel{V_E}^{2}}{\cancel{200K}} - \frac{5\cancel{V_F}^{0}}{\cancel{200K}} + \frac{2V_G}{\cancel{200K}} - \frac{2\cancel{V_F}^{0}}{\cancel{200K}} = 0$$

$10 = -2V_G$

$\therefore V_G = -5V$

Note: $V_G = V_0 \Rightarrow \boxed{V_0 = -5V}$

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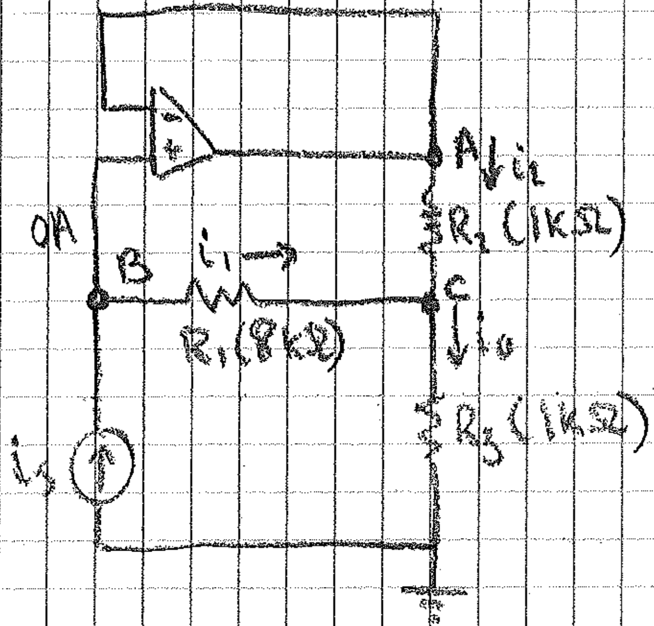
4) A non-inverting current amplifier in portrayed in CKT below. Calculate the gain i_o/i_s. Take $R_1 = 8K\Omega$, and $R_2 = R_3 = 1K\Omega$



<u>Note:</u> $V_A = V_B$ by principle of short

KCL @ B

$i_s = i_1 + 0A$

$i_s = \frac{V_B - V_C}{8K}$

$i_s = \frac{V_B}{8K} - \frac{V_C}{8K}$ (1)

KCL @ C

$i_1 + i_2 = i_o$

$\frac{V_B - V_C}{8K} + \frac{V_A - V_C}{1K} = \frac{V_C - 0}{1K}$

$\frac{V_B}{8K} - \frac{V_C}{8K} + \frac{8V_A}{8K} - \frac{8V_C}{8K} = \frac{8V_C}{8K}$

$V_B - V_C + 8V_A - 8V_C = 8V_C$

$\cancel{V_B}^{V_A} + 8V_A = 17V_C$

$9V_A = 17V_C$

$V_B = V_A = 17/9\, V_C$ (2)

(1,2) → $i_s = \frac{17/9 V_C}{8K} - \frac{V_C}{8K}$

$i_s = \frac{8/9 V_C}{8K}$

$i_s = \frac{V_C}{9K}$ (3)

& $i_o = V_C/1K$

∴ $V_C = i_o 1K$ (4)

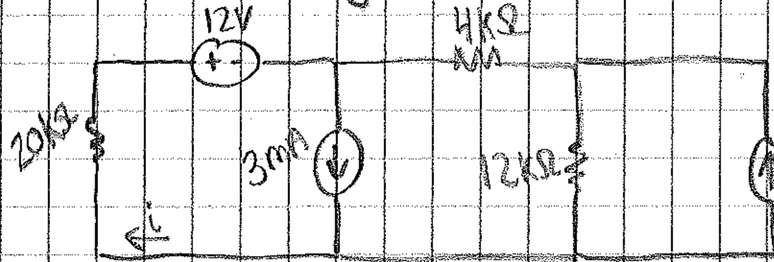
(3,4) → $i_s = \frac{i_o 1K}{9K}$

$\boxed{\frac{i_o}{i_s} = 9}$

HW # 5

$\frac{20}{20}$ good job. Jared Fowler

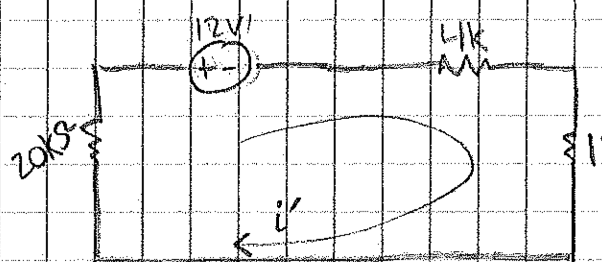
1) Find i using superposition.



3 Sources

12V, 3mA, 9mA

Keep 12V, Kill others



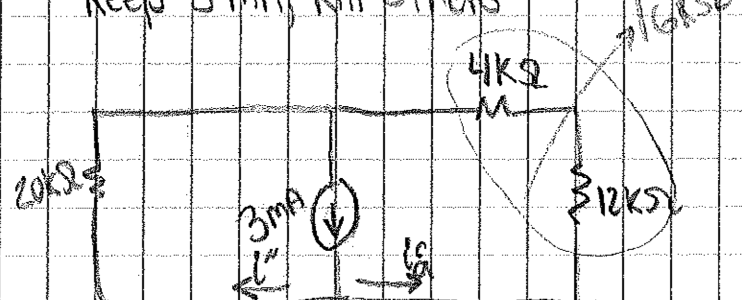
Using KVL:

$$20k(i') + 12V + 4k(i') + 12k(i') = 0$$

$$i' = -12/(20k + 4k + 12k)$$

$$i' = -\tfrac{1}{3}\text{ mA} \quad (1)$$

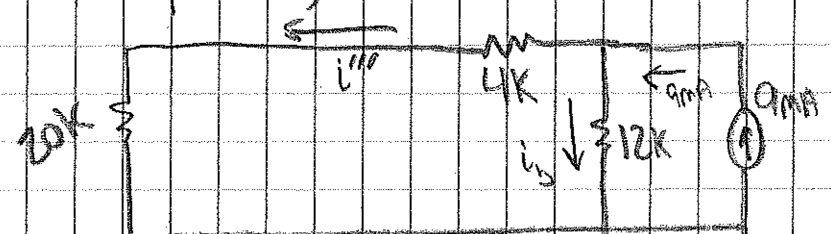
Keep 3 mA, Kill others



Use Current Division:

$$i'' = 3\text{mA}\left(\frac{16k}{36k}\right) = \cancel{3}\text{mA}\left(\frac{4}{\cancel{9}_{3}}\right) = \tfrac{4}{3}\text{ mA} \quad (2)$$

Keep 9 mA, kill others



Use Current Division

$$i''' = 9\text{mA}\left(\frac{12K}{36K}\right) = 9\text{mA}\left(\frac{1}{3}\right) = 3\text{mA} \quad (3)$$

SO: $i = i' + i'' - i'''$

$$= -\tfrac{1}{3}\text{mA} + \tfrac{4}{3}\text{mA} - 3\text{mA}$$

$$\boxed{i = -2\text{ mA}}$$

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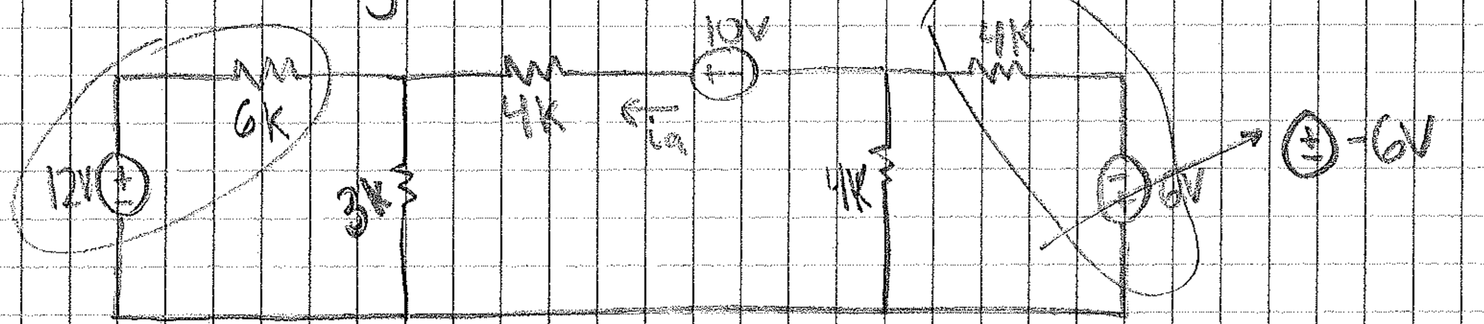
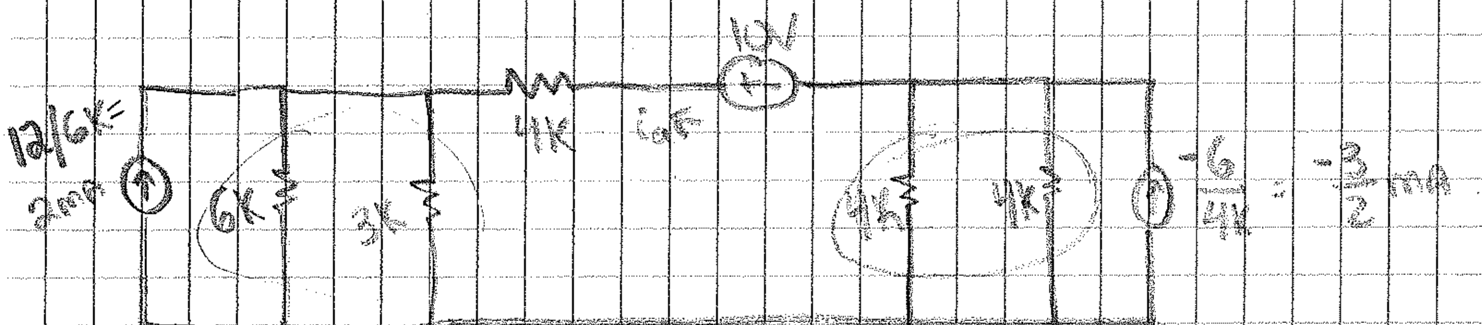
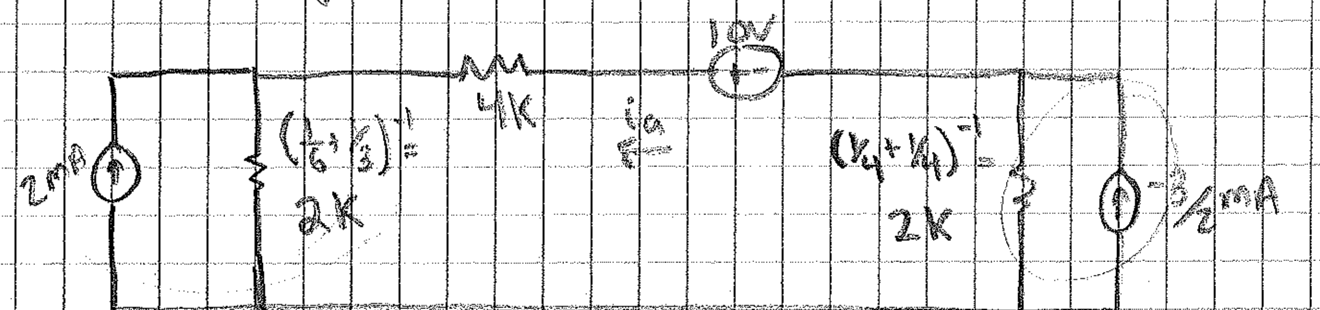
2) Find i_a using source transformation.



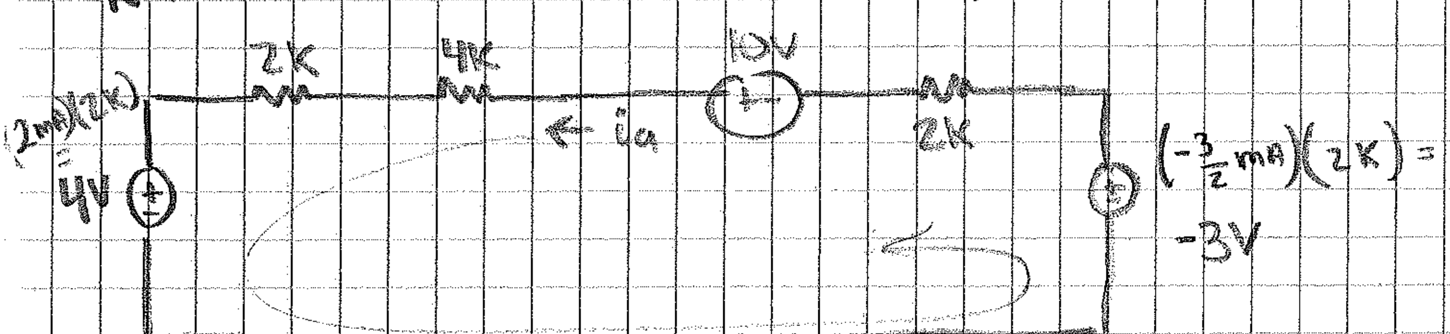
T -> N T -> N



use equivalance rule for parallel resistors



N -> T N -> T



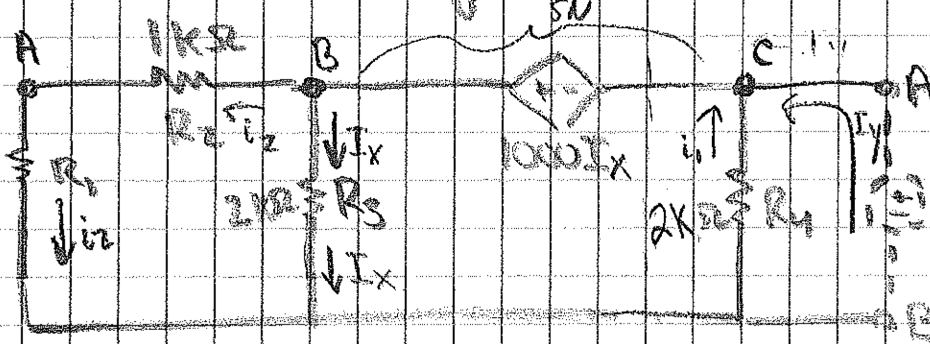
Use KVL:

$$(4K)(i_a) + (2K)(i_a) + 4V - (-3V) + (2K)(i_a) - 10V = 0$$

$$(8K)(i_a) - 3V = 0 \rightarrow \boxed{i_a = \tfrac{3}{8}\text{mA}} = \boxed{375\ \mu A}$$

I Fowler

3) Find the Thevenin equivalent between A-B terminal.

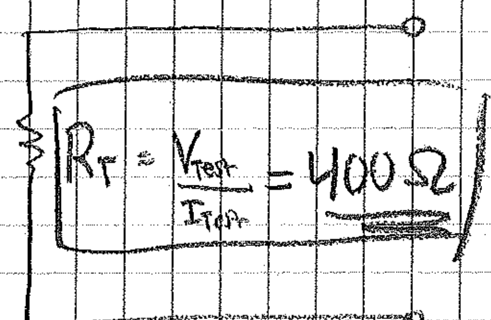


→ Test Voltage of 1V

Note: In a all dependent circuit, there is no voltage output in the Thevenin equivalent. What we are trying to find is the equivalent resistance of the entire circuit, R_T, such that I_T is the same regardless of voltage.

For example: if $(V_M / I_M) = R_T \rightarrow (V_N / I_N) = R_T$

So, want to find:



$$\boxed{R_T = \frac{V_{Test}}{I_{Test}} = 400\,\Omega}$$

Let $V_{Test} = V_o = 1V$

Note: $i_2 = i_2 \Rightarrow \frac{V_A - 0}{1k} = \frac{V_B - V_A}{1k} \Rightarrow 2V_A = V_B$ (1)

KCL @ Super Node:

Note: $V_B - V_C = 1000 I_x$ & $I_x = \frac{V_B}{2K}$

$I_y + i_1 = I_x + i_2$

$V_B - V_C = \frac{1k}{2k} V_B$

$I_y + \frac{0 - V_C}{2k} = \frac{V_B - 0}{2k} + \frac{V_B - V_A}{1k}$

$\frac{1}{2} V_B = V_C$ (2) $\rightarrow V_C = V_A$

$I_y - \frac{V_C}{2k} = \frac{V_B}{2k} + \frac{V_B}{1k} - \frac{V_A}{1k}$

& $V_C = 1V$ ... (4)
& $V_B = 2V$

$(2K) I_y - V_C = \cancel{V_B} + \cancel{2V_B} - 2V_A$ (3) with $3V_B$

$\therefore I_y = \frac{1}{400} A$ & $R_T = \frac{1}{1/400} = \boxed{400\,\Omega}$

$(1,2,3) \Rightarrow (2K) I_y - (1V) = (6V) - 2(1V)$

$(2K) I_y = 5V \Rightarrow I_y = 5V/2K$

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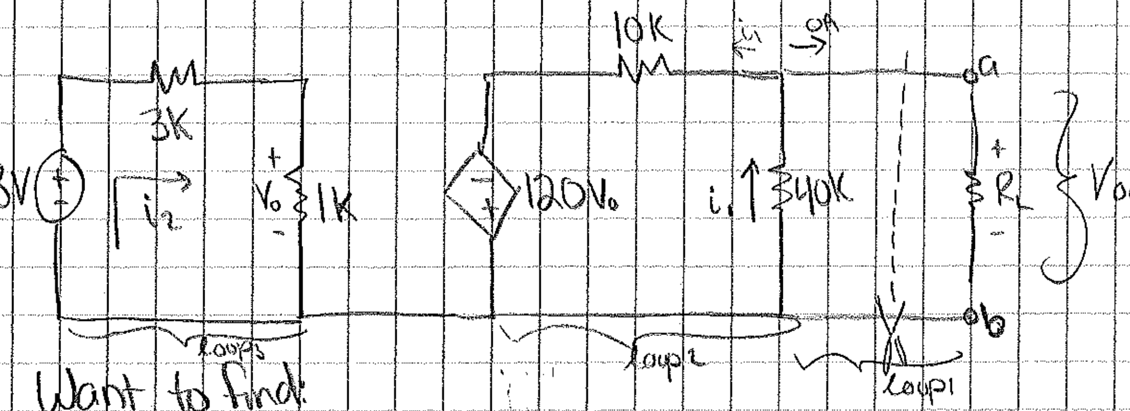
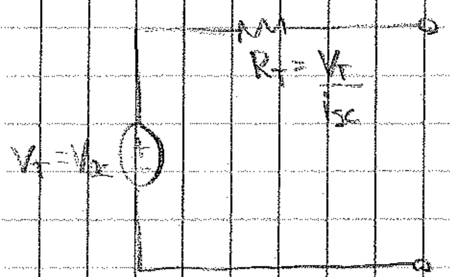
4) For the circuit below, what resistor connected across terminals a-b will absorb maximum power from the circuit? What is that power?



Want to find:



KVL @ loop1

(1) $V_{oc} + (40k)(i_1) = 0$

KVL @ loop2

$((40k)i_1) + (10k)i_1 - 120V_o = 0$

(2) $(50k)i_1 - 120V_o = 0$

KVL @ loop3

$-8V + 3k(i_2) + 1k(i_2) = 0$

$-8V + 4k(i_2) = 0$ where $V_o = (1k)i_2$ ($i_2 \to$ 2mA)

$4k\,i_2 = 8$

$\underline{i_2 = 2mA}$ (3)

$\underline{V_o = 2V}$ (4)

$(2,4) \rightarrow (50k)i_1 - 120(2) = 0$

$\underline{i_1 = 24/5\ mA}$ (5)

$(5,1) \rightarrow V_{oc} + \cancel{40}^{8}k(24/\cancel{5}_{1}\ mA) = 0 \rightarrow \boxed{V_{oc} = -192V}$

continue

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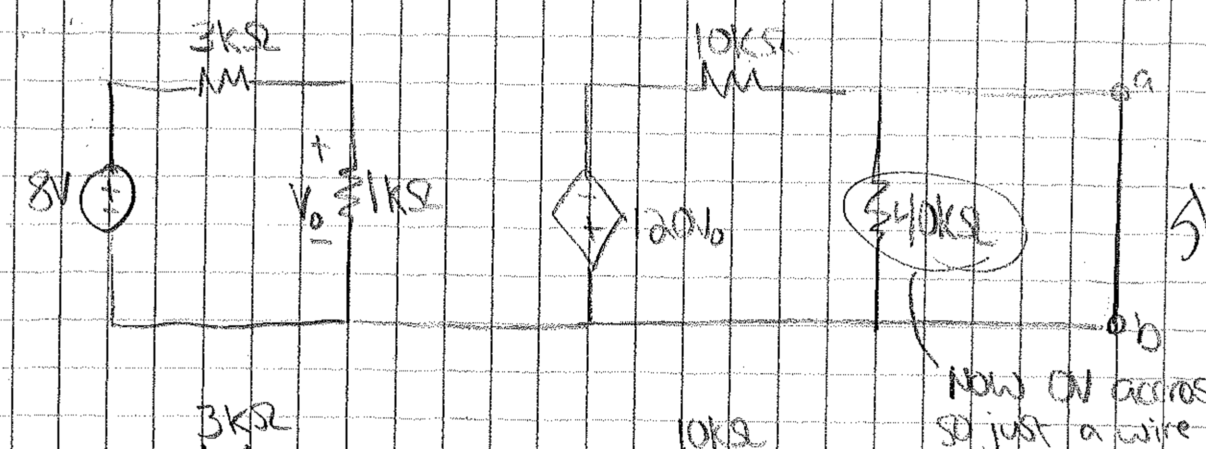
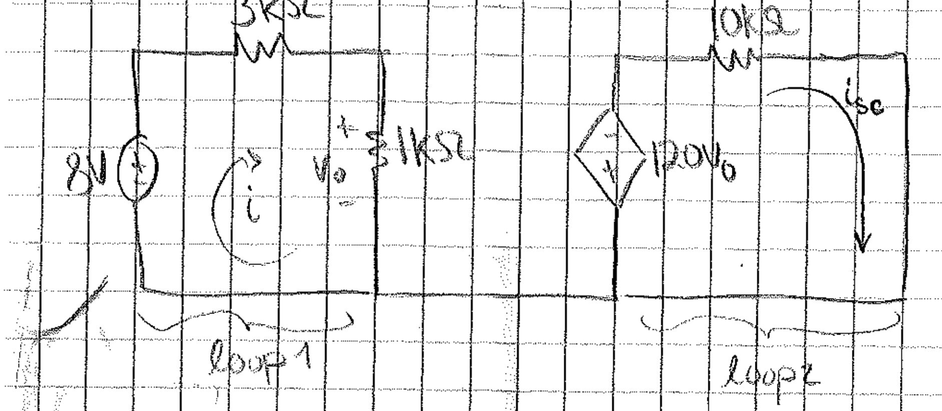




KVL @ loop1:

$-8V + 3ki + 1ki = 0$; $V_0 = 1ki$

$8V = +4ki$

$\underline{i = +2mA}$; $\underline{V_0 = +2V}$

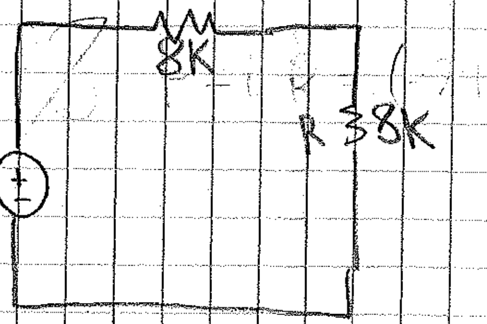
KVL @ loop2:

$120V_0 + 10Ki_{sc} = 0$

$120(+2) + 10Ki_{sc} = 0$

$\underline{i_{sc} = -24mA}$

$\therefore\ R_T = \frac{V_T}{i_{sc}} = \frac{-192V}{-24mA} = \boxed{8K\Omega}$



Max power absorbed when $R = R_T$

$V = iR$

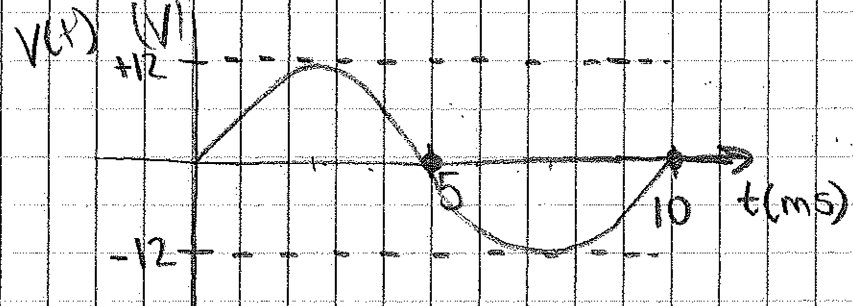
$192 = i(16K)$

$i = 192/16K = \frac{96}{8K} = \frac{12}{K} = \underline{12mA}$

Note: $P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{192^2}{4(8K)} = \boxed{1.152W}$

HW #6 19/20 Jared Fowler

1) The Voltage across a 10 μF capacitor is shown below. Determine and plot the waveform for the capacitor current.



Note: $i = C\frac{dv}{dt}$; Amplitude: 12; Period: 5ms

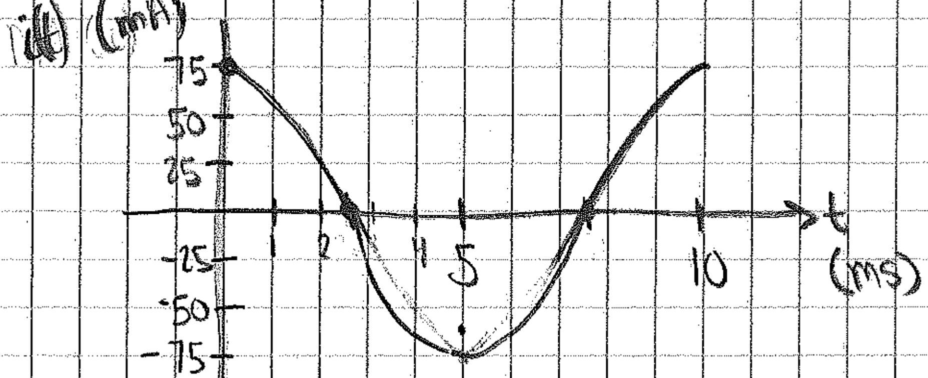
The voltage plot takes on this form:

$V(t) = 12\sin(200\pi t)$ b/c $n = 2\pi/.01 = 200\pi$

$i(t) = (10\mu F)\left(12\sin(200\pi t)\frac{d}{dt}\right)$

$i(t) = (10\mu F)(12)(200\pi)(\cos(200\pi t))$

$\boxed{i(t) = 0.0754\cos(200\pi t)}$



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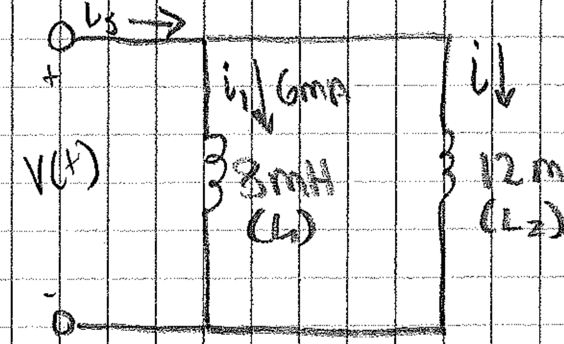
2) Two inductors are connected in parallel as shown in the CKT below. Find i.



$V = L\frac{di}{dt}$

$\frac{1}{8} + \frac{1}{12}$

$L = \frac{L_1 L_2}{L_1 + L_2}$ $i_s = i_1 + i$

Note that the voltage across both inductors is equal.

$i_s = i_1 + i_2$

$i_1 = i_2 = i_s$

$V = L\frac{di}{dt}$

$i_1 = \frac{L_2}{L_1 + L_2} i_s$ & $i = \frac{L_1}{L_1 + L_2} i_s$

$6mA = \frac{12mH}{20mH} i_s$ $i = \frac{3mH}{20mH}(10mA)$

$V = L\frac{di}{dt}$

$V = 20mH \frac{di}{dt}$ $6mA = \frac{3}{5} i_s$ $i = \frac{2}{5}(10mA)$

$L\frac{di}{dt} = V$

$V = 20mH(i_s)$

$\underline{i_s = 10 mA}$ $\boxed{i = 4 mA}$

(20mH)

$V = 20mH i_s$

$V = 6mA(8m)$

$48 = 20 i_s$

$i_s =$

$V = (20mH)$

$(20mH)(i_s) = (6mA)(8mH)$

$i_s = \frac{48}{20}$

$\frac{20}{8}$ $\frac{5}{2}$

$\frac{2}{5}$ .001

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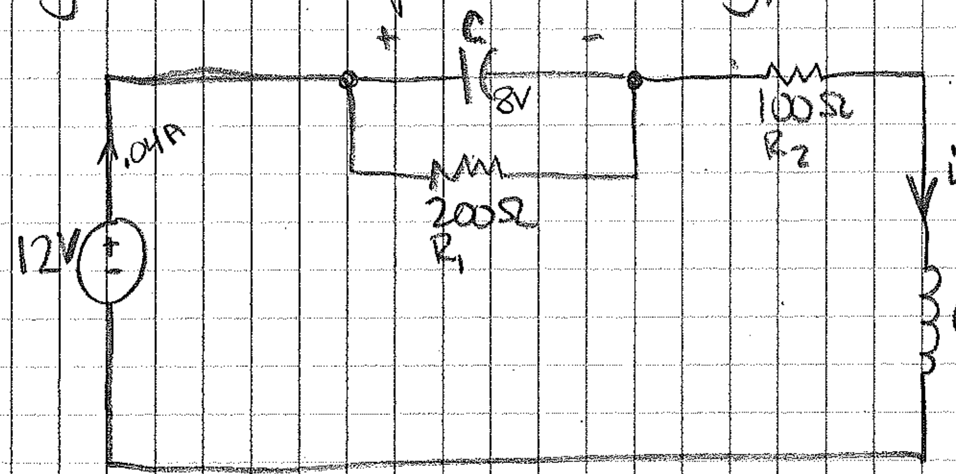
3) Find the value of C if the energy stored in the capacitor in the figure below is equal to stored energy in the inductor.



<u>Note:</u> energy stored (w) = $\frac{1}{2} C V_c^2$ & $W = \frac{1}{2} L i_L^2$

$$\cancel{\tfrac{1}{2}} C V_c^2 = \cancel{\tfrac{1}{2}} L i_L^2$$

$$C V_c^2 = L i_L^2$$

<u>Note:</u> $V_c = V_{R_1}$, and in DC circuit an inductor has 0V, and a capacitor acts like an open circuit...

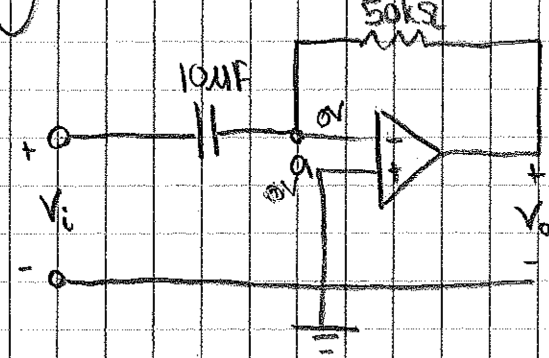
$$C(200 i_L)^2 = L i_L^2$$

$$C(40000)\cancel{i_L^2} = L\cancel{i_L^2}$$

$$C = L/40000 = .1/40000$$

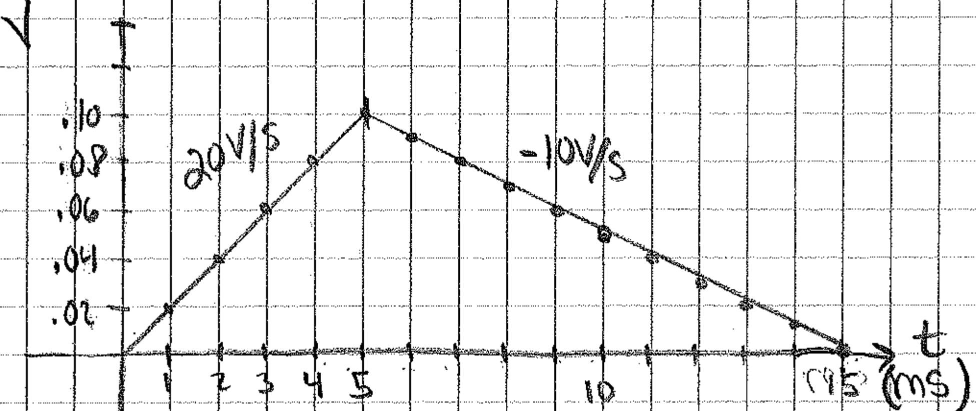
$$\boxed{C = 3\,\mu F}$$

4) A voltage waveform has the following characteristics: a positive slope of 20 V/s for 5 ms followed by a negative slope of 10 V/s for 10 ms. If the waveform is applied to a differentiator with $R = 50k\Omega$, $C = 10\,\mu F$, sketch the output voltage waveform.



$$C\frac{dv}{dt} = \frac{0 - V_o}{\cancel{50k}\ R}$$

$$V_o = -RC\frac{dv}{dt} \checkmark$$



Note: $V_o = -RC\dfrac{dv_i}{dt} \Rightarrow$

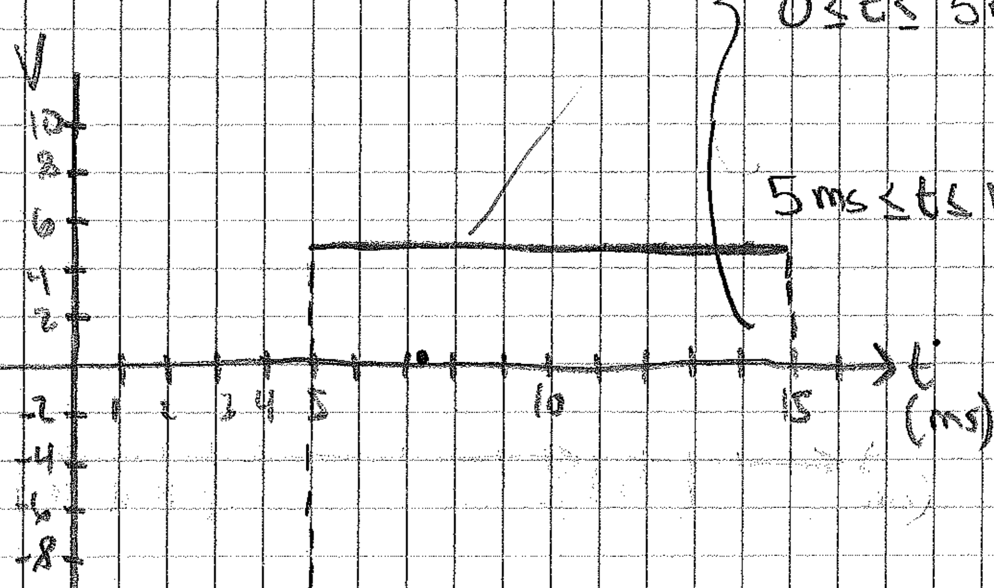
∴ assume: $t < 0$: $V_o = 0V$

$0 \le t \le 5\,ms$: $V_o = (50k)(10\mu)(20 V/s)$

$\underline{V_o = -10\,V}$

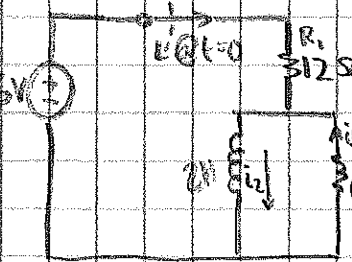
$5\,ms \le t \le 15\,ms$: $V_o = (50k)(10\mu)(-10 V/s)$

$\underline{V_o = 5V}$

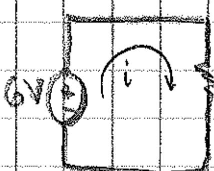


HW #7; Engr M20 26/26 Jared Fowler

1) Find $i(t)$ for $t>0$ and sketch the waveform in the following:



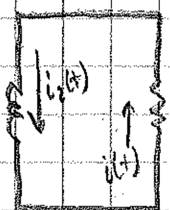
Note: Assume that @ $t<0$ the ckt is at stable state → inductor looks like a short.



$i = 6/12 = \underline{500\,mA}$ (I.C.)

Note: @ $t(0^+)$, the current will be 500mA, b/c current through inductor cannot change instantaneously.

After switch open, we have:



Note that $i_L(t) = i(t)$ for $t>0$.

KVL: $L\frac{di}{dt} + iR = 0 \Rightarrow \frac{di}{dt} + \frac{iR}{L} = 0$ (Eq1)

(Eq2) $i = i_n + i_f$ & $i_f = K_1$ b/c 0 is constant $\Rightarrow i_f \Rightarrow \cancel{\frac{dK_1}{dt}}^{0} + K_1\frac{R}{L} = 0 \Rightarrow \underline{K_1 = 0}$

, Now for $i_n \Rightarrow \frac{di_n}{dt} + \frac{R}{L} i_n = 0$

Assumed solution of $i_n = K_2 e^{st}$

Substitute into (Eq1) $\rightarrow \frac{dK_2e^{st}}{dt} + \frac{R}{L}K_2e^{st} = 0$

$s\cancel{K_2e^{st}} + \frac{R}{L}\cancel{K_2e^{st}} = 0$

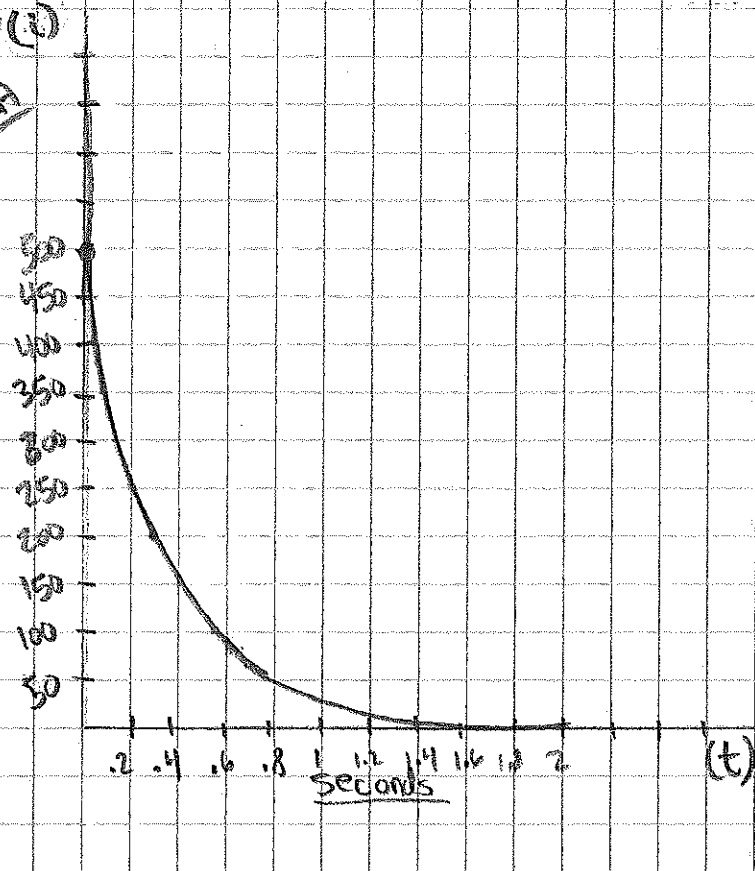
$s = -\frac{R}{L} = \frac{6}{2} = \underline{-3}$

Substitute into (Eq2)

$i(t) = K_2e^{-3t} + 0$

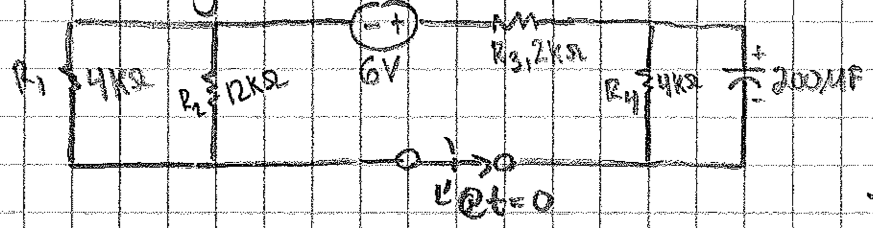
$i(0) = 500\,mA = K_2e^{0} \rightarrow \underline{K_2 = 0.5}$

$\therefore \boxed{i(t) = 0.5e^{-3t}}$



J Fowler

2) Find $V_c(t)$ for $t>0$ in the ckt below and plot the response including time interval prior to the switch opening.



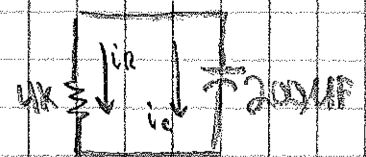
Note: Assume that @ t<0 the ckt is at stable state
→ capacitor looks like open

Note: @ $t<0$, $V_{R_4}=V_c$

KVL: $-6+2ki+4ki+3ki=0$

$i=\frac{6}{9k}=\frac{2}{3}mA$

$\therefore V_c=(4k)(\frac{2}{3}mA)=\frac{8}{3}V$ (I.C.)



(Eq1)

KCL: $i_c+i_R=0 \rightarrow \left(\cancel{C}^{.0002}\frac{dV}{dt}+\frac{V_c}{4k}=0\right)\cdot 10^4 = 2\frac{dV}{dt}+\frac{10}{4}V_c=0 \Rightarrow \frac{dV_c}{dt}+\frac{5}{4}V_c=0$

(Eq2)

$V_c(t)=V_n+V_F$ & $K_2=V_F$ b/c 0 is constant $\Rightarrow V_F=\frac{d0}{dt}+\frac{5}{4}K_2=0 \Rightarrow K_2=0$

Assumed solution, $V_n=K_1e^{st}$

Substitute into (Eq1)

$\frac{d}{dt}K_1e^{st}+\frac{5}{4}K_1e^{st}=0$

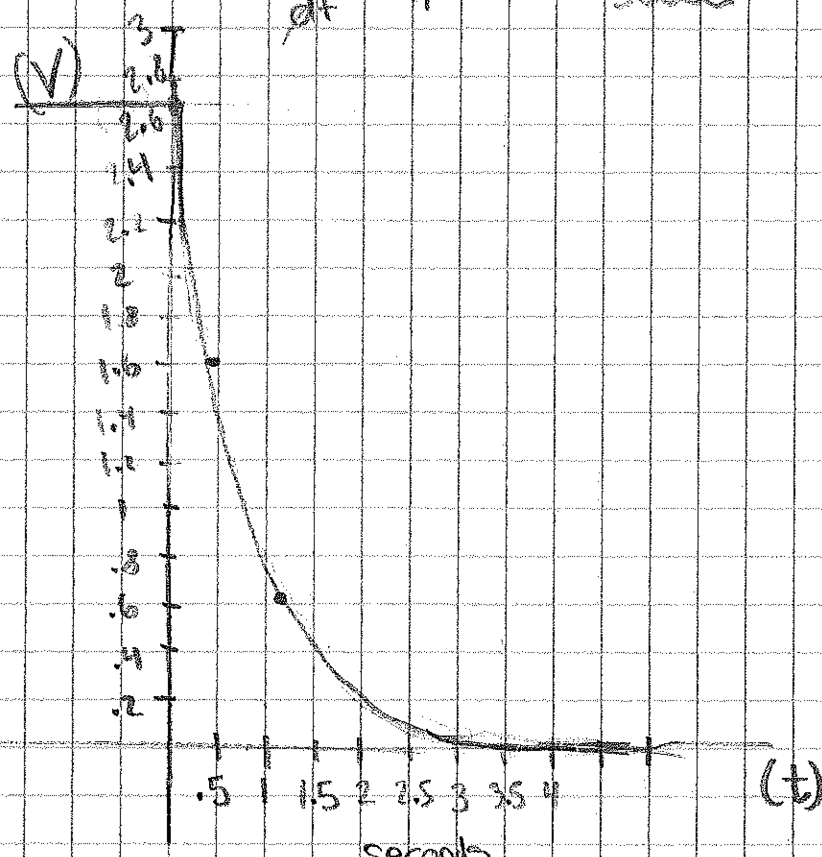
$sK_1e^{st}+\frac{5}{4}K_1e^{st}=0 \Rightarrow s=-\frac{5}{4}$

Back into (Eq2)

$V_c(t)=K_1e^{-5/4t}$

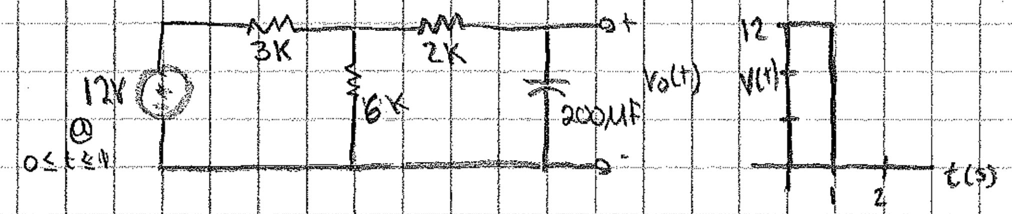
$V_c(0)=\frac{8}{3}=K_1e^{0}$ $\therefore K=\frac{8}{3}$

$\therefore \boxed{V_c(t)=\frac{8}{3}e^{-\frac{5}{4}t}}$

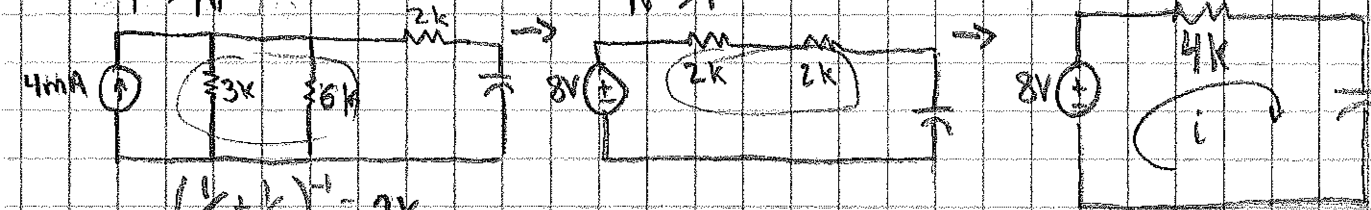


JFowler

3) Determine the equation for the voltage for $V_o(t)$ for $t>0$ for the ckt below when subjected to the input pulse shown below.



T→N N→T



$\left(\frac{1}{3k}+\frac{1}{6k}\right)^{-1} = 2k$

KCL: $i_R = i_c \Rightarrow \frac{8-V_c}{4k} = C\frac{dv}{dt} \Rightarrow \frac{dv}{dt} + \frac{V_c}{(4k)C} = \frac{8}{4k(C)} \Rightarrow \underbrace{\frac{dv}{dt} + 1.25V_c = 10}_{}$

(Eq. 1)

Note: @ $t<0$, the voltage is 0 (I.C.)

for $0 \le t \le 1$, $v(t) = V_n + V_f$

$V_f = K_2$ b/c 10 is constant $\underset{(Eq1)}{\Rightarrow}$ $\frac{dK_2}{dt}^{\nearrow 0} + 1.25K_2 = 10 \Rightarrow K_2 = 8$

$V_n = K_1 e^{st} \underset{(Eq1)}{\Rightarrow} \frac{d}{dt}K_1e^{st} + 1.25K_1e^{st} = 0 \Rightarrow sK_1e^{st} + 1.25K_1e^{st} = 0 \Rightarrow S = -1.25$

$\rightarrow V(t) = K_1 e^{-1.25t} + 8$

$V(0) = 0 = K_1 + 8 \rightarrow K_1 = -8$ $\therefore$ $\boxed{@\ 0 \le t \le 1,\ V_o(t) = 8 - 8e^{-1.25t}}$

Note: $V(1) = 8 - 8e^{-1.25} = 5.707$ (I.C.)

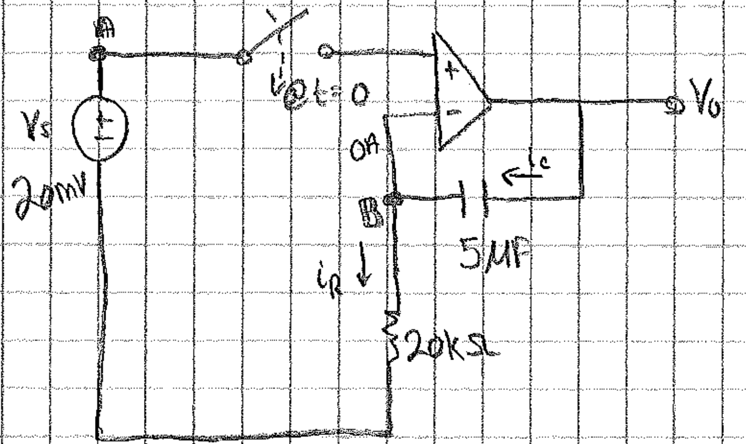
for a sourceless circuit, $V(t) = Ke^{-1.25t}$ @ $t>1$

$V(1) = 5.707 = Ke^{-1.25} \Rightarrow K = 5.707e^{1.25}$

$\therefore \boxed{@\ t>1,\ V(t) = 5.707e^{-1.25(t-1)}}$

Jarel Fowler

4) Find $V_o(t)$ for $t>0$ when $V_s = 20mV$ in the following CKT:



Note: @ $t(0)$, $V_c = 0 \rightarrow V_o(0) = 20mV$ (I.C.)

KCL @ (-) input

$i_c + 0A = i_R$

$C\frac{dV_c}{dt} = \frac{V_B - 0}{20K}$ Note: $V_A = V_B = 20mV$

$C\frac{dV_c}{dt} = \frac{20mV}{20K} \Rightarrow \frac{dV_c}{dt} = \frac{1mV}{1K \cdot 5\times10^{-6}} \Rightarrow \frac{dV_c}{dt} = .2$

$\int dV_o = \int 0.2\,dt$

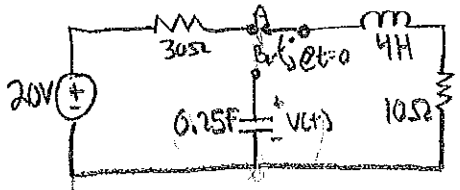
$V_o(t) = 0.2t + C$ & $V(0) = 20mV = 0.2(0) + C \Rightarrow C = .02$

$\therefore \boxed{V_o(t) = 0.2t + 0.02 \text{ @ } t>0}$

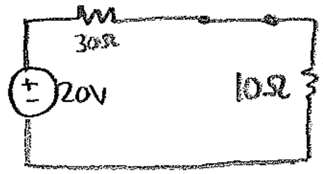
Note: Eventualy voltage will become saturated based upon amp-amp voltage supply inputs

Engr M20, HW#8 $\frac{17}{20}$ Jared Fowler

1) The switch in figure below moves from position A to B @ $t=0$. Find $V(t)$ for $t>0$.



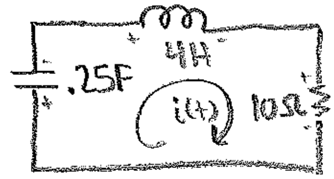
Note: @ $t(0^-)$



$\rightarrow$ KVL: $-20+30i+10i=0 \rightarrow i(0^-)=500\text{mA}$ (I.C.)

Note: $V_R(0^-)=V_C(0^+) \rightarrow V_C(0^+)=5V$

Note: @ $t(0^+)$



$\rightarrow$ KVL: $L\frac{di}{dt}+10i+V_c=0$ Note: $i=C\frac{dv}{dt}, \frac{di}{dt}=C\frac{d^2v}{dt^2}$

$$\rightarrow LC\frac{d^2v}{dt^2}+10C\frac{dv}{dt}+V_c=0$$

$$\rightarrow \frac{d^2v}{dt}+\frac{5}{2}\frac{dv}{dt}+V=0 \quad \text{(EQ1)}$$

$X=X_n+X_f$, $X_f=0$ because 0 is constant

$$X_n \rightarrow ke^{st} \rightarrow \frac{d^2(ke^{st})}{dt^2}+\frac{5}{2}\frac{d(ke^{st})}{dt}+ke^{st}=0$$

$$s^2\cancel{ke^{st}}+\frac{5}{2}s\cancel{ke^{st}}+\cancel{ke^{st}}=0 \rightarrow s^2+\frac{5}{2}s+1=0$$

Quadratic Formula: $s_1, s_2=\frac{-\frac{5}{2}\pm\sqrt{\frac{25}{4}-4}}{2}$ $\begin{cases} -\frac{5}{4}+\frac{3}{4}=-\frac{1}{2} \\ -\frac{5}{4}-\frac{3}{4}=-2 \end{cases}$ $\rightarrow \omega_0=1, Z=\frac{5}{4}$ "over-damped"

$$V(t)=k_1e^{-\frac{1}{2}t}+k_2e^{-2t}$$

$$V(0)=5=k_1e^0+k_2e^0 \rightarrow k_1=5-k_2$$

-1

$$i(0)=0.5=C\frac{dv}{dt}\Big|_{t=0}=.25(-\tfrac{1}{2}k_1e^0+(-2)k_2e^0) \rightarrow 2=-\tfrac{1}{2}k_1-2k_2$$

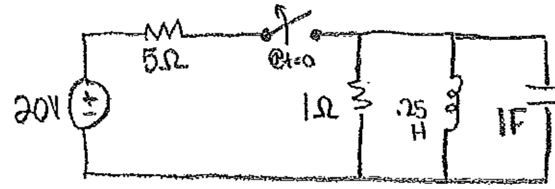
$$\rightarrow 2=-\tfrac{1}{2}(5-k_2)-2k_2$$

$$\frac{4}{2}+\frac{5}{2}=-2k_2+\tfrac{1}{2}k_2 \rightarrow k_2=-3, k_1=8$$

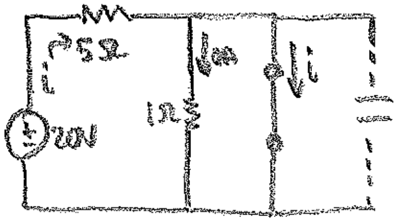
$\therefore$ $\boxed{V(t)=8e^{-\frac{1}{2}t}-3e^{-2t} \text{ @ } t>0}$

JTaylor

2) Find the voltage across the capacitor as a function of time for $t>0$ for the circuit in Fig below. Assume Steady State exists @ $t=0$.



Note: @ $t(0^-)$



$\rightarrow i_L = 20/5 = \underline{4A = i(0^-)}$ (C acts like short @ start)

(I.C.)

$\underline{V_C(0^-) = V_L(0^-) = 0V}$

Note: @ $t(0^+)$

$\rightarrow$ KCL: $i_L + i_R + i_C = 0$

$\rightarrow \frac{d}{dt}\left[\frac{1}{L}\int v\,dt + i(0) + \frac{V}{R} + C\frac{dv}{dt} = 0\right]$

$\rightarrow \cancel{C}\frac{d^2v}{dt^2} + \frac{1}{R}\frac{dv}{dt} + \frac{1}{L}v = 0$

$\rightarrow \frac{d^2v}{dt^2} + \frac{dv}{dt} + 4v = 0$ (Eq1)

$x = x_n + x_f,\ x_f = 0$

$x_n \rightarrow Ke^{st} \rightarrow S^2 + S + 4 = 0$

$\rightarrow \omega_0 = 2,\ 1 = 2\zeta\omega_0 \rightarrow \zeta = 1/4$

$\rightarrow$ "under-damped"

QF: $S_1, S_2 = \frac{-1 \pm \sqrt{1-16}}{2}$ $\begin{cases} -\frac{1}{2} + j\frac{\sqrt{15}}{2} \\ -\frac{1}{2} - j\frac{\sqrt{15}}{2} \end{cases}$

$\rightarrow V(t) = e^{-\frac{1}{2}t}\left(K_1 \sin\frac{\sqrt{15}}{2}t + K_2\cos\frac{\sqrt{15}}{2}t\right)$

$V(0) = 0 = e^0(K_1(0) + K_2(1)) \rightarrow \underline{K_2 = 0}$

$i(0) = 4 = C\frac{dv}{dt}\Big|_{t=0} = (1)\left[e^{-\frac{1}{2}t}K_1\sin\frac{\sqrt{15}}{2}t\right]\frac{d}{dt}$

$= -\frac{1}{2}e^0 K_1 \cancel{\sin(0)} + (e^0)\left(\frac{\sqrt{15}}{2}\cos(0)K_1\right)$

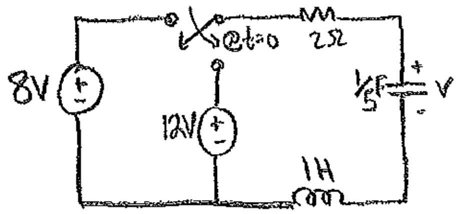
$4 = \frac{\sqrt{15}}{2}K_1 \rightarrow K_1 = 8/\sqrt{15}$

Note: Initial current through C will run bottom $\rightarrow$ top, $\therefore$, equation is negated.

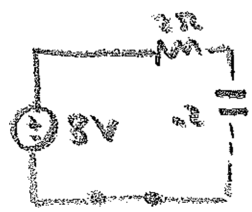
$\therefore \boxed{V(t) = -e^{-\frac{1}{2}t}\left(\frac{8}{\sqrt{15}}\right)\sin\frac{\sqrt{15}}{2}t \quad @\ t>0}$

JFowler

3) Find V for $t > 0$.



Note: @ $t(0^-)$



$\rightarrow \underline{i(0^-) = 0}$

$\rightarrow \underline{V_c(0^-) = 8V}$ b/c $V_R = \cancel{i}R = 0V$.

Note: @ $t(0^+)$

$\rightarrow$ KVL: $-12 + 2i + V + L\frac{di}{dt} = 0$ Note: $i = C\frac{dv}{dt}$, $\frac{di}{dt} = C\frac{d^2v}{dt^2}$

$\rightarrow LC\frac{d^2v}{dt} + 2C\frac{dv}{dt} + V = 12$

$\rightarrow \underline{\frac{d^2v}{dt} + 2\frac{dv}{dt} + 5V = 60}$ (EQ1)

$x = x_n + x_f$

$x_f = K \rightarrow 5K = 60 \rightarrow \underline{K = 12} = x_f$

$x_n \rightarrow Ke^{st} \rightarrow S^2 + 2S + 5 = 0$

Note: $\omega_0 = \sqrt{5}$, $\zeta = 2/\sqrt{5} < 1$

$\therefore$ "under-damped"

Q.F.: $S_1, S_2 = \frac{-2 \pm \sqrt{4 - 20}}{2}$ $\begin{cases} -1 + j2 \\ -1 - j2 \end{cases}$

$\rightarrow V(t) = e^{-t}(k_1 \sin 2t + k_2 \cos 2t) + 12$

$V(0) = 8 = e^0(k_1(0) + k_2(1)) + 12 \rightarrow \underline{k_2 = -4}$

$i(0) = \cancel{0} = \cancel{C}\frac{dv}{dt}\Big|_{t=0} = \left[e^{-t}(k_1 \sin 2t - 4\cos 2t)\right]\frac{d}{dt}$

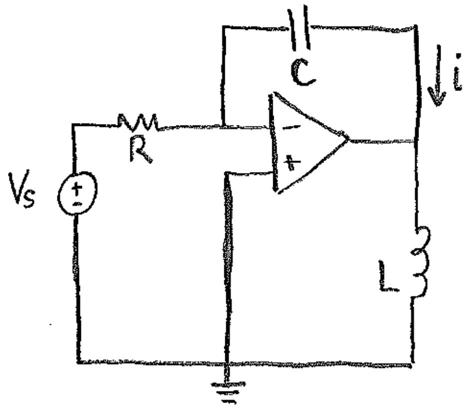
$0 = -\cancel{e^{-t}}(k_1 \cancel{\sin 2t} - 4\cos 2t) + \cancel{e^{-t}}(2k_1 \cos 2t + 8 \cancel{\sin 2t})$

$0 = -1(-4) + 2k_1 \rightarrow \underline{k_1 = -2}$

$\therefore \boxed{V(t) = e^{-t}(-2\sin 2t - 4\cos 2t) + 12 \quad @ t > 0}$

JFowler

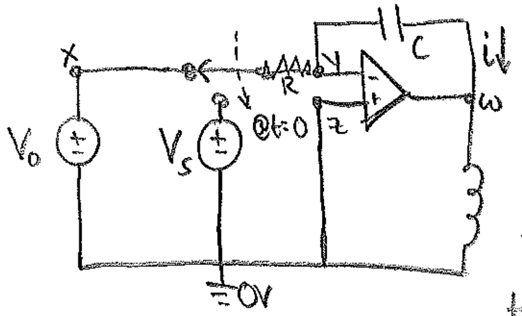
4) For the op-Amp Circuit below, find the differential equation for $i(t)$.



see soln

7, -2

<u>Note:</u> The purpose of an op-amp is to measure the voltage between inputs and output the delta voltage multiplied by a multiplier. V_s is changing... let's see it as this:



NOW, at stable state there is no current across the capacitor, i.e., $i(0^-) = 0$ because capacitor acts like open in DC circuit in Stable State. Also @ $t(0^-)$, the voltage is $V(0^-) = V_0$

Note also that ground, 0V, is greater than op-amp output which will be negative, based upon inverting output. Current is drawn into the op-amp more than delivered out. In this case, the inductor has little to <u>NO</u> effect upon the function $i(t)$ through capacitor.

KCL @$t(0)$, $i_R + 0 = i_c$

$$\frac{V_s - V_y}{R} = C\frac{dV}{dt} \longrightarrow \frac{V_s}{R} = C\frac{dV}{dt} + \frac{V_y}{R} \rightarrow \frac{dV}{dt} + \frac{V_y}{RC} = \frac{V_s}{RC}$$

Note: with L acting as short, KVL tells us that $V_y = V_c$ b/c $-V_s + V_R + V_c = 0$

$$\frac{dV}{dt} + \frac{V}{RC} = \frac{V_s}{RC} \qquad \underline{X_f = K = V_s}, \quad X_n \to Ke^{st} \longrightarrow s = -1/RC$$

$$V(t) = Ke^{-1/RC\,t} + V_s$$

$$V(0) = V_0 \rightarrow K = (V_0 - V_s)$$

$$\rightarrow V(t) = (V_0 - V_s)e^{-1/RC\,t} + V_s$$

$$i(t) = C\frac{dV}{dt} = C\left[(V_0 - V_s)e^{-1/RC\,t} + V_s\right]\frac{d}{dt}$$

$$i(t) = \frac{-C}{RC}(V_0 - V_s)\,e^{-1/RC\,t}$$

$$\boxed{i(t) = \frac{1}{R}(V_s - V_0)\,e^{-1/RC\,t}}$$

ENGR M20 HW#9 Jared Fowler

20/20

1) Express the following functions in cosine form:

a) $4\sin(\omega t - 30^\circ) \rightarrow 4\cos(\omega t - 120^\circ)$

b) $-2\sin(6t) \rightarrow -2\cos(6t - 90^\circ)$

c) $-10\sin(\omega t + 20^\circ) \rightarrow -10\cos(\omega t - 70^\circ)$

2) For the following pairs of sinusoids, determine which one leads and by how much.

a) $V(t) = 10\cos(4t - 60^\circ)$ and $i(t) = 4\sin(4t + 50^\circ)$

$i(t) = 4\cos(4t - 40^\circ) \quad \therefore \boxed{i(t) \text{ leads } V(t) \text{ by } 20^\circ}$

b) $V_1(t) = 4\cos(377t + 10^\circ)$ and $V_2(t) = -20\cos(377t)$

$V_2(t) = 20\cos(377t + 180^\circ)$

$\therefore \boxed{V_2(t) \text{ leads } V_1(t) \text{ by } 170^\circ}$

c) $x(t) = 13\cos 2t + 5\sin 2t$ and $y(t) = 15\cos(2t - 11.8^\circ)$

Note: $A\cos\omega t + B\sin\omega t = C\cos(\omega t - \theta)$, $C = \sqrt{A^2+B^2}$, $\theta = \tan^{-1}\frac{B}{A}$

$\rightarrow X(t) = \sqrt{13^2+5^2}\cos(2t - 21.04^\circ)$

$\rightarrow X(t) = 13.93\cos(2t - 21.04^\circ)$

$\boxed{y(t) \text{ lead } x(t) \text{ by } 9.24^\circ}$

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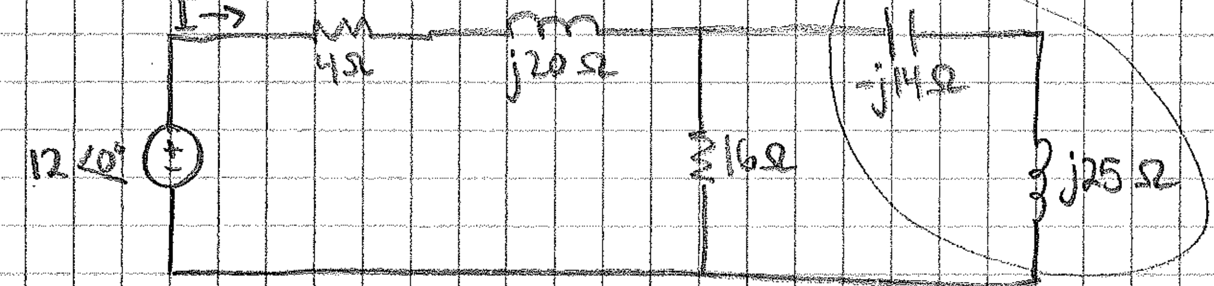
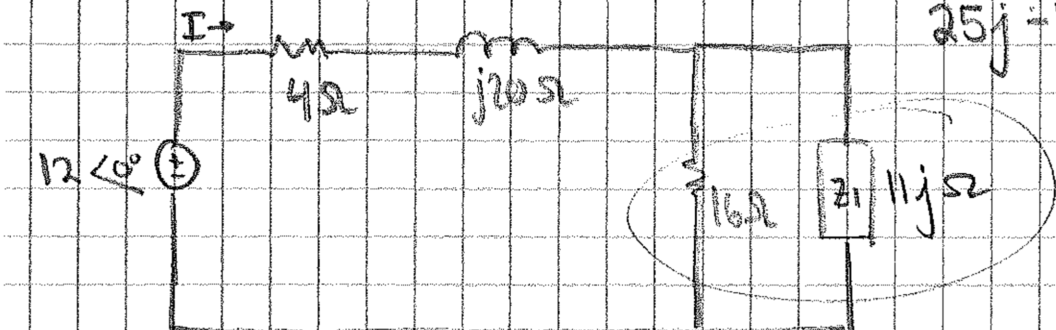
3) For the circuit shown, find Z_{eq} and use that to find current I.
Let $\omega = 10$ rad/s.

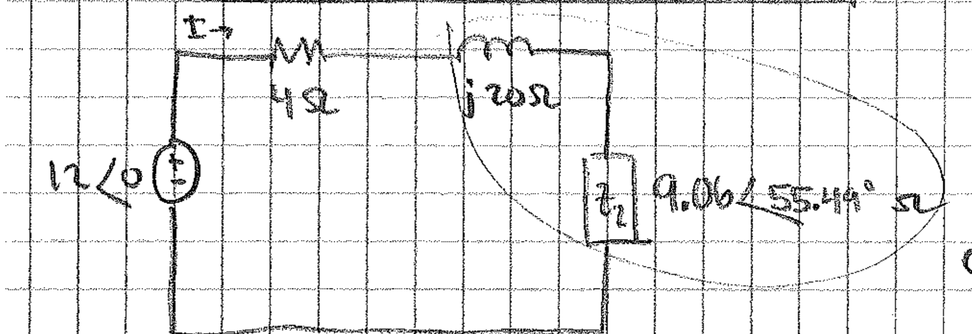


$25j - 14j = 11j\ \Omega$



$$\frac{16 \cdot 11j}{16\Omega + 11j} = \frac{(16\angle 0^\circ)(11\angle 90^\circ)}{19.42\angle 34.51^\circ}$$

$9.06\angle 55.49^\circ\ \Omega$



$9.06\angle 55.49^\circ = 5.13 + 7.46j\ \Omega$

→ $B = 9.06 \sin(55.49)$
$A = 9.06 \cos(55.49)$

$5.13 + 7.46j + 20j$

$= 5.13 + 27.46j\ \Omega$

... Now add the 4Ω → $\boxed{Z_{eq} = 9.13 + 27.46j}\ \Omega$

... or $\boxed{Z_{eq} = 28.94\angle 71.61^\circ}\ \Omega$

$$I = \frac{V}{R} = \frac{12\angle 0}{28.94\angle 71.61^\circ} = .41\angle -71.61^\circ$$

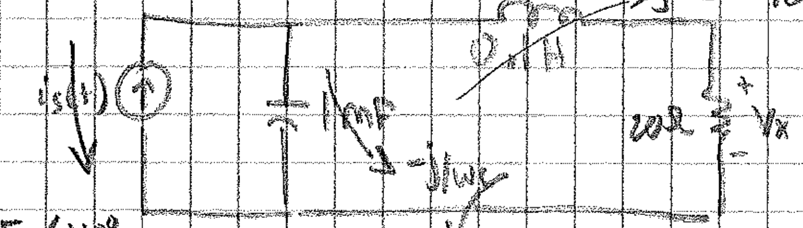
$\boxed{I = .41\angle -71.61^\circ\ A}$ → $i(t) = 0.41 \cos(10t - 71.61^\circ)$ A

... Not sure what your looking for... giving us ω...

JFeuler

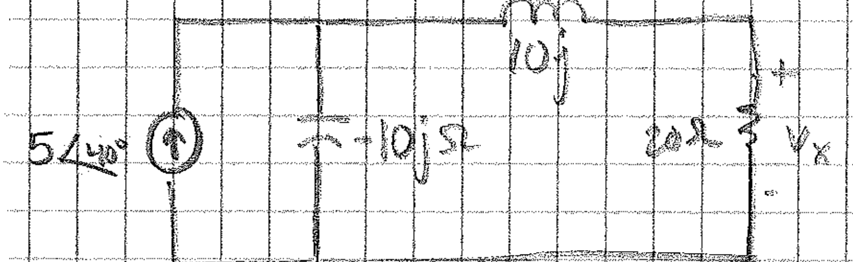
4) Determine V_x in the circuit shown. Let $i_s(t) = 5\cos(100t + 40°)$.

$j\omega L = 100\cdot(.1)j = 10j\ \Omega$

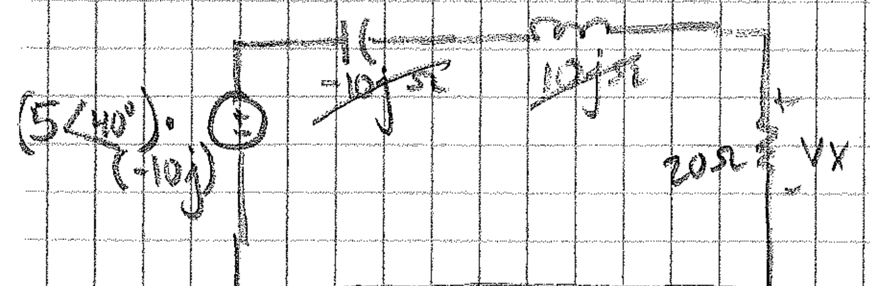


$5\angle 40°$

$$\frac{-j}{100\cdot(.001)} = -10j\ \Omega$$



N -> T



$\rightarrow V_x = (5\angle 40°)(-10j)$ → $10\angle -90°$

$= (5\angle 40°)(10\angle -90°)$

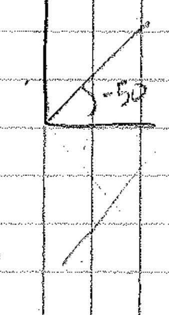
$V_x = 50\angle -50°$ V

or

$V_x = 32.14 - 38.3j$ V

or

$V_x = 50\cos(100t - 50°)$ V



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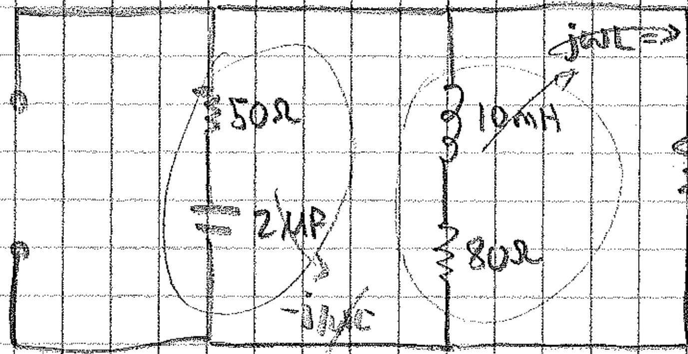
5) The network below is part of a schematic describing an industrial electronic sensing device. What is the total impedance of the circuit @ 2 KHz?



$j\omega L \Rightarrow 125.66j\ \Omega$ **Note:** $\omega = 2\pi f,\ f = \frac{1}{T}$

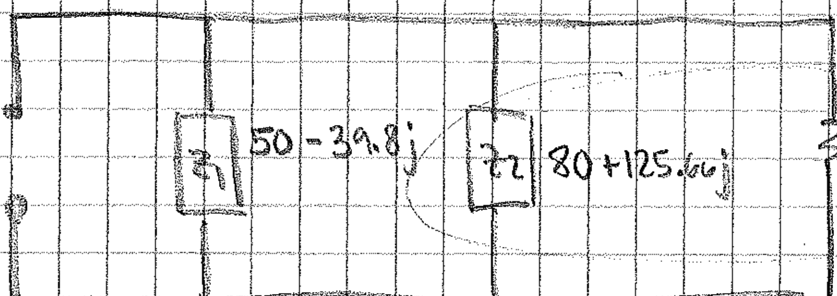
$2000\ Hz = f$

$\rightarrow \omega = 2\pi(2k) =$

$12566.4\ \frac{rad}{s}$

$-j/\omega C$

$$\frac{-j}{(12566.4)(2\times10^{-6})} = -39.8j\ \Omega$$



$$\frac{(80+125.66j)(100)}{100+80+125.66j} = \frac{(148.97\angle 57.52°)(100\angle 0°)}{180+125.66j}$$

$$= \frac{14897\angle 57.52°}{219.5\angle 34.92°} = 67.9\angle 22.6°$$

Now the final...

$$\frac{(67.9\angle 22.6)(50-39.8j)}{(50-39.8j)+67.9\angle 22.6} = \frac{(67.9\angle 22.6)(63.91\angle -38.52)}{(50-39.8j)+(62.69+26.1j)} = \frac{4339.5\angle -15.92}{112.69-13.7j}$$

$$Z = \frac{4339.5\angle -15.92}{113.52\angle -6.90} = \boxed{38.23\angle -9.02°\ \Omega \text{ or } 37.8-6j\ \Omega}$$