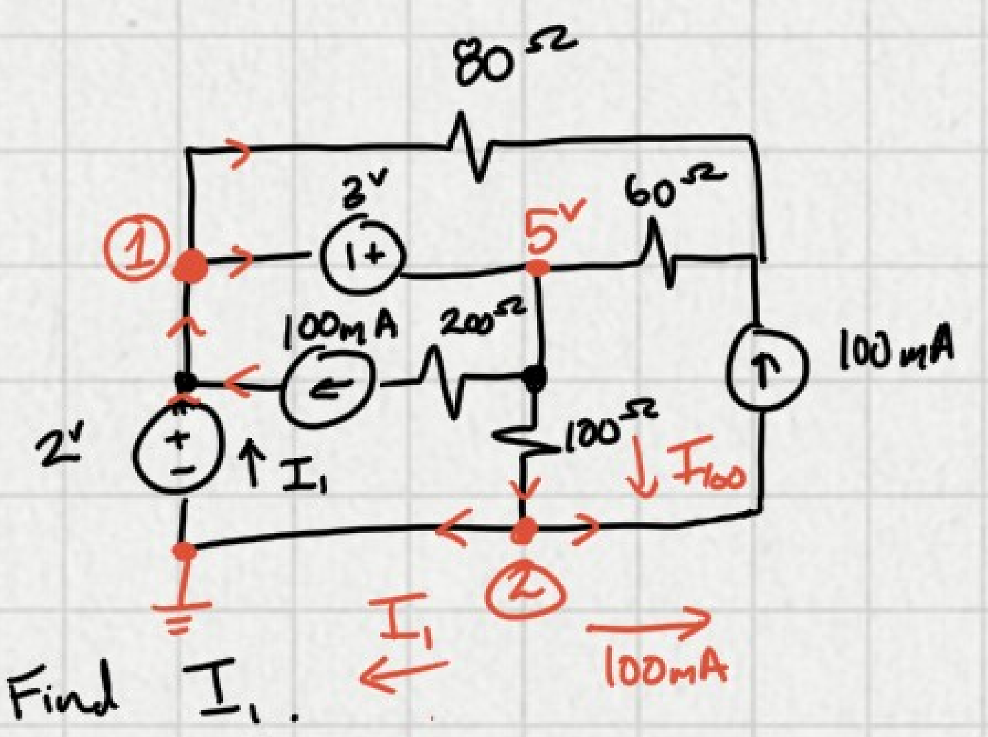
Homework 1

Given the ckt:



Find I_1.

As a beginner, a student may get flustered by this problem. You know you need current, and you have learned only a few techniques, but remember, all the techniques you have learned are nothing more than the application of Ohm's Law, KVL, KCL & then later on Maxwell's eqns.

So for me, a personal choice, to find anything to do with current, I would first go to KCL since it is a law about current. The problem states to find I_1. From the diagram, I see only 2 nodes that I_1 can flow into or out of. I have labeled them in red as node ①, ①, & node ②, ②.

It can be seen immediately that node ① is more demanding than node ②. So I chose to start my analysis there. Because all of the components must work in harmony you can choose any method and location and you must get the same answer.

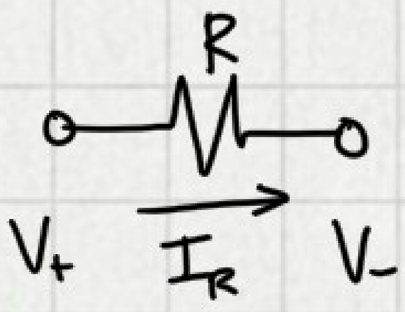
Analyzing Node ②.

For any system, you must know the rules of each component. Let's go over the rules for this ckt's components.

- **Wire**
  - treated as a Ø resistance component.
  - no voltage drop across it.
    - wires can have voltage it cannot change along the wire, only across a component.
  - is a path for current.
- **Voltage Source**
  - can only set the voltage difference between the 2 nodes it touches.
  - YIELDS NO CURRENT INFORMATION
- **Current Sources**
  - can only set the current through the branch it is connected to
  - YIELDS NO VOLTAGE INFORMATION
- **Resistors**
  - follows Ohm's Law
  - Ohm's law states that the current through a resistor is proportional to the voltage across the resistor. Given by:

$$V_R = R \cdot I_R$$

$$V_R = V_+ - V_-$$



  - Also, current must flow from V_+ to V_- always.

So given these rules and KVL and KCL we can analyze this ckt fairly straight-forward.

At node 2, the KCL is:

$$I_{100} = I_1 + 100mA \quad \text{or}$$

$$I_1 = I_{100} - 100mA$$

Therefore, to find I_1 all we need to do is find I_{100}.

We I_{100} is the current through the 100Ω resistor. If we can find the voltage across it, then we can find the current through it. Notice, I placed a reference ground @ node 2. Therefore, I'm saying this node is Ø V. The 2V source is setting node 1 to 2V with respect to ground. And the 3V source raises the voltage on the other side of the resistor to 5V. The 100Ω resister has 5V across it. The current through it must be:

$$I_{100} = \frac{5^V}{100^\Omega} \qquad V = R \cdot I \text{ or } I = \frac{V}{R}$$

$$\therefore I_{100} = 50mA.$$

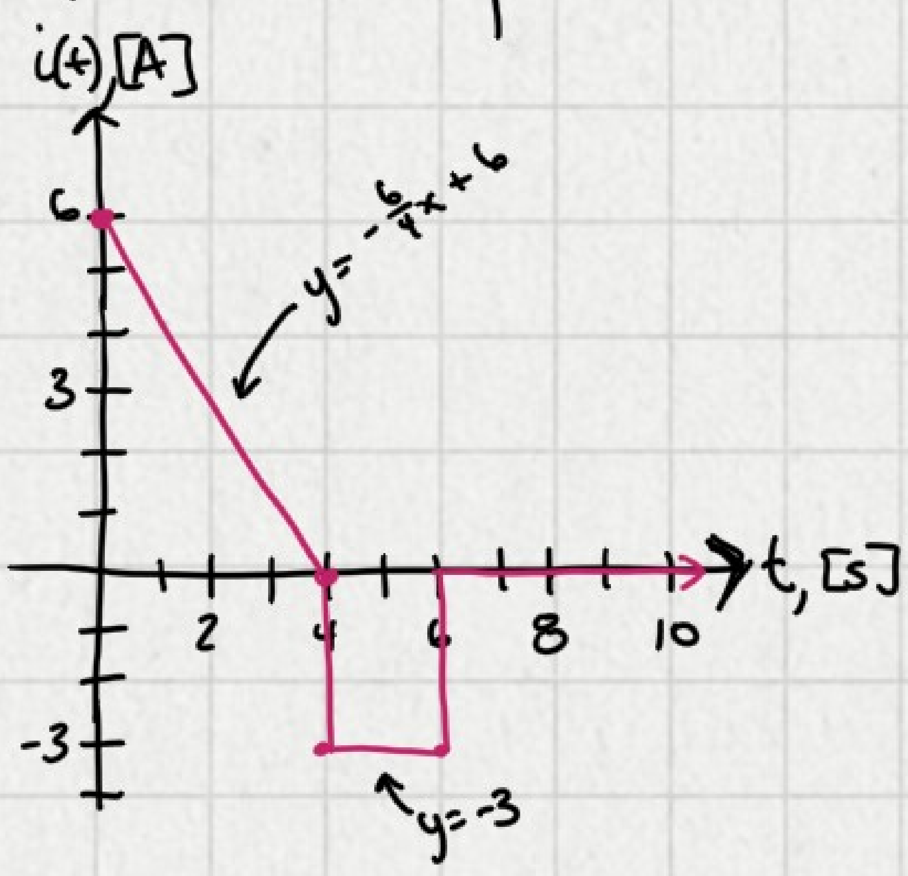
$$\therefore I_1 = 50mA - 100mA$$

$$\boxed{I_1 = -50\ mA}$$

All the negative sign means is the direction of the assumed I_1 was guessed in the wrong direction.

Check in a simulator to make sure!!!

Given the plot:

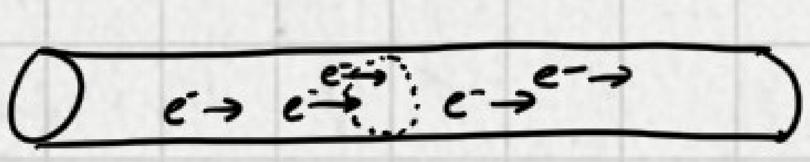


Compute & sketch the net charge that flows through the cross-section of wire the plot is representing.

This problem is seeing if you understand the concept of current.

You should know by now that current is the amount of charge carriers that pass through a designated area. In ENA, the charge carriers are electrons.

To illustrate that point see the image below



You know that matter is made of atoms and atoms have electrons so understand you are not counting all the electrons only the ones passing through the area.

This is written mathematically as:

$$i(t) = \frac{dq}{dt}$$

current is the change of charge given the amount of time needed to change.

This means time does matter.

If 1 Coulomb of charge needs 1 sec of time to pass through the cross-section, then you have 1 Amp of current.

If 1 Coulomb of charge needs 1 minute to pass through then it is around 17 mA.

We can use separation of variable to find the equation of $q(t)$. Assuming an initial condition of $q(0) = 0^{\text{Coulombs}}$

If $\quad i(t) = \frac{dq}{dt}$

then $\quad \int i(t)\,dt = \int dq$

which becomes

$$\int i(t)\,dt + q(0) = q(t)$$

we can write the current equation using the step function (a.k.a. the Heaviside function)

$$i(t) = \left[-\tfrac{3}{2}t + 6\right]\cdot\left[u(t) - u(t-4)\right] + \ldots$$
$$\ldots \left[-3\right]\left[u(t-4) - u(t-6)\right]$$

Note: The problem asks for the net charge so which means the difference. You must always have multiple points unless you use calculus to find the instantaneous change.

Note: definite integrals yield area info.

And we will.

$$\int_{-\infty}^{\infty} \left(-\tfrac{3}{2}t+6\right)\cdot\left(u(t)-u(t-4)\right) + (-3)\left(u(t-4)-u(t-6)\right)dt$$

is the same as

$$\int_0^4 -\tfrac{3}{2}t + 6\,dt + \int_4^6 -3\,dt$$

$$\int_0^4 -\tfrac{3}{2}t + 6\,dt = \left[-\tfrac{3}{2}\tfrac{t^2}{2} + 6t\right|_{t=0}^{4}$$

$\hookrightarrow -\frac{3}{4}\cdot 4^2 + 6\cdot 4 = 12$ Coulombs

&

$$\int_4^6 -3\,dt = \left[-3t\right|_{t=4}^{6}$$

$\hookrightarrow (-18) - (-12) = -6$ Coulombs

Therefore the total net charge through the cross-section is

$12^{\text{Coulombs}} - 6^{\text{Coulombs}} = \boxed{6 \text{ Coulombs}}$

I am assuming the sketch part means to sketch a plot. This is where the initial conditions comes into play. $q(0) = 0$

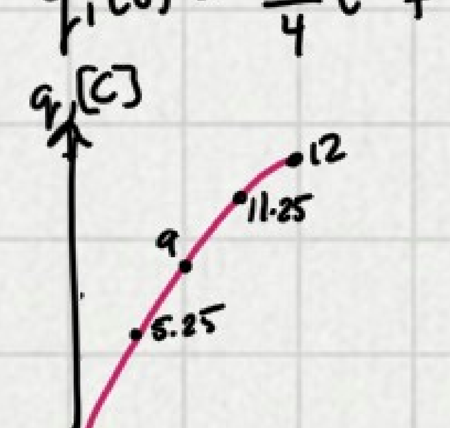
$$q_1(t) = \int -\tfrac{3}{2}t + 6\,dt = -\tfrac{3}{4}t^2 + 6t + C_1$$

for $t = 0$ to 4 seconds

$q_1(0) = 0 = -\frac{3}{4}\cdot 0^2 + 6\cdot 0 + C_1$

therefore $C_1 = 0$

$$q_1(t) = -\tfrac{3}{4}t^2 + 6t$$



for $t = 4$ to 6 seconds

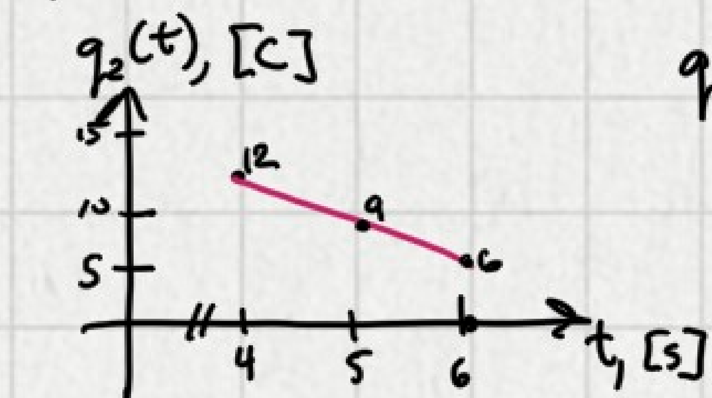
$q_2(t=4) = 12^{\text{Coulombs}}$

$q_2(t) = \int -3\,dt = -3t + C_2$

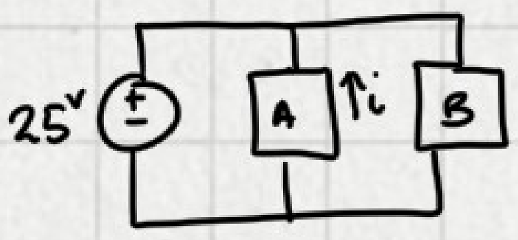
$q_2(4) = 12 = -3\cdot 4 + C_2 \therefore C_2 = 24$

$q_2(t) = -3t + 24$

$q(t) = q_1(t) + q_2(t)$



Given the conceptual ckt:



where:

$i(t) = -23 \cdot t + 115$, mA

Find the total charge that pass through element A, in the interval of time $0 \le t \le 7_s$.

Recall $q = \int_{t_0}^{t+t_0} i(t)\,dt$

$\therefore \quad q = \int_0^7 (-23 \cdot t + 115) \times 10^{-3}\,dt$

this will account for the milli part

$$q = 10^{-3}\left[-\frac{23}{2}t^2 + 115t\right|_{t=0}^{7}$$

$$q = 10^{-3}\left[\frac{-23}{2} \cdot 49 + 805\right]$$

$$q = 10^{-3}\left[805 - 563.5\right]$$

$q = 10^{-3}[241.5]$ Coulombs

or $\boxed{q = 241.5 \text{ mC}}$

How much energy does element A absorb in the same time interval?

You must have learned the Power of a electrical component is equal to voltage times current. Therefore,

$P = V \cdot I$ and from physics you know that power is energy per time. So

$$v(t) \cdot i(t) = \frac{dU}{dt} \quad \text{or}$$

← Energy

$$U = \int_{t_0}^{t_0+T} v(t) \cdot i(t)\,dt$$

Since $v(t)$ is a constant all we need to do is multiply the integral we have already done by 25^V and we have the energy.

Therefore,

$$U = 25^V \cdot 241.5 \text{ mC}$$

$\hookrightarrow U = 6{,}037.5$ mJ

(I do not believe this is right)

$\boxed{6.0375 \text{ Joules}}$

(please read on)

I do have a problem with the wording.

Power notation for absorbtion is when current flows from a higher potential to a lower potential.

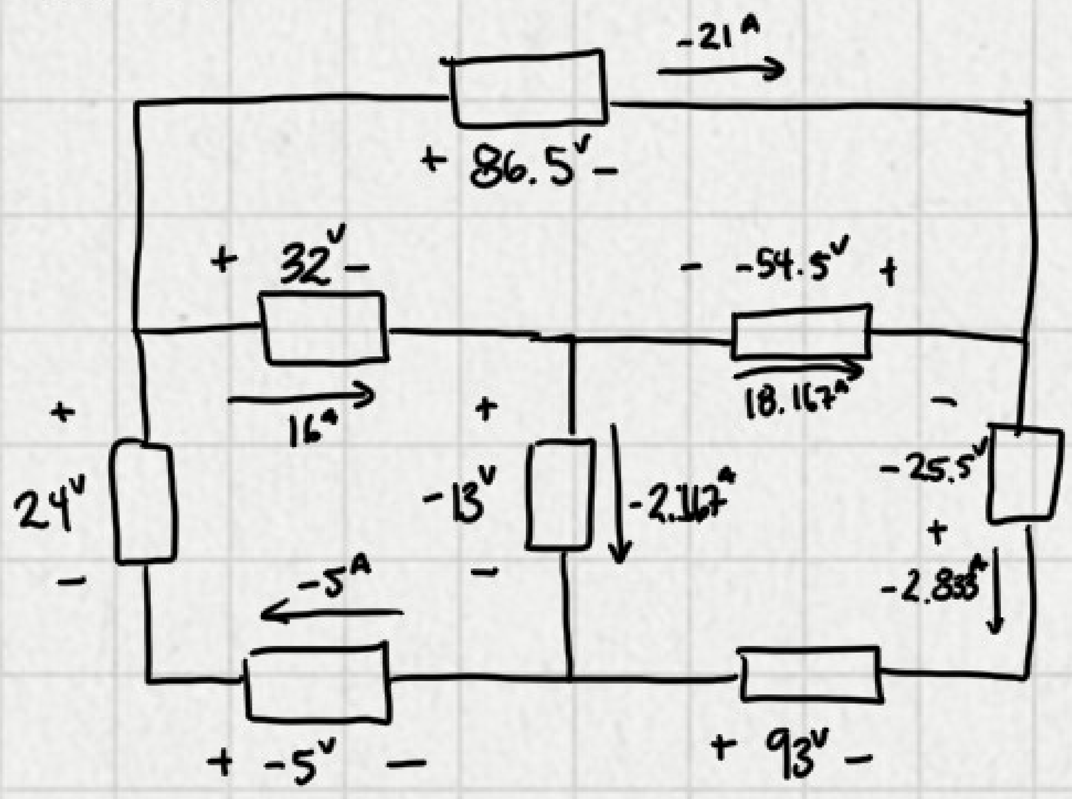
Power emitted is when current flows from a lower potential to a higher one.

In this problem, element A has current flowing from lower to higher potential, therefore, I would say it isn't absorbing power rather it is emitting.

If this is the point of the wording, then a negative sign must be implemented and the answer becomes

$\boxed{-6.0375 \text{ Joules}}$

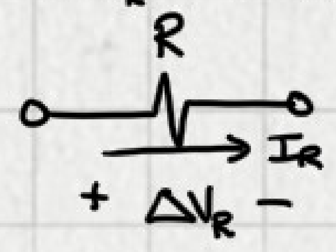
Given the ckt below:



Determine which components are sources & which are resistors.

Well we know that resistor obey Ohm's Law. That is current through a resistor flows from high to low potentials. And the relationship is linearly proportional.

$$\Delta V_R = R \cdot I_R$$



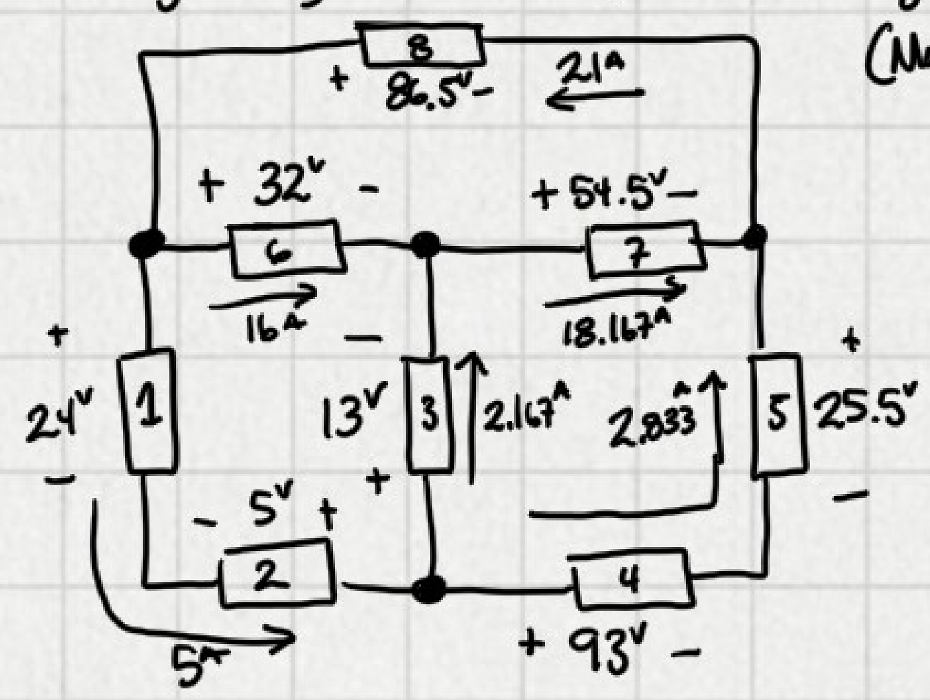
Now a source will either tell you voltage information or current information. If a voltage source, then realize the current can go either direction. If a current source, then the voltage can drop with either polarity.

So if given a snapshot at one time, for one instance a voltage or current source can look like it is also following Ohm's law.

So really, the question should ask. Which components cannot be resistors. Therefore, we are also told there are only 5 resistors & 3 sources to help out as well.

First, let's redraw the ckt so there are no negative signs in the magnitude values. Also, now is a good time to use KVL & KCL to make sure everything adds up correctly!!!

(Note: They do!!)



Components that follow Ohm's Law, therefore we will assume can only be resistors.

Components:

1, 3, 4, 6, 7 (Note: 5 components)

The rest cannot for sure be resistors because they do not adhere to high to low convention.

Components 2, 5, 8 are either voltage or current sources.

(Note: 3 components)

Now solve for the resistors Resistance values.

We know the Resistance is the relationship of the voltage across the resistor and the current that flows through it. Therefore:

$$R = \frac{\Delta V_R}{I_R}$$

So:

$$R_1 = \frac{24^V}{5^A} = 4.8^\Omega$$

$$R_3 = \frac{13^V}{2.167^A} \approx 6^\Omega$$

$$R_4 = \frac{93^V}{2.833^A} \approx 32.83^\Omega$$

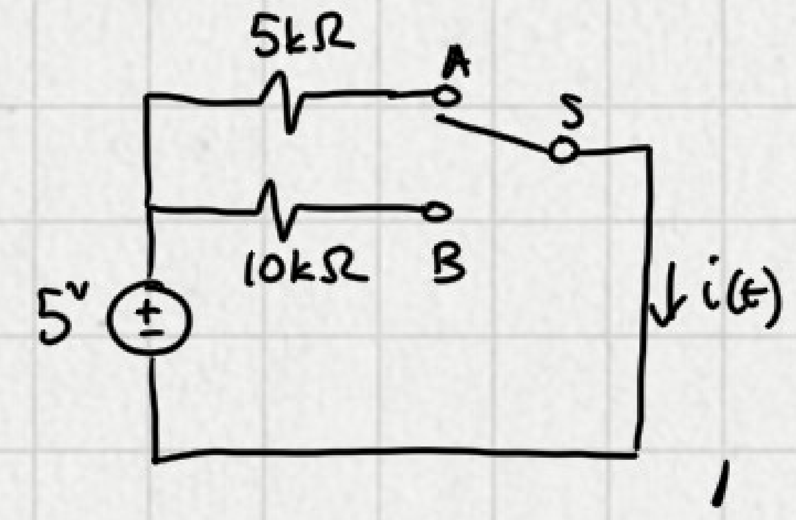
$$R_6 = \frac{32^V}{16^A} = 2^\Omega$$

$$R_7 = \frac{54.5^V}{18.167^A} \approx 3^\Omega$$

For more appreciation of this problem, go back and replace a resistor with a voltage or current source of the value given in the ckt. See if it changes any of the values of voltage or current.

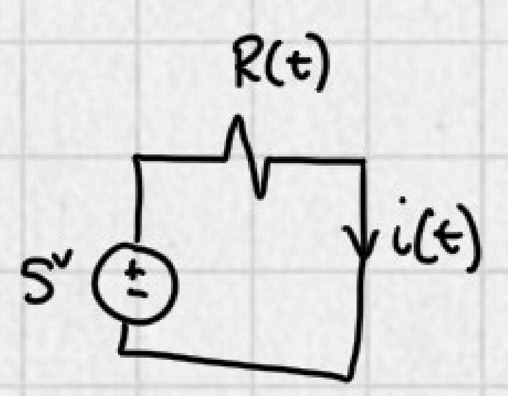
Note: IT SHOULDN'T.

Given the ckt:



where s stays at position A for 1ms and position B for 4ms. Find average value of $i(t)$.

This ckt can be written as:



where $R(t) = \begin{cases} 0, & t<0 \\ 5k\Omega, & 0\le t< 1ms \\ 10k\Omega & 1ms \le t < 4ms \\ 0 & 4m < t \end{cases}$

or $R(t) = 5k\Omega\left(u(t) - u(t-1ms)\right) + \ldots$

$\ldots\ 10k\Omega\left(u(t-1ms) - u(t-4ms)\right)$

Regardless of how you model this ckt, the current is still set by the resistor. And we know resistors follow ohms law. Therefore,

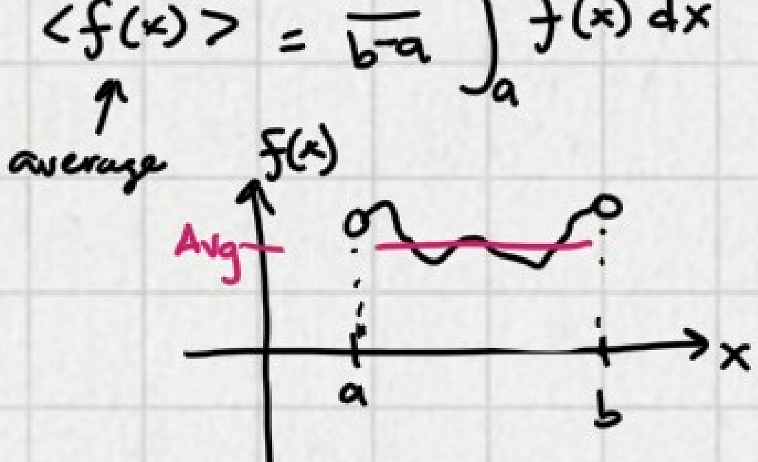
$$i(t) = \frac{v(t)}{R(t)} = \frac{5^v}{R(t)}$$

don't feel like writting again

We know from Calculus that the average for any function is given by:

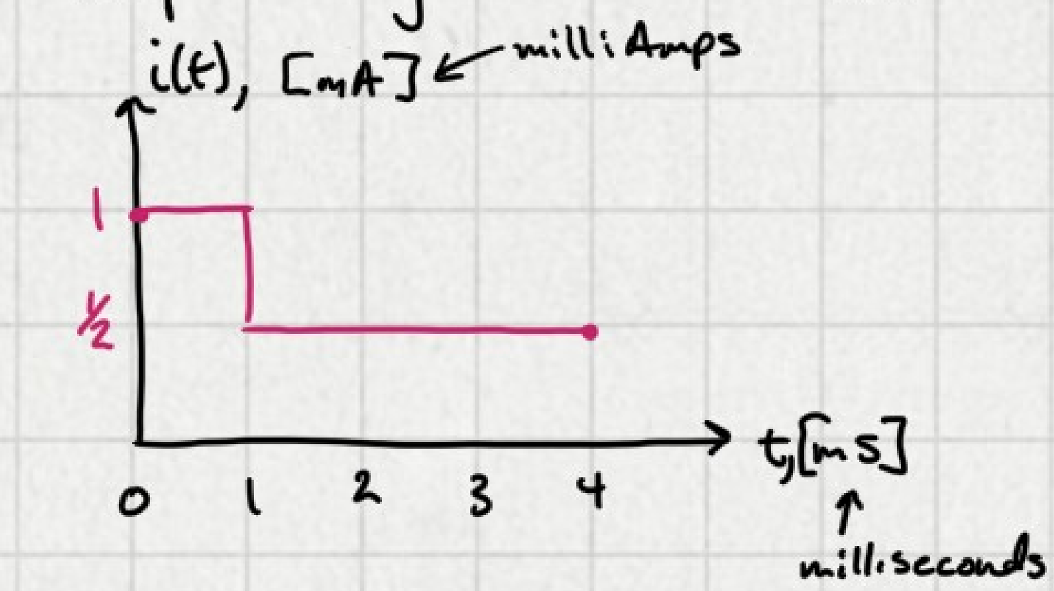
$$\langle f(x)\rangle = \frac{1}{b-a}\int_a^b f(x)\,dx \qquad \text{for}$$

average



Using this definition, we can find the avg of $i(t)$

Graphically we see $i(t)$:



Equation

$$i(t) = \frac{5^v}{5k\Omega}\left(u(t) - u(t-1ms)\right) + \ldots$$

$$\ldots\ \frac{5^v}{10k\Omega}\left(u(t-1ms) - u(t-4ms)\right)$$

Therefore,

$$\langle i(t)\rangle = \frac{1}{4ms-0}\int_0^{4ms} (1\,mA)\left(u(t) - u(t-1ms)\right) + \ldots$$

$$\ldots\ \left(\tfrac{1}{2}mA\right)\left(u(t-1ms) - u(t-4ms)\right)dt$$

↳ $\langle i(t)\rangle = \frac{1}{4ms}\left[\int_0^{1ms} 1mA\,dt + \int_{1ms}^{4ms} \frac{1}{2}mA\,dt\right]$

↳ $\langle i(t)\rangle = \frac{1}{4ms}\left[\left[1mA\cdot t\right|_{t=0}^{1ms} + \left[\frac{1}{2}mA\cdot t\right|_{t=1ms}^{4ms}\right]$

↳ $\langle i(t)\rangle = \frac{1}{4ms}\left[1mA\cdot ms + \frac{4}{2}mA\cdot ms - \frac{1}{2}mA\cdot ms\right]$

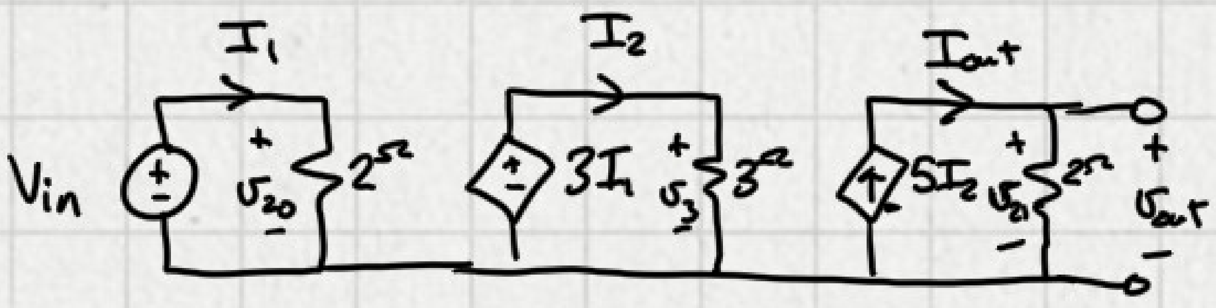
↳ $\langle i(t)\rangle = \frac{1}{4ms}\left[\frac{5}{2}mA\cdot ms\right]$

↳ $\boxed{\langle i(t)\rangle = \frac{5}{8}mA}$

Does this make sense?

We see the current goes as low as ½ mA and we are above that so that's good. We see that we are only at 1mA for a fraction of the time so we shouldn't be very high from ½ mA. So a quick analysis says we are at least in the ball park.

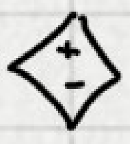
Given the ckt:



Given: $V_{in} = 10^V$

Before answering questions, let's take a moment to let this ckt sink in. Notice there are 3 stages. Each stage is not connected to the other via wires. All that bottom wire is doing is saying all 3 have the same reference. You need a closed loop for it to affect each other.

Also notice the diamond shape. This means the source's value (magnitude) is dependent on another parameter. A voltage dependent source will look like

 where the polarity is defined by the plus & minus

and a current dependent source will look like:

 where the current direction is given by the arrow.

Where I have seen confusion is when a voltage source is dependent on a current flowing through a component some where else or vice versa.

My suggestion at this point is to just understand this is a mere modeling technique and to not get caught up right now on the how.

So let's write some eqns:

KVL	KCL
$v_{in} = v_{20}$	$I_1 = I_{20}$
$3I_1 = v_3$	$I_2 = I_3$
$v_{21} = v_{out}$	$I_{out} = 5I_2 = I_{21}$

Ohms Law (Resistors)

$\Delta V_R = R \cdot I_R$

$\therefore\ v_{20} = 2 \cdot I_{20}\ ,\ v_3 = 3 \cdot I_3,\ v_{21} = 2 \cdot I_{21}$

Find O/P voltage & current in terms of v_{in}.

This is nothing more than manipulation of the equations.

$I_{out} = 5I_2$

$I_2 = I_3 = \frac{v_3}{3} = \frac{\cancel{3}I_1}{\cancel{3}} = I_{20} = \frac{v_{20}}{2} = \frac{v_{in}}{2}$

$\therefore \boxed{I_{out} = \frac{5 \cdot v_{in}}{2}}$ $\therefore \boxed{I_{out} = \frac{5(10^V)}{2^\Omega} = 25^A}$

$v_{out} = v_{21} = 2I_{21} = 2\,I_{out} = \cancel{2} \cdot \frac{5 \cdot v_{in}}{\cancel{2}}$

$\boxed{v_{out} = 5\,v_{in}}$ $\therefore \boxed{v_{out} = 5(10^V) = 50^V}$

Find the voltage gain. $\left[\frac{V_{out}}{V_{in}}\right]$

we already have a relationship of vout & vin, just rearrange.

$v_{out} = 5 \cdot v_{in}$ or $\boxed{\frac{v_{out}}{v_{in}} = 5}$

Find power delivered by sources.

$P_{V_{in}} = V_{in} \cdot I_1$ and $I_1 = \frac{V_{in}}{2}$

$\therefore$

$\boxed{P_{V_{in}} = \frac{V_{in}^2}{2} = \frac{(10)^2}{2} = \frac{100}{2} = 50^W}$

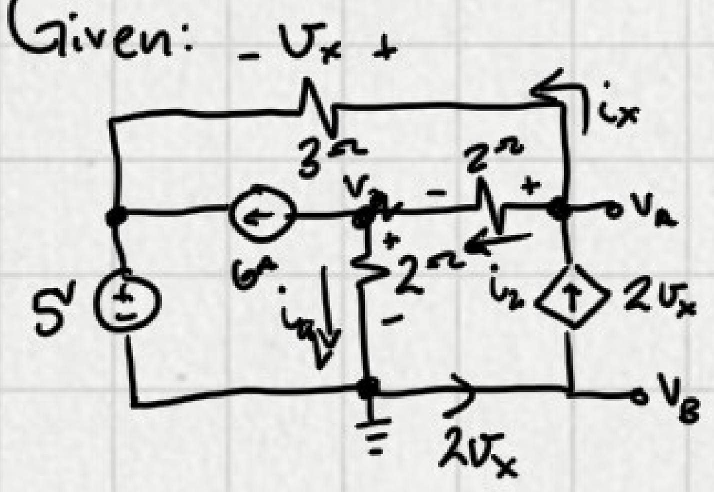
$P_{3I_1} = (|3I_1|)(I_2)$ and $I_2 = \frac{|3I_1|}{3} = \frac{|3\frac{V_{in}}{2}|}{3} = \frac{V_{in}}{2}$

$\therefore \left(3\frac{V_{in}}{2}\right)\left(\left|\frac{V_{in}}{2}\right|\right) \rightarrow \boxed{P_{3I_1} = \frac{3}{4}V_{in}^2 = \frac{3}{4} \cdot 10^2 = 75^W}$

$P_{5I_2} = (V_{out})(5I_2) = (5 \cdot V_{in})(5\frac{V_{in}}{2})$

$\boxed{P_{5I_2} = \frac{25}{2}V_{in}^2 = \frac{25 \cdot 100}{2} = 25 \cdot 50 = 1250^W}$

Given:



Find $V_A - V_B = V_{AB}$
Using nodal analysis.

I just randomly labeled nodes V_q & V_a.

The KCL for each node is:

(V_q) $i_2 = 6^A + i_q$

(V_a) $2v_x = i_2 + i_x$

---

now we write the equation for each current.

$i_2 = \frac{V_a - V_q}{2^\Omega}$ $6^A = 6^A$ ohm's Law

$i_q = \frac{V_q}{2}$ ∴ (V_q) becomes

$\frac{V_a - V_q}{2} = 6 + \frac{V_q}{2}$ or equation 1 $\boxed{V_a - 2V_q = 12}$

---

now let's find the current equations for (V_a)

$V_x = V_a - 5^V$ ← found via KVL

$i_x = \frac{V_x}{3^\Omega} = \frac{V_a - 5^V}{3^\Omega}$ ← Ohm's law

recall: $i_2 = \frac{V_a - V_q}{2}$ ∴ (V_a) becomes

$2(V_a - 5^V) = \frac{V_a - V_q}{2^\Omega} + \frac{V_a - 5^V}{3^\Omega}$

↳ $12V_a - 60^V = 3V_a - 3V_q + 2V_a - 10^V$

equation 2 $\boxed{7V_a + 3V_q = 50^V}$ 2 unknowns 2 equations

∴

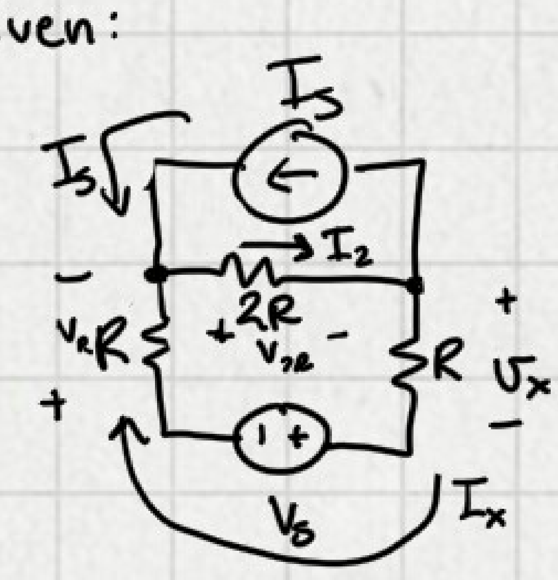
$$2\times3 \quad \begin{array}{ccc} V_a & V_q & \text{Knowns} \end{array} \\ \begin{bmatrix} 1 & -2 & 12 \\ 7 & 3 & 50 \end{bmatrix}$$

$$\text{rref}\begin{bmatrix} 1 & -2 & 12 \\ 7 & 3 & 50 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 8 \\ 0 & 1 & -2 \end{bmatrix}$$

∴ $\boxed{V_a = 8^V}$ ← check's out using a simulator
$V_q = -2^V$

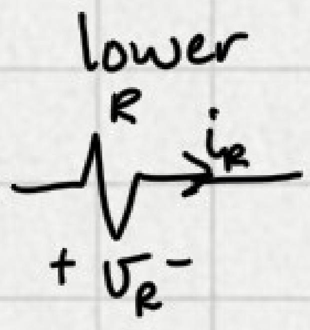
Use whatever linear algebra technique you want. I like rref.

Given:



Also the equation $v_x = AI_s + BV_x$
All this question is asking is to make A & B in terms of R.

If placing a reference node helps I would suggest doing so, but know its not needed. Draw assumed currents & their corresponding voltage polarity.
Recall Ohm's law says current goes from high to lower potential.



(A must !!!)

∴ KVL says:
$V_s + V_x + V_{2R} + V_R = 0$

also
$V_{current} = V_{2R}$ ← no new information gained.
the current source voltage will be whatever it needs to be to satisfy anything in parallel

KCL says
$I_s + I_x = I_{2R}$ on both nodes.

Ohm's law says:
$V_R = R \cdot I_x$
$V_x = R \cdot I_x \rightarrow I_x = \frac{V_x}{R}$
$V_{2R} = 2R \cdot I_{2R}$

we can start anywhere to solve for V_x so why not the KVL:

$V_s + V_x + \underbrace{2R \cdot I_{2R}}_{V_{2R}} + \underbrace{R \cdot I_x}_{V_R} = 0$

∴ $V_s + V_x + 2R(I_s + I_x) + RI_x = 0$

$V_s + V_x + 2RI_s + 3RI_x = 0$

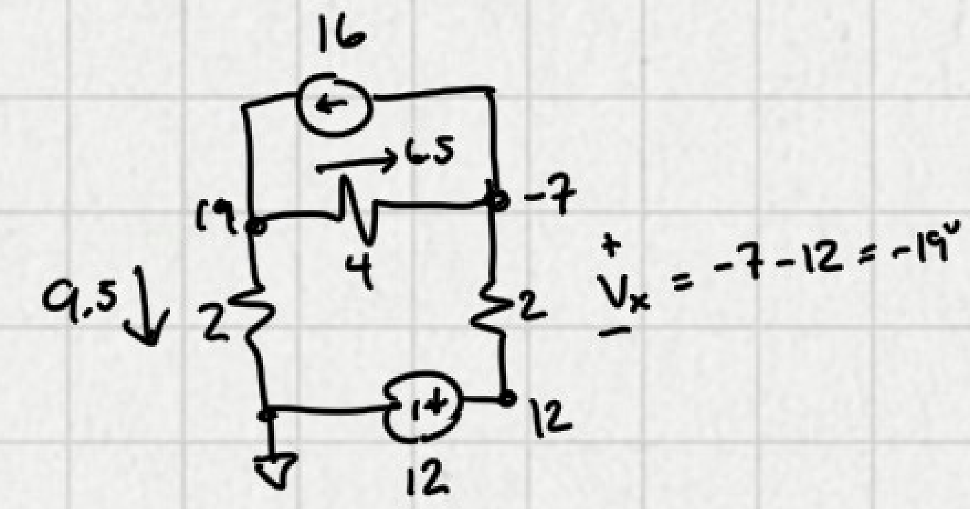
Recall $I_x = \frac{V_x}{R}$

$V_s + V_x + 2RI_s + \frac{3\cancel{R}V_x}{\cancel{R}} = 0$

∴ $4V_x = -V_s - 2RI_s$

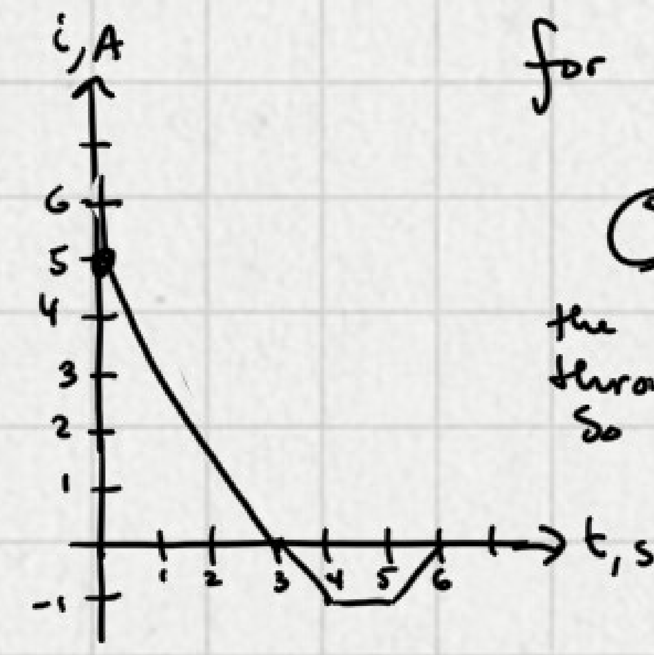
↳ $V_x = (-\frac{1}{4})V_s + (\frac{-R}{2})I_s$

Using a simulator to check

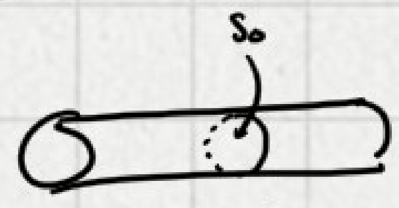


using equation
$V_x = (-\tfrac{1}{4})(12) + (\tfrac{-2}{2})16 = 19^V$
checked out for that case and I'm fairly confident it will for all cases.

Given:



for



the charge flowing through the cross-section So

Find the charge for the time $0<t<6$.

we know that current is the relationship of charge flowing through a cross section for a given time.

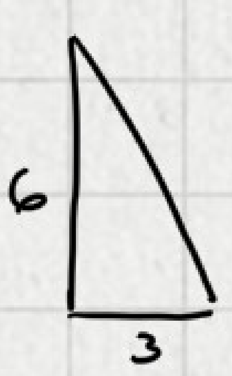
$$i(t) = \frac{dq(t)}{dt} \quad \text{or} \quad \int i(t)\,dt = \int dq$$

for a given time:

$$q(t) = \int_{t=t_0}^{t=t_0+T} i(t)\,dt$$

we really don't need to do calculus here due to the function being straight lines we can find the area under the curves using geometry.

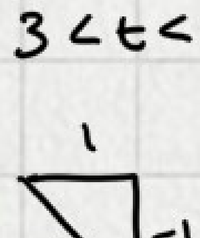
for $0<t<3$ we see:



where the area of a triangle is $\frac{1}{2}bh$

$\therefore\ A_1 = \frac{5 \cdot 3}{2} = 7.5$

for $3<t<4$ we see:



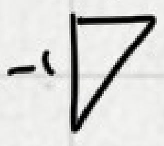
$\therefore\ A_2 = \frac{(1)(-1)}{2} = -\frac{1}{2}$

for $4<t<5$ we see

Area of a square is $b \cdot h$

$A_3 = (1)(-1) = -1$

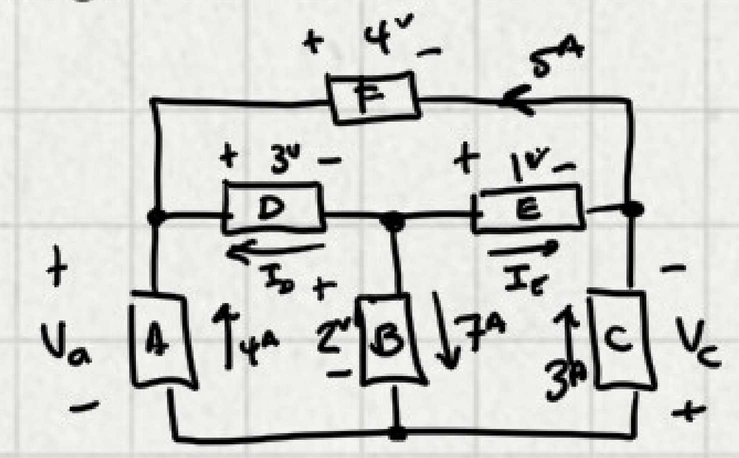
for $5<t<6$ we see



$A_4 = \frac{(1)(-1)}{2} = -\frac{1}{2}$

And the total charge that flowed is the summation of all Areas which is $7.5C - 2C = \boxed{5.5C}$

Given



a) If element A generates 20^W what is V_a?

To generate power the sign convention needs to have current going from low to high. And it is.

$P = VI \quad \therefore \quad 20 = V_A \cdot 4^A \ \therefore\ \boxed{V_A = 5^V}$

b) What is the power absorbed by element B?

To absorb power the sign convention says the current should be going from high to low, and it is.

$\boxed{P = 2 \cdot 7 = 14^W}$

c) If element C generates 3^W of power, what is V_c?

we see to generate power the polarity needs to be in the opposite direction for the current given. Therefore,

$P_c = (-V_c) \cdot I_c \rightarrow V_c = -\frac{P_c}{I_c} = \frac{-3^W}{3^A} = \boxed{-1^V}$

d) If element D absorbs 27^W what is I_D?

We see the current is going in the wrong direction to absorb power for the voltage given. So a negative sign will be needed.

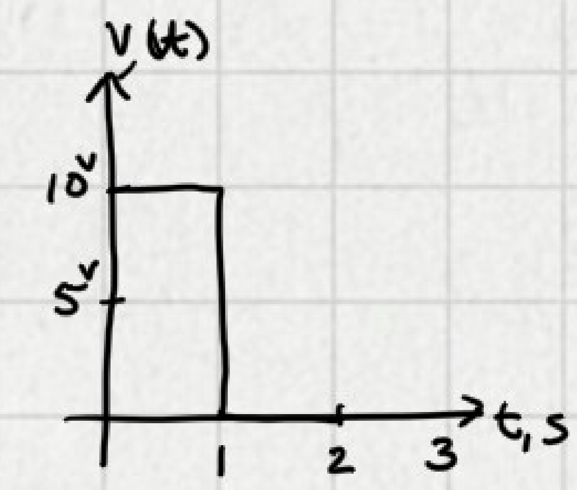
$I_D = \frac{-P_D}{V_D} = \frac{-27^W}{3^V} = \boxed{-9^A}$

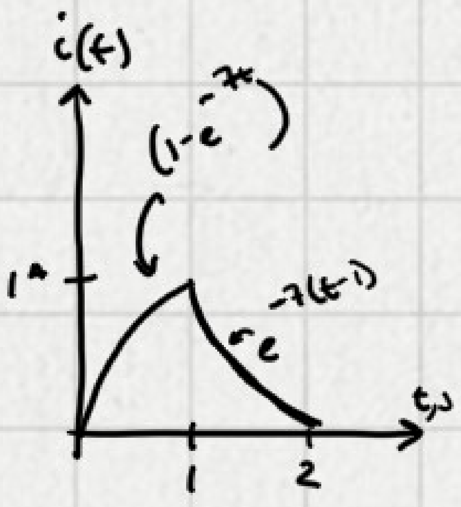
e) if element E absorbs 2^W, find I_E.

$I_E = \frac{P_E}{V_E} = \frac{2^W}{1^V} = \boxed{2^A}$

f) Find the power absorbed by element F, $P_F = V_F \cdot I_F = -4^V \cdot 5^A = \boxed{-20^W}$

Given:





a) calculate & sketch the power of this device.

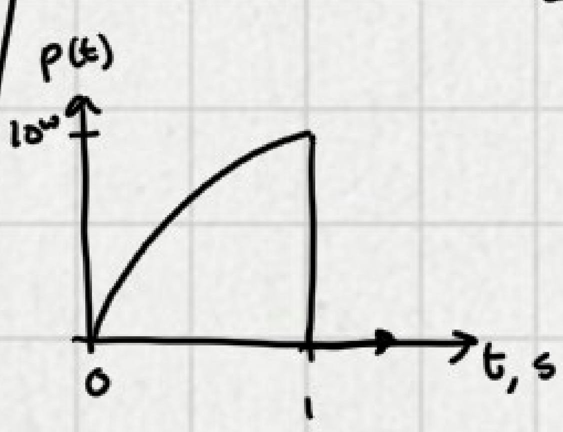
$p(t) = v(t) \cdot i(t)$

$\therefore$

$$p(t) = \left[10(u(t) - u(t-1))\right]\left[(1-e^{-7t})(u(t)-u(t-1)) + \dots \right.$$
$$\left. \dots (e^{-7(t-1)})(u(t-1) - u(t-2))\right]$$

which reduces to:

$$p(t) = \left[10(1-e^{-7t})\right]\left[u(t) - u(t-1)\right]$$



b) Find the work expended by the source. Recall that work is $W(t) = \int P(t)\,dt$

$\therefore$

$$w(t) = \int_0^1 10(1-e^{-7t})\,dt$$

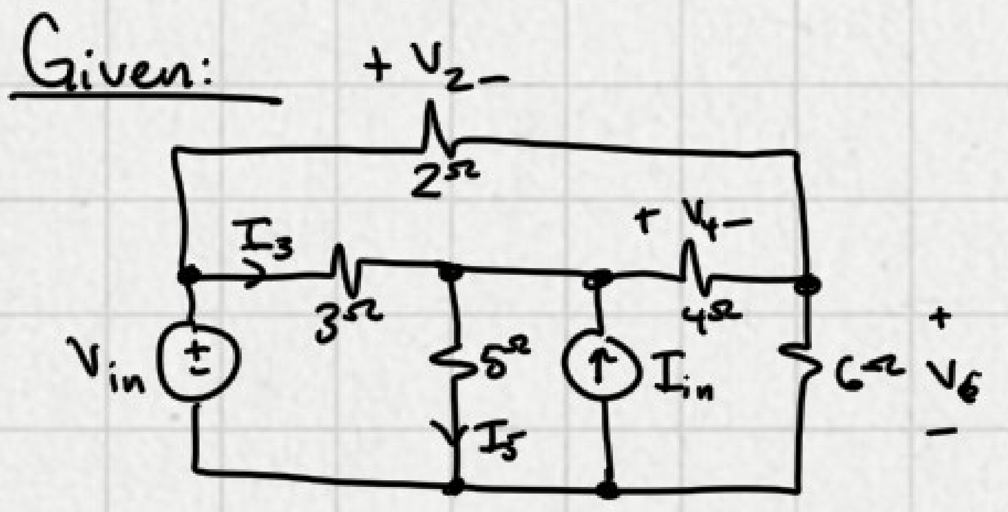
$$w(t) = 10\int_0^1 1 - e^{-7t}\,dt$$

$$w(t) = 10\left[t - \frac{e^{-7t}}{-7}\right]_{t=0}^{1}$$

$$w(t) = 10\left[\left(1 + \frac{e^{-7}}{7}\right) - \left(0 + \frac{1}{7}\right)\right]$$

$$w(t) = 10\left[\frac{6+e^{-7}}{7}\right] \approx 8.57$$

Given:



Also we know the power consumed (absorbed) by each resistor is

$P_{2\Omega} = 98^W$ $\quad$ $P_{5\Omega} = 768.8^W$

$P_{3\Omega} = 12^W$ $\quad$ $P_{6\Omega} = 486^W$

$P_{4\Omega} = 16^W$

a) Find V_2, I_3, V_4, I_5, V_6

This is nothing more than repeated use of $P = VI$ & Ohms law where

$P = \frac{V^2}{R}$ or $P = I^2R$

$\therefore V_2 = \sqrt{P_2 R_2} = \sqrt{98^W \cdot 2^\Omega}$

$\boxed{V_2 = 14^V}$

$I_3 = \sqrt{\frac{12^W}{3^\Omega}} = \boxed{2^A}$

$V_4 = \sqrt{16^W \cdot 4^\Omega} = \boxed{8^V}$

$I_5 = \sqrt{\frac{768.8^W}{5^\Omega}} = \boxed{12.4^A}$

$V_6 = \sqrt{486^W \cdot 6^\Omega} = \boxed{54^V}$

b) Find total power delivered by both sources.
We just need to find their voltage and current using KVL & KCL for both.

KVL

$V_{in}\ V_2 + V_6 = 14^V + 54^V = 68^V$

KCL

$I_{V_{in}} = I_2 + I_3 = \left(\frac{\overset{14^V}{\cancel{V_2}}}{2^\Omega} + 2^A\right) = 9^A$

$\boxed{P_{V_{in}} = (68^V)(9^A) = 612^W}$

KVL

$V_{I_{in}} = V_4 + V_6 = 8^V + 54^V = 62^V$

KCL

$I_{in} = I_5 + I_4 - I_3 = 12.4^A + \overset{2^A}{\cancel{\frac{8^V}{4^\Omega}}} - 2^A = 12.4^A$

$\boxed{P_{I_{in}} = (62^V)(12.4^A) = 768.8^W}$ $\quad$ $\boxed{\text{Total Power} = 1380.8^W}$

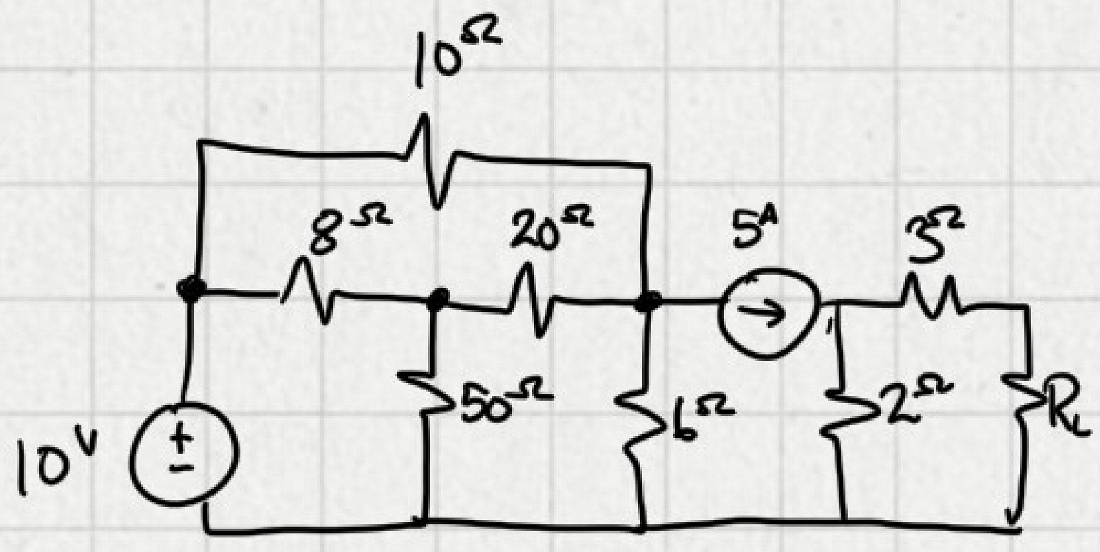
For part B the total power must also be the power of the absorbed power. Which all you had to do is add up each resistor power to get the same answer.

Oh well. I already solved c).

$\boxed{V_{in} = 68^V}$

$\boxed{I_{in} = 12.4^A}$

Given the ckt:



Find R_L so that the maximum power is transfered to it from the sources.

This has 2 main points that I can see it trying to make.

1) The use of Tellegen's theorem

2) How to find equivalent resistance with sources in play.

Let's address Tellegen's Theorem. So this theorem states that to find the most power transfered to your load then the network or system's impedance must match the load impedance.

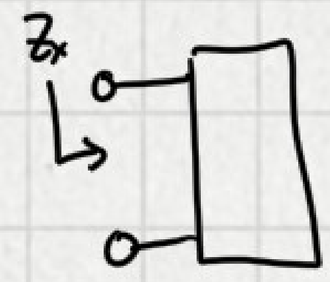
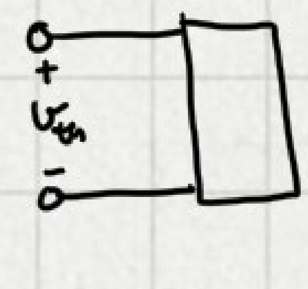
In a figure representation:

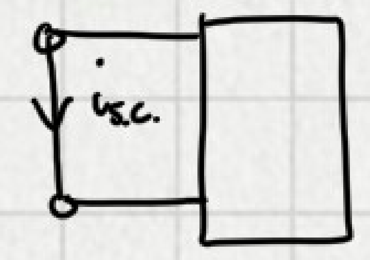
if $Z_{Tx} = Z_L$, then the load will receive the most ~~voltage~~ it can.

So, therefore, in this problem we just need to find the impedance of the ckt prior to the load from the load point of view. In other words,

How to find equivalent resistance. Well there are 2 approaches and both are the same.

- find the voltage of the open which is a.k.a. v_{thev}, then find the current if you shorted the terminals. In other words:

If  then find 

then find 

Once v_{th} & i_{sc} are known the R_{eq} is $\frac{v_{th}}{i_{sc}}$

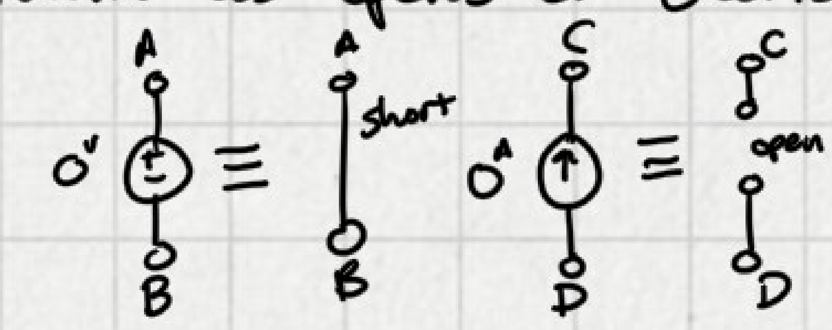
My personal preference to finding R_{eq} is to make one equation where you inject some v_x and find an equation relating the i_x. After which, you make the relationship $\frac{v_x}{i_x} = R_{eq}$.

A key note of importance is to zero out all other sources present. The sources do not yield impedance information, only voltage & current information depending on which type of source.

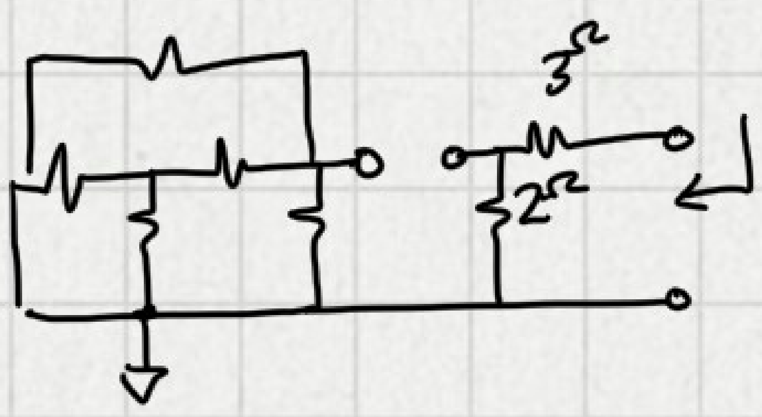
Therefore, voltage sources are set to 0^V and current sources are set to 0^A. Now a point to note. A wire is a component that allows current to flow through it in any direction w/ 0^V drop across it. This is exactly how a voltage source w/ 0^V acts as well. Therefore, we note the voltage sources as wires.

We also note that current source can any voltage across and the current is 0^A when we zero this out. An open ckt acts the same way.

So when doing this technique we must zero out all other sources, and we can represent them as opens or shorts



Once we use this we see immediately how simplified this ckt becomes



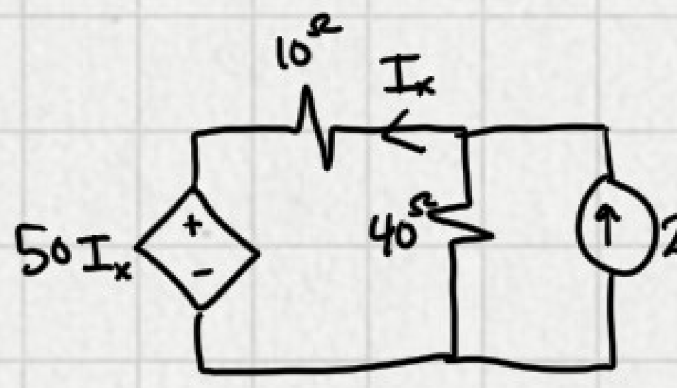
we see that the current sources cuts off the influence of the other side of the ckt. And the only impedance of concern are the 2^{Ω} & 3^{Ω} resistors

$\therefore$ R_L must be equal to 5^{Ω} to get the max power.

$\boxed{R_L = 5^{\Omega}}$

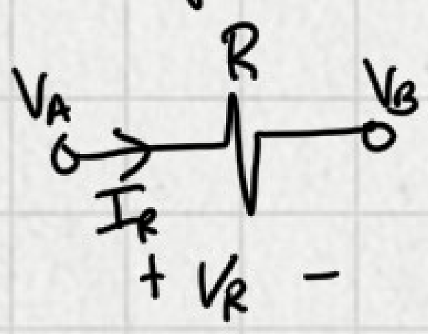
I highly suggest to bild in a ckt simulator to play with component to prove max power $V_{R_L} \cdot I_{R_L}$ is only when $R_L = 5^{\Omega}$. Also that the other side plays no role on the power of R_L only the current source & 2^{Ω} & 3^{Ω} resistors.

Given the ckt:



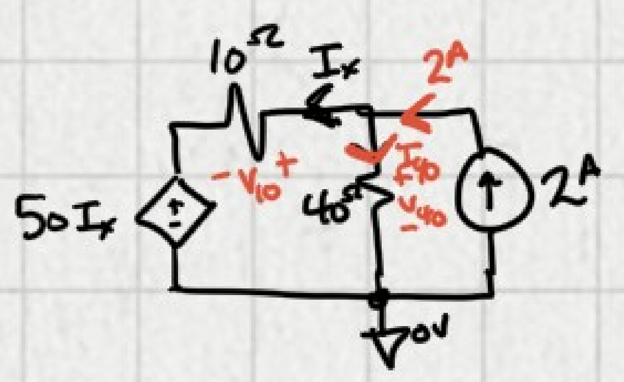
Find the magnitude of I_x.

So here I_x has already been assumed to go from right to left. Therefore Ohm's Law for a resistor says current must flow from higher potential to lower potential.



$V_R = V_A - V_B$

Let's derive our equations:



KVL

$50I_x + V_{10} = V_{40}$

KCL

$2^A = I_x + I_{40}$

Ohm's Law

$V_{10} = 10^\Omega \cdot I_x$

$V_{40} = 40^\Omega \cdot I_{40}$

Using these equations, I want to be able to get one equation one unknown, I_x, if possible.

starting w/ KVL we see

$$50 I_x + V_{10} = V_{40}$$

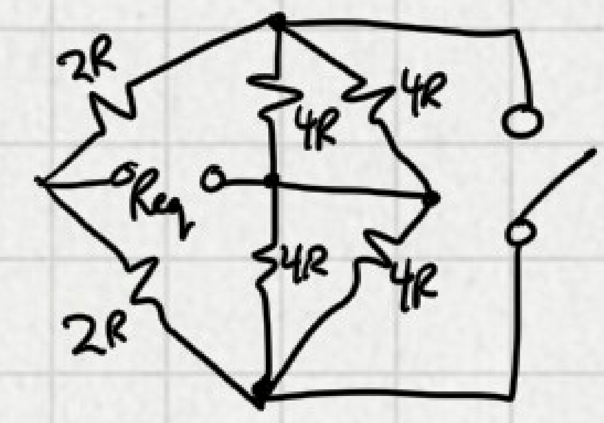
↳ $50 I_x + 10^\Omega I_x = V_{40}$

Where $V_{40} = 40^\Omega \cdot \cancel{I_{40}}^{(2^A - I_x)} = 80^V - 40^\Omega I_x$

↳ $50 I_x + 10 I_x = 80^V - 40 \cdot I_x$

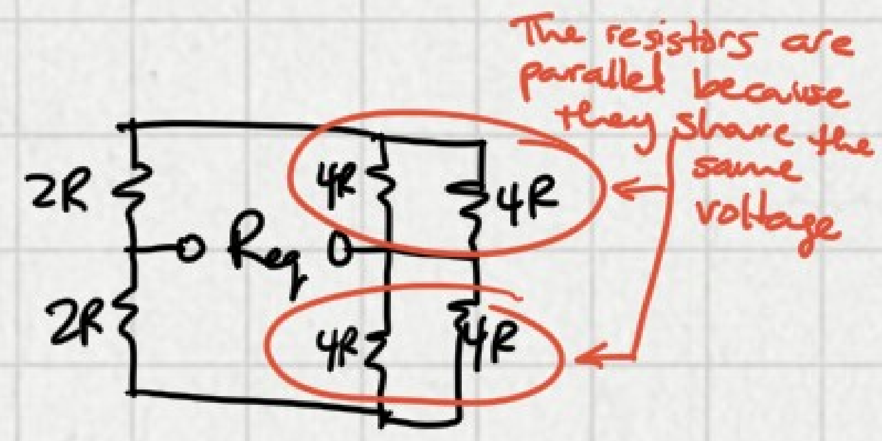
↳ $100 I_x = 80$ ∴ $\boxed{I_x = \frac{80}{100} = \frac{8}{10} = 0.8^A}$

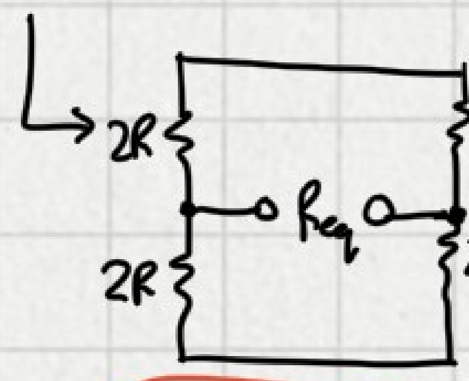
Given the ckt:



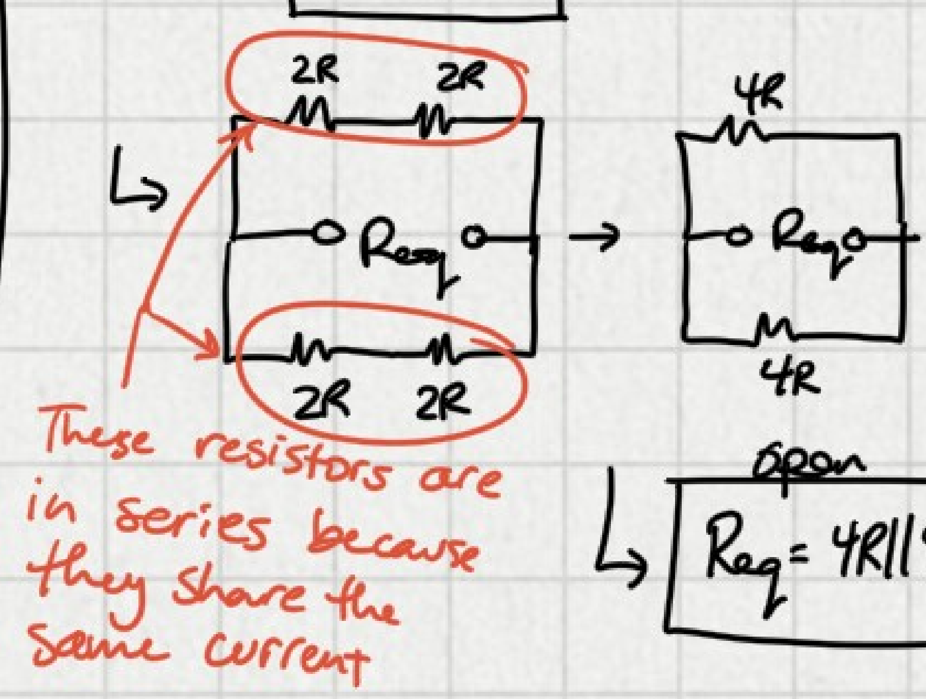
Find Req w/ the switch open & closed.

if open the ckt becomes



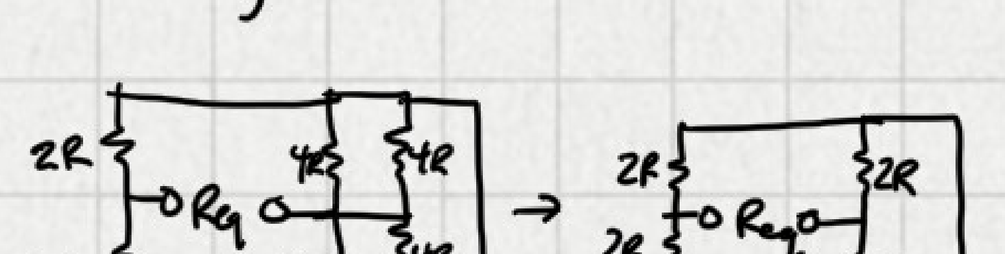


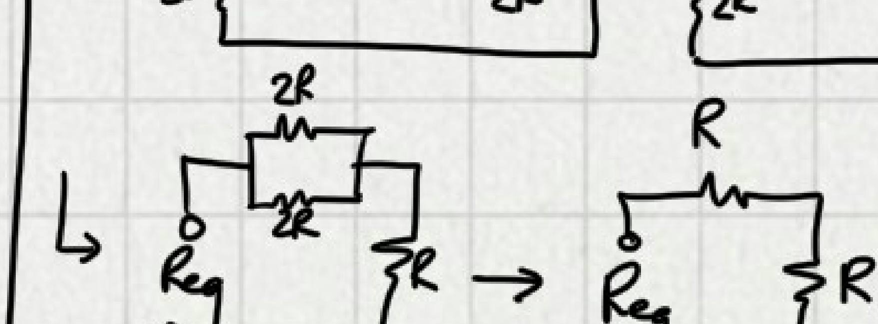
$2R = 4R \| 4R = \frac{4R \cdot 4R}{4R+4R} = \frac{16R^2}{8R}$



↳ $\boxed{R_{eq}^{open} = 4R \| 4R = 2R}$

Solving for a closed switch

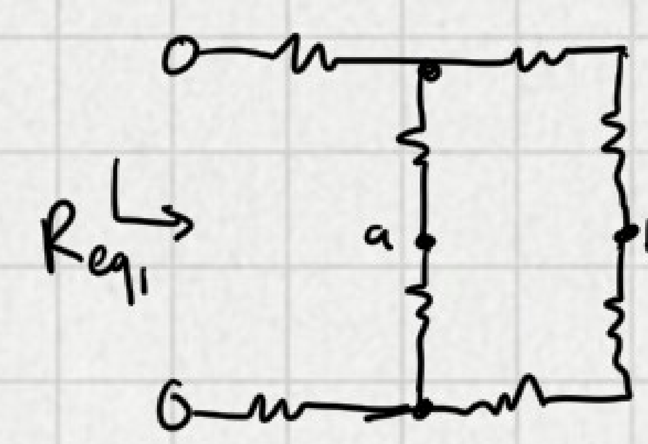


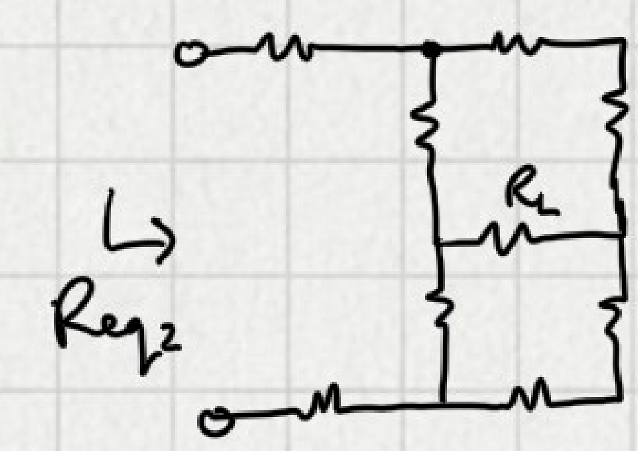


∴ $R_{eq_{closed}} = 2R$

This problem is testing is conceptualization of parallel and series resistance equivalence. if resistors shares the same voltage nodes they can be parallel reduced, while if they share the same current they can be series reduced.

Given the ckt

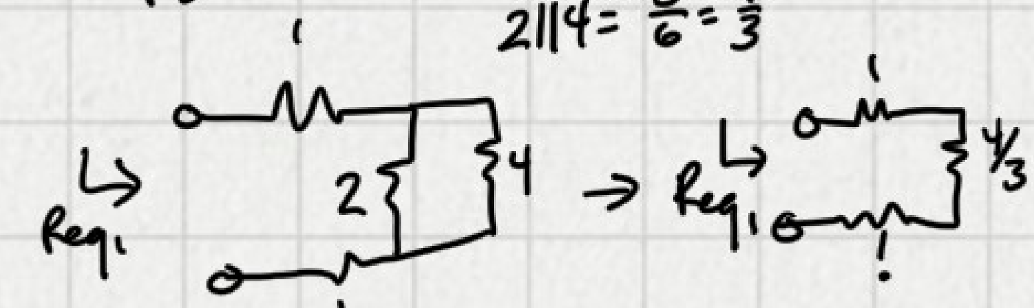




if all the resistors are 1^Ω except R_L, can a relationship be made between R_{eq_1} & R_{eq_2}

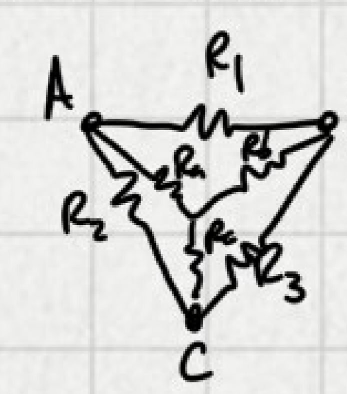
well R_{eq_1} can be reduced to

$2 \| 4 = \frac{8}{6} = \frac{4}{3}$



$\boxed{R_{eq_1} = 1 + 1 + \frac{4}{3} = \frac{10}{3}\Omega}$

For R_{eq_2} we need to know the Y-Δ transformation

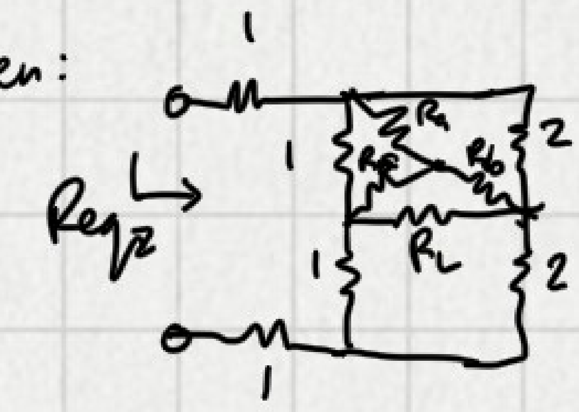


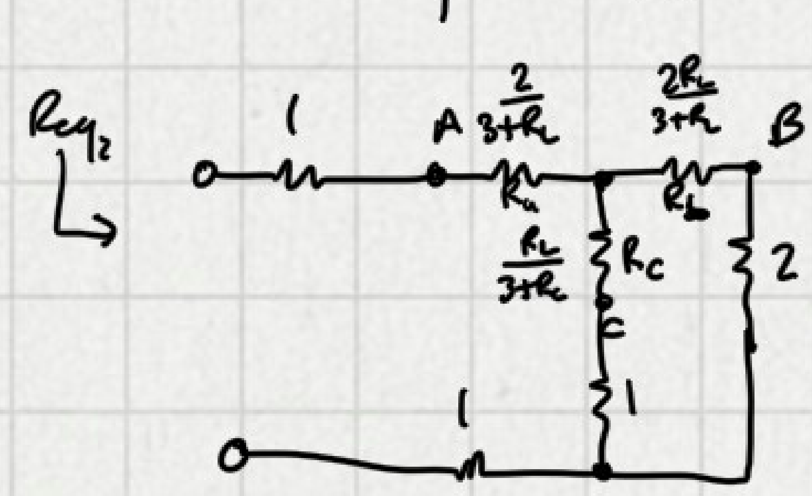
$R_a = \frac{R_1 R_2}{R_1+R_2+R_3}$

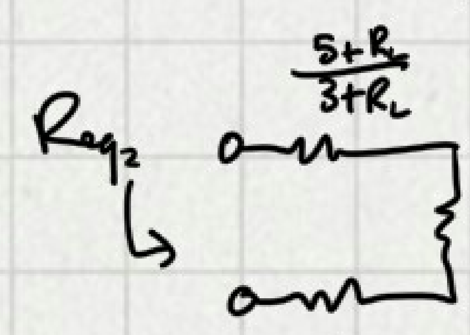
$R_b = \frac{R_1 R_3}{R_1+R_2+R_3}$

$R_c = \frac{R_2 R_3}{R_1+R_2+R_3}$

Given:







$\frac{3+2R_L}{3+R_L} \| \frac{6+4R_L}{3+R_L}$

∴ $\dfrac{\frac{(3+2R_L)(6+4R_L)}{(3+R_L)^2}}{\frac{9+6R_L}{\cancel{(3+R_L)}}} = \frac{2(3+2R_L)^2}{3\cancel{(3+2R_L)}(3+R_L)}$

$R_{eq_2} = \frac{5+R_L}{3+R_L} + \frac{2/3\,(3+2R_L)}{(3+R_L)} + \frac{3+R_L}{3+R_L}$

$R_{eq_2} = \frac{5+R_L + 2 + \frac{4}{3}R_L + 3 + R_L}{3+R_L}$

$R_{eq_2} = \frac{10 + \frac{10}{3}R_L}{3+R_L} = \frac{30+10R_L}{9+3R_L}$

$\boxed{R_{eq_2} = \frac{10(3+R_L)}{3(3+R_L)} = \frac{10}{3}}$

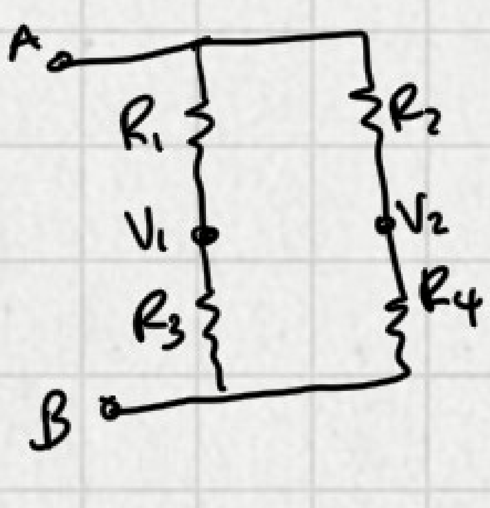
(cont'd)

(cont'd)

This problem is showing a couple of things.

1) That voltage is the same across both sets of resistors and the voltage division is both halved on both sides due to symmetry.

2) Wheatstone bridge property

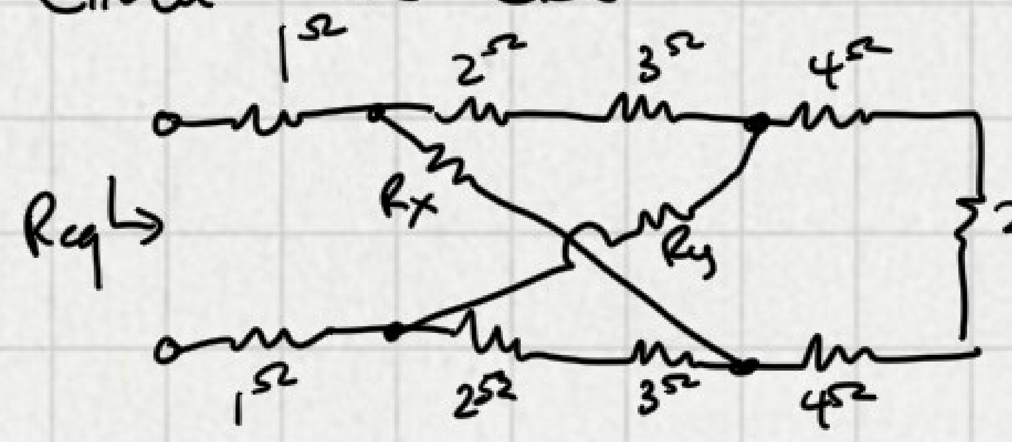


if given this arrangement then we know $V_1 - V_2 = 0^V$ if $R_1 R_4 = R_2 R_3$ or $\frac{R_1}{R_3} = \frac{R_2}{R_4}$

and in this case they were. So what you ask? Well if there is no potential difference @ those nodes then regardless of a resistor there or not, no current will flow. If no current flow then it doesn't change the equivalent resistance by adding any resistor there. Not even a short circuit.

$\therefore \quad R_{eq_1} = R_{eq_2}$

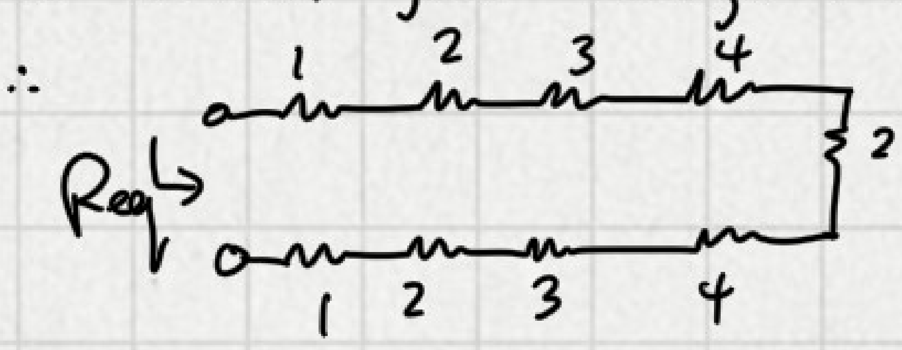
Given the ckt:



What is R_{eq}:

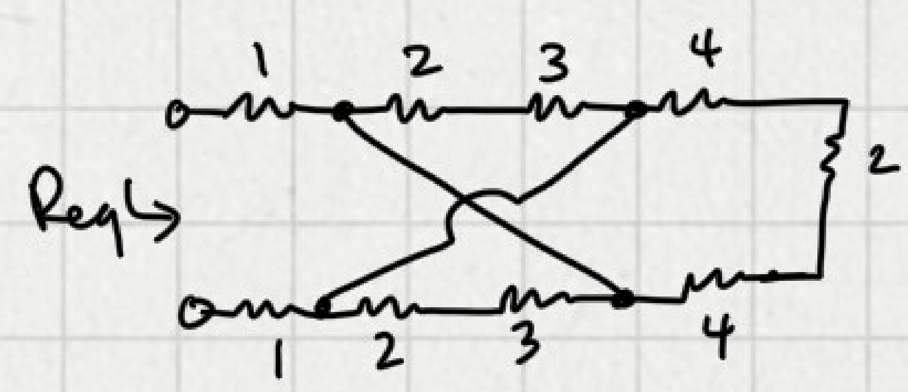
a) when $R_x = R_y = \infty$. This means they are acting as opens w/ no current flow through them.

$\therefore$

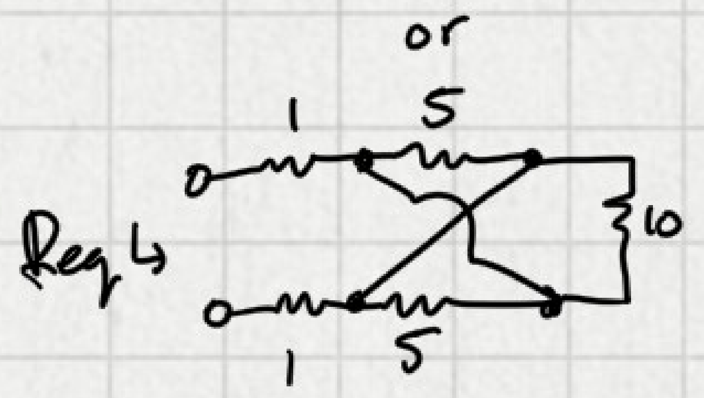


$R_{eq} = 2(1+2+3+4) + 2 = \boxed{22^\Omega}$

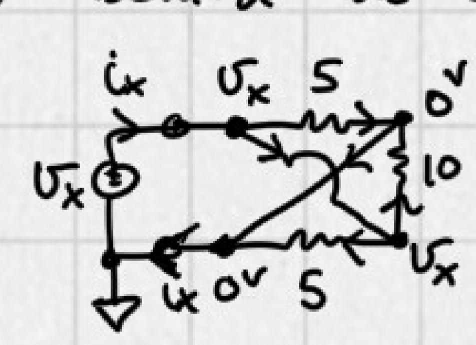
b) When $R_x = R_y = 0$. This means they are acting as shorts or wires.



or



we see there will be 2^Ω so let's analyze the resistance behind the 2 - 1^Ω resistors



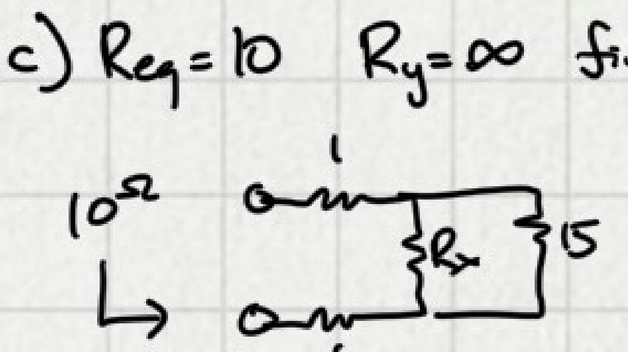
$i_x = \frac{v_x}{5} + \frac{v_x}{10} + \frac{v_x}{5} = \left(\frac{2}{5} + \frac{1}{10}\right) v_x$

$v_x \left(\frac{4}{10} + \frac{1}{10}\right) = i_x \rightarrow v_x \left(\frac{5}{10}\right) = i_x$

$\frac{v_x}{i_x} = 2^\Omega \therefore$

$R_{eq} = 2^\Omega + 2^\Omega = \boxed{4^\Omega}$

c) $R_{eq} = 10$ $R_y = \infty$ find R_x

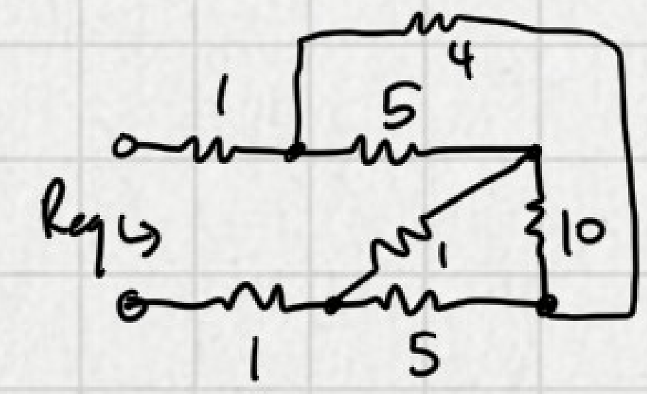


$R_x \| 15 = \frac{15 R_x}{R_x + 15}$

$10 = 7 + \frac{15 R_x}{R_x + 15} \rightarrow 3R_x + 45 = 15 R_x$

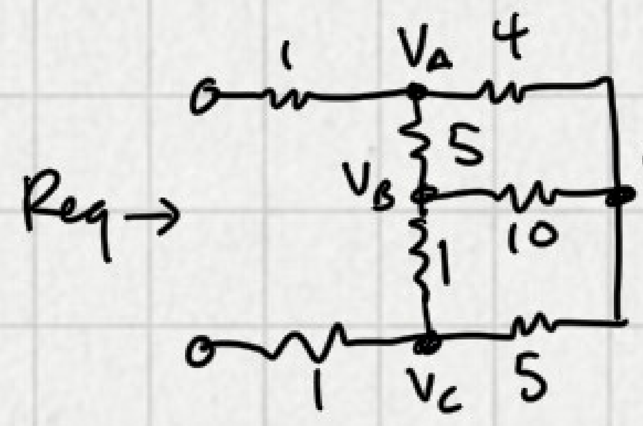
$12 R_x = 45 \rightarrow \boxed{R_x = \frac{45}{12} = 3.75^\Omega}$

D)



Can R_{eq} be found by doing only series & parallel reduction techniques?

Let's redraw and see if it becomes clearer.

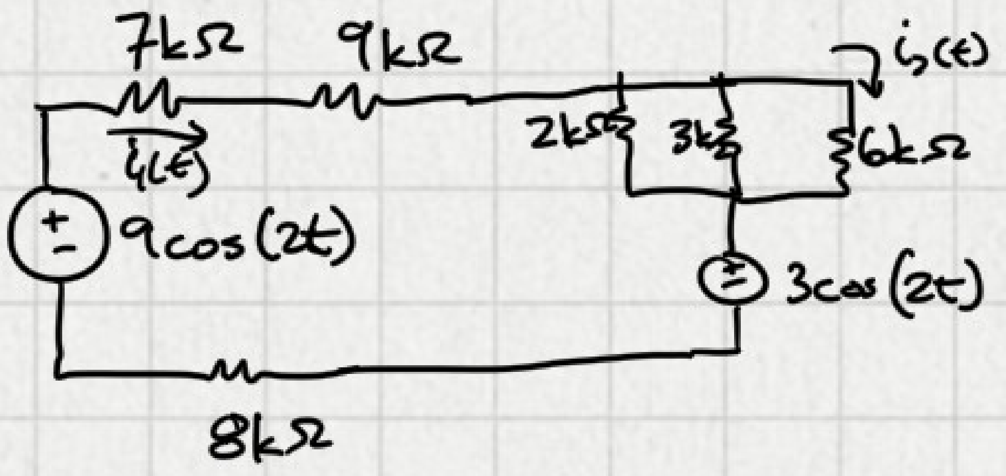


We see we can't simplify any components using parallel or series due to components being attached to nodes that will be absorbed.

No is the answer.

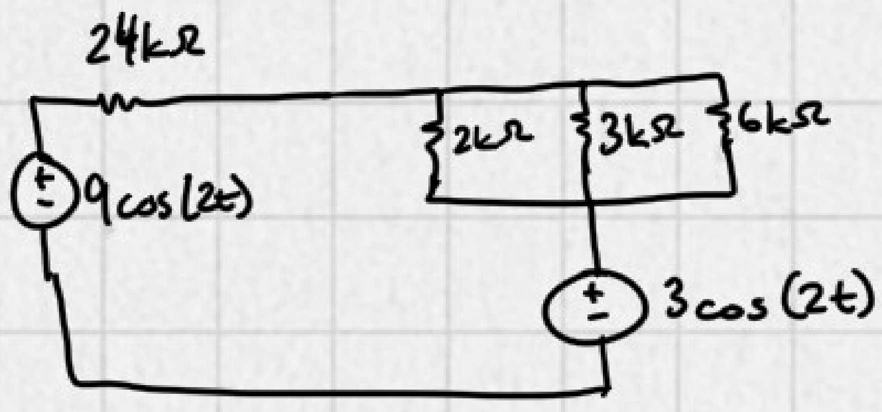
You gotta use good old KVL & KCL techniques.

Given the ckt:



find $i_1(t)$ & $i_2(t)$?

First let's simplify



to find $i_1(t)$ we see it is the total current. So we need the total resistance.

$$2k \| 3k = \frac{6}{5} k\Omega$$

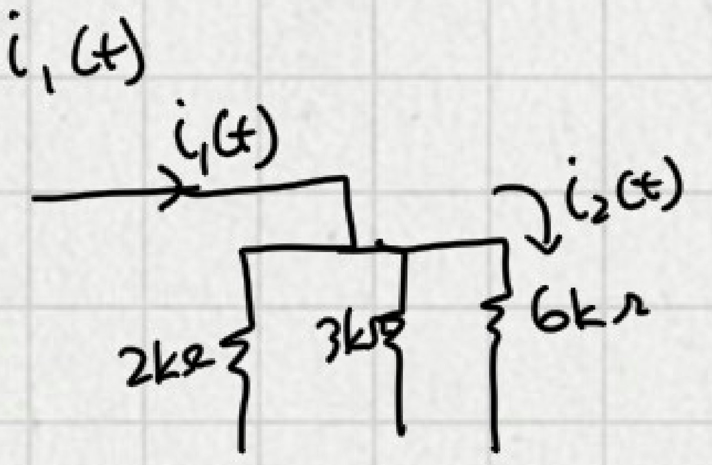
$$\frac{6}{5}k \| 6k = \frac{\frac{36}{5}}{\frac{30}{5}+\frac{6}{5}} = 1k$$

$$R_{Tot} = 1k + 24k = 25k\Omega$$

$$\Delta V_{tot} = 9\cos(2t) - 3\cos(2t)$$
$$= 6\cos(2t)$$

$$\therefore i_1(t) = \frac{\Delta V_{tot}}{R_{tot}} = \frac{6\cos(2t)}{25k\Omega} = \boxed{240\mu A\cos(2t)}$$

and $i_2(t)$ is a current divider of $i_1(t)$



$$i_2(t) = \frac{1k\Omega}{6k\Omega} \cdot i_1(t) \therefore i_2(t) = \frac{1}{6} i_1(t)$$

$$\boxed{i_2(t) = 40\mu A \cdot \cos(2t)}$$