2020 Spring, Electrical and Electronic Circuits (4190.206A 001)

Homework #1

Due date: Apr. 20, 2020 11:59pm

If you submit after the due date, your score will be deducted by 20%.

No more submission will be accepted after Apr. 22, 2020. 11:59pm

1			2		3		4			5						6		
a	b	c	a	b	a	b	a	b	c	a		b	c	d	E	a	b	c
					7		8		9	10		11	12	13		14	15	
d	e	f	g	H	a	b	a	b						a	b		a	b
16																		

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Student ID Number : 2013-12815.

To reduce the grading burden of TA, the homework will be graded all-or-nothing style. We will grade just a few problems randomly sampled from the homework and renormalize the total grading according to the relative weight of each problem. Also, within each problem, there may be several sub-problems, but we will grade only a few sub-problems within each problem, and the score of each problem will be determined by the graded sub-problems proportionally.

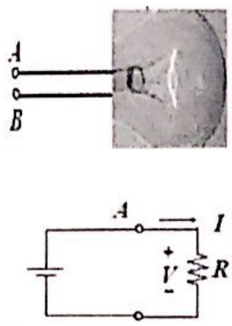
For example, if problem 1 is composed of 5 sub-problems, we will decide which sub-problems will be graded later, and if you solved that sub-problems correctly, you will get the full credit of problem 1. In the worst case, you might have solved all other sub-problems correctly, but got the wrong answers in all the graded sub-problems. That is an unfortunate situation, but the score for that entire problem will become 0. Without this policy, we cannot grade so much homework efficiently.

The homework should be *hand-written*, converted into a pdf file, and uploaded to ETL. The pdf file may either be a scanned-copy or camera-taken picture of your homework. We will post solutions for every homework and announce the problems and sub-problems to be graded after the hard deadline.

The homework should be written with your hand-writing on a paper. Computer-typed homework won't be accepted!

If you solve the homework problems using digital pen on a tablet, it will be considered as your hand-writing, but make sure that your hand-writing is legible.

1-1. (point 6) Use the definition of current, voltage, power to find the answer.



$= 40\Omega \cdot 3A = 120V \cdot$

Figure 1

(a) For 1 hour, 5.58*10[21] electrons pass through a lightbulb. Find the magnitude of current.

$= 0.9 \times 6.2 \times 10^{21}$

$= 0.9 \cdot 10^3 \cdot 6.2 \times 10^{18} \cdot$

$\sim 900.1C \cdot$

$I \sim 900C / 3600s$

$\boxed{\therefore 0.25A}$

(b) A motor with an operating resistance of 40 ohm is connected to a voltage source. When I measured the current, it is 3A. What is the magnitude of voltage of the source? $\boxed{120V}$

$\frac{1}{4}P = \frac{1}{2}V \cdot \frac{1}{2}I$ $\quad \frac{1}{2}V = \frac{1}{2}I(R)$

(c) An electric bulb is rated 220V and 10W. When it is operated on 110V, find the power consumption. $P \cancel{W} = V \cdot I$.

$10(W) = 220(V)\ I(A)$

$I = \frac{1}{22} A$

at 110V,

$P = 110V \cdot \frac{1}{22} \cdot \frac{1}{2} A$

$= \boxed{2.5W}$

1-2. (point 8) The voltage and current at the terminals of the circuit element in Figure.2 are zero for t<0 and t>10s. In the interval between 0and 10s the expressions are

V=12t ,0<t<10 s

I= t(10-t) ,0<t<10 s

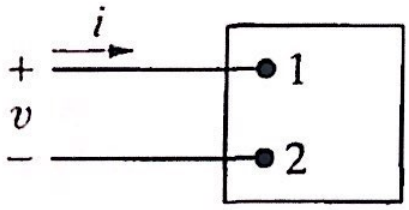
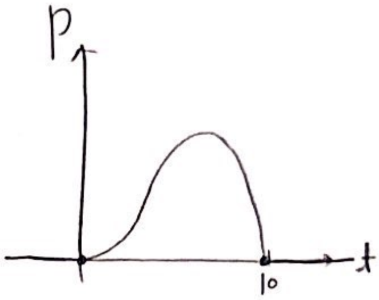


Figure 2

(a) Draw the graph for power vs time. $V \cdot I$

$$p = V \cdot I = \begin{cases} 12 \cdot t^2 \cdot (10-t) & (0 < t < 10) \\ 0 & (t < 0,\ t > 10) \end{cases}$$



(b) Find the average power between 0 and 10 seconds.

$$\int_0^{10} p\, dt = \int_0^{10} 12\, t^2 (10-t)\, dt$$
$$= 12 \cdot \int_0^{10} (-t^3 + 10t^2)\, dt$$
$$= 12 \cdot \left[-\frac{1}{4}t^4 + \frac{10}{3}t^3 \right]_0^{10}$$
$$= 12\left(-\frac{1}{4} + \frac{1}{3}\right) \cdot 10^4$$

$\frac{1}{12}$

$\therefore$ average power between 0 ~ 10 s

$= \boxed{1000\ W} = \boxed{1\ kW}$

1-3. (point 4) Assume that the circuit in Figure.3 consists of lumped elements connected by ideal wires. (5k 이l

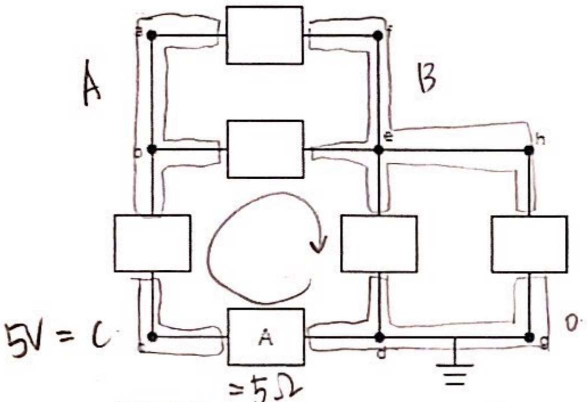
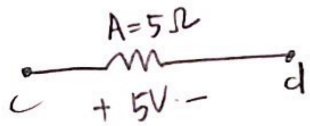


Figure 3



$I_{cd} = 1A$

= A-B

(a) Assuming that $V_{cb} + V_{be} + V_{ed} = 5V$, please find V_{cd}. $\boxed{5V}$

= C-A   B

(by KVL, $V_{dc} = -5V$ $\therefore V_{cd} = 5V$)

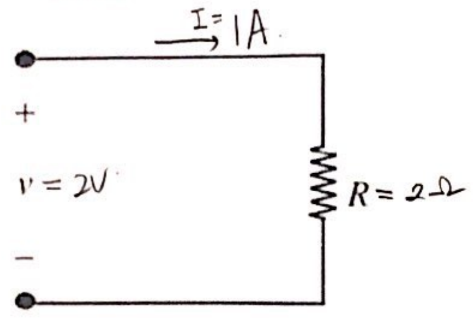
7.

(b) Assume that the resistor A is 5ohm. Considering the sign, determine I_{dc}. (In this case, I_{dc} means current flowing from d to c is positive.)

$$I_{dc} = \frac{V_{dc}}{R_A} = \boxed{-1A}$$

V_{dc}

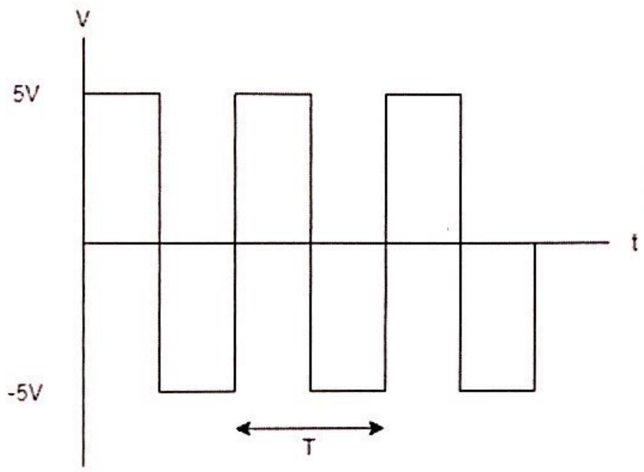
1-4. (point 10) In the following problem, please find out the average powers dissipated in the resistor for the following types of voltage sources. Assume that $R = 2\Omega$ in the following circuit.

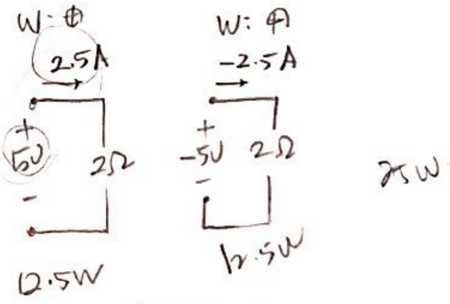


(a) (point 2) v=2V $\boxed{2W}$

(b) (point 4) If the square wave signal has a peak-to-peak of 10V

(hint : For periodic signals, the average power can be obtained by piecewise power consumption over one cycle and dividing by the cycle of time.)

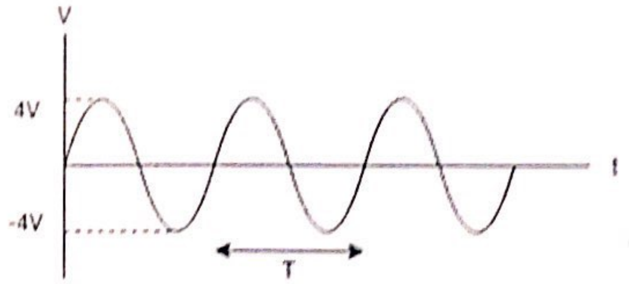




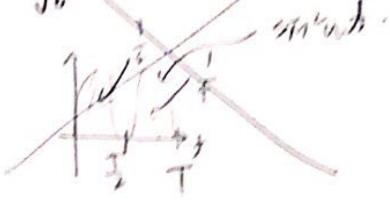
$\boxed{\frac{25}{T} W}$

(c) (point 4) $v = 4\sin(\pi t)$

(Hint : $\int_{t_1}^{t_1+T} \sin^2(wt)\,dt = \frac{T}{2}$, where T is period. For periodic signals, the average power can be obtained by integrating the power over one cycle and dividing by the cycle of time.)



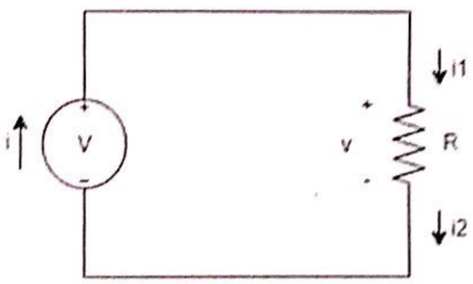
$\int_0^T 4\sin(\pi t)\,dt$



$v = 4\sin\pi t$
$i = 2\sin\pi t$ $\longrightarrow$ $\int_{t_1}^{t_1+T} 8\sin^2\pi t\,dt = \frac{T}{2}\cdot 8 = 4T/T = \boxed{4}$

$v = 4\sin(\pi t)$
$i = 2\sin(\pi t)$ $\quad \int_{t_1}^{t_1+T} 8\sin^2(\pi t)\,dt = 8\frac{T}{2} = 4T/T = 4$

1-5. (point 5) There is a battery V and a resistor R in the circuit. Answer the following questions. For questions from (c) to (e), please answer them in terms of $\boxed{\text{V and R.}}$



(a) Is i1 always equal to i2? (when the wire is ideal) $\boxed{\text{Yes}}$

(b) Is v always equal to V? (") $\boxed{\text{Yes}}$

(c) What is the power consumed by the resistor? $\boxed{\frac{V^2}{R}}$

(d) What is the power consumed by the battery? $\boxed{-\frac{V^2}{R}}$

(e) What is the power supplied by the battery? $\boxed{\frac{V^2}{R}}$

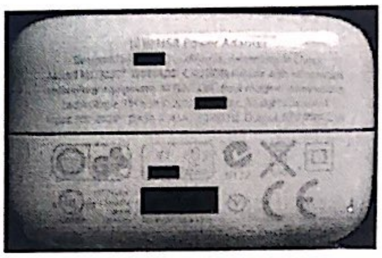
1-6. (point 17) Nowadays, many of the small electric devices use USB power adapter as its power source. Let's calculate how much power these USB power adapters can handle and think how does it affect our daily lives. In the following calculation, we will assume that there is no power loss in the conversion.

a) (point 2) USB interface has a long history with multiple versions, but when the early generation of the smartphones and tablets started to adopt USB power adapter, the most popular USB version was either 1.1 or 2.0, and the maximum current the typical USB ports on PC can provide was limited to 500 mA. What is the maximum power these USB ports can supply? (Hint: the voltage of the USB standard is always 5.0V except the power delivery (USB PD) specs which is not quite popular yet.)

$P = VI \le 5.0(V) \cdot 0.5(A) = 2.5(W)$

Answer: $\boxed{2.5}$ W

b) (point 2) The first *pad released in 2010 from A* company was shipped with USB power adapter that can provide up to ~~2.1A~~ 2.0 of current. However, people also used to connect this device to the USB ports on the PC or tried to charge it with other USB power adapters because the power adapter sold from A* company was too expensive. And in most of the case, *pad showed a warning message "Not Charging", even though in many cases it was being charged slowly. Assume that it used to take about 2 hours to charge *pad to 100% with the original charger (assume 2.0A for simple calculation) when it is off, then how long would it have taken to charge it with the typical USB port on PC in those days?

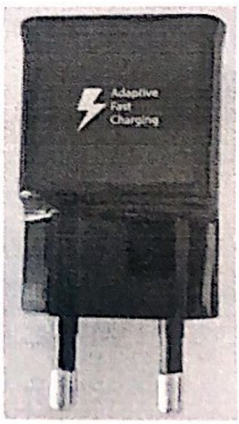


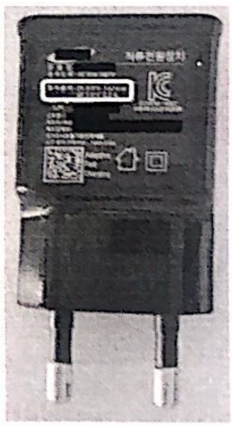
Answer: $\boxed{8}$ hours

$4 \uparrow P = VI \downarrow \frac{1}{4}$

(FYI, USB ports on the recent computers support USB 3.0, and it can provide more than 0.5A.)

c) (point 2) For example, my USB power supply can support either 9.0V 1.67A mode or 5.0V 2.0A mode. As its marking on the front face says, it can adjust the output power level for faster charging. Fast charging or quick charging is a new standard to shorten the charging time and it became popular only around mid-2010s. It can charge your smartphone faster only when your smartphone supports such a mode. My phone shows that it is in a "faster charging mode" when it is connected to such a power supply. Assuming there is no power loss





1.67
6.69
15.03 W

10.00 W

during conversion, which mode will charge the smartphone faster and how many times is it faster?

Answer: 9.0 V 1.67 A mode, 1.503 times faster

d) (point 2) Check your own USB power supply for your smartphone, and find out how much current it can support. If your USB power supply can support multiple modes, please list all those modes.

Answer: model name or model No. of your USB power supply: TX-P260QD-KR

Voltage and current: USB C : 20V, 3A / QC3.0 : 12V/1.5A choose.

e) (point 3) Check your own smartphone model name or number and find out the capacity of the battery in your smartphone from the internet. Battery capacity is generally specified in terms of mAh. 100 mAh means it can provide 100 mA for 1 hour or 10 mA for 10 hours. And if the specification of the battery capacity does not say anything, it is probably using Lithium-ion battery and the output voltage can be between 3.6V and 3.85V. Let's assume that its nominal output voltage is 3.7V. Calculate the total amount of energy stored in your battery when it is fully charged. (Hint: 1 J (Joule) is the amount of energy when 1W (watt) of power is spent for 1 second. Therefore, if 1 Wh (watt-hour) is stored, it can do a work of 3600 J. If you are not familiar with the power conversion, please re-read section 1.5.1 of the textbook.) 1821 mA·1hr (3.7V)(1.821)·3600 = W·s = J

Answer: Phone model name or No. (manufacturer): iPhone 8 (Apple)

Battery capacity (mAh): 1821 (If it is written in other units, please specify it.)

Maximum amount of energy stored in your device (J): 24255 J

(FYI, according to some reference, an average man with 60kg of weight needs roughly 9×10^6 J of energy per day.)

f) (point 2) Based on the answers from d) and e), how long should it take to charge your smartphone to its full capacity theoretically? If your power supply and phone support multiple charging mode, choose the fastest option. Assume that there is no power loss during conversion.

Answer (min or hour): 0.3743 hour (∵ battery charger is for iPad).

g) (point 2) Nowadays, many people carry the portable phone charging battery. If you have your own portable battery, please find out its specification. If you do not own one, you can use the specification of mine (3.6V/10400mAh). Find out the maximum energy it can contain, and also calculate how many times it can charge your phone from empty to full.

Answer: maximum energy stored in the portable battery (J): 134784 J

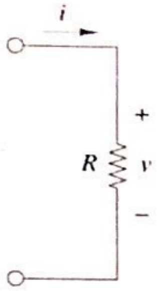
Number of times it can charge your phone: 5 (truncate to integer.)

h) (point 2) According to FAA (US Federal Aviation Administration) regulation, "A device with a lithium ion battery that exceeds 160 watt hours (Wh) is prohibited as carry-on or checked baggage". Is your smartphone allowed on board according to this regulation?

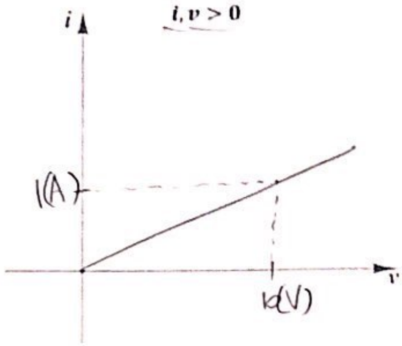
Answer: Yes

1-7. (point 4) Answer the following questions.

(a) Draw the i-v characteristic graph of a resistor when $R = 1\Omega$.



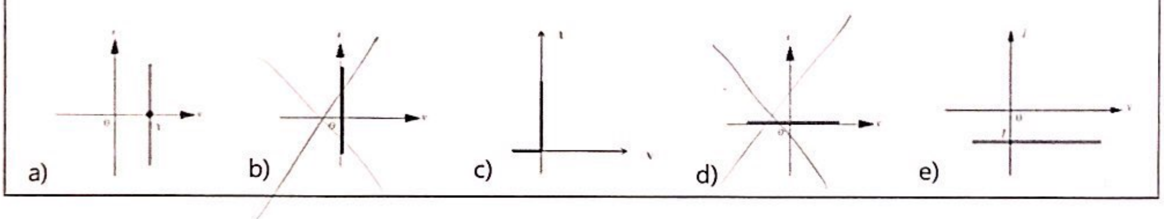
Circuit symbol



i-v characteristic

(b) Choose the correct i-v characteristic graph for each element or circuit

1)Ideal diode	2)Voltage source	3)Current source	4)Short circuit	5)Open circuit
c	a	e	b	d



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1-8. (point 2) Answer the following questions.

$$\frac{i_1}{i_2} = \frac{R_2}{R_1}$$

$$i_1 R_1 = i_2 R_2$$

$$i_1 + i_2 = i$$

$$\Sigma R = \quad \frac{R_1+R_2}{R}$$

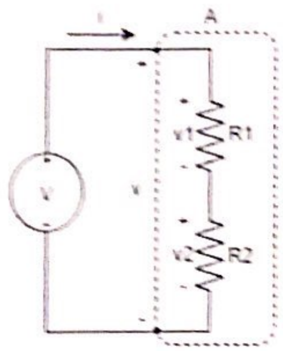


Figure 4

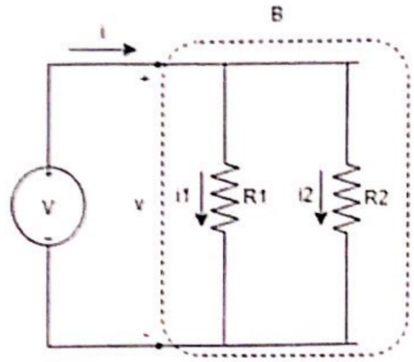


Figure 5

(a) For the circuit in figure 4, express v1, v2 in terms of V, R1, R2.

$$v_1 = \frac{R_1}{R_1+R_2} V$$

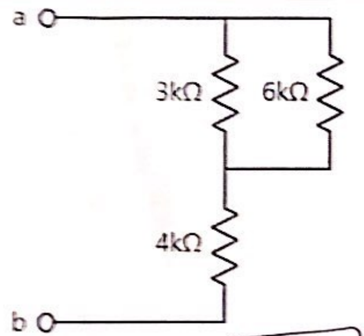
$$v_2 = \frac{R_2}{R_1+R_2} V$$

(b) For the circuit in figure 5, express i1, i2 in terms of i, R1, R2.

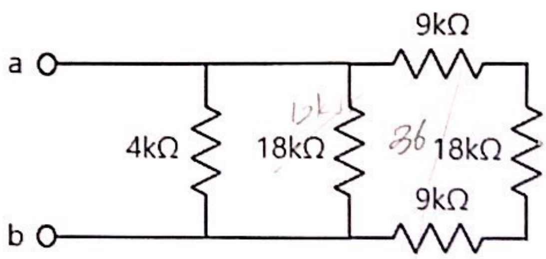
$$i_1 = \frac{R_2}{R_1+R_2} i$$

$$i_2 = \frac{R_1}{R_1+R_2} i$$

1-9. (point 6) Calculate the resistance between terminal a and b

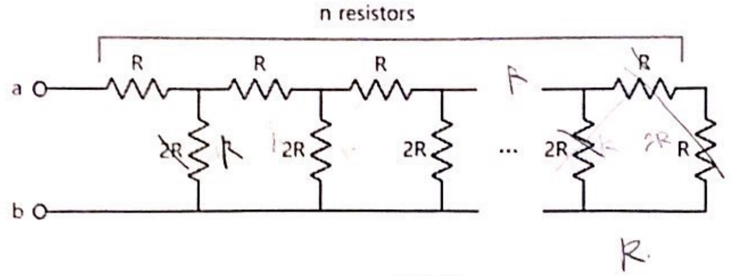


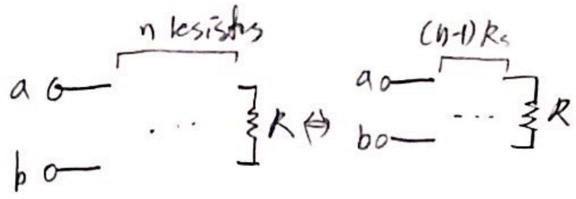
R_{ab}= 6kΩ



R_{ab}= 3kΩ

1-10. (point 4) Calculate the resistance between terminal a and b





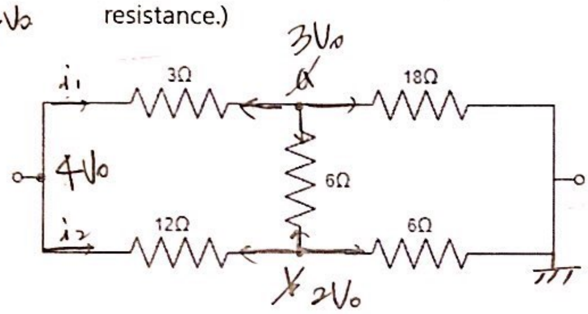
R.

$\boxed{2R.}$

<Node Analysis>.

1-11. (point 10) Find the equivalent resistance from the indicated terminal pair of the network. (Hint : Imagine that we applied a voltage source with V_0 between the two indicated terminals. Using the node analysis method, you can find out all the voltages at the nodes in terms of V_0. Then you can find out the currents flowing in the 3Ω resistor and the 12Ω resistor in terms of V_0, and therefore you can find out the total current coming out of the voltage source in terms of V_0. This should be enough information to find out the total resistance.)

$\Sigma V = 4V_0$



$i_1 = \frac{1}{3} V_0 \,/\, i_2 \; \frac{1}{6} V_0$

$\Sigma i = \frac{1}{2} V_0 \quad \Sigma V = 4V_0$

$\boxed{\therefore \Sigma R = 8\,\Omega}$

Node a: $\frac{a - V_0}{3} + \frac{a-b}{6} + \frac{a}{18} = 0.$

$\Rightarrow \cancel{6}a - 6V_0 + \cancel{3}a - 3b + a = 0.$

$\Rightarrow 10a = 6V_0 + 3b \quad \cdots ①$

Node b: $\frac{b - V_0}{12} + \frac{b-a}{6} + \frac{b}{6} = 0.$

$\Rightarrow b - V_0 + 2b - 2a + 2b = 0.$

$\Rightarrow 5b = V_0 + 2a$

$\Rightarrow 10a = 25b - 5V_0 \quad \cdots ②$

by ① & ② $25b - 5V_0 = 6V_0 + 3b.$

$22b = 11 V_0 \qquad \therefore b = \frac{1}{2} V_0$

$① \Rightarrow 20a = 12V_0 + 3V_0.$

$\therefore a = \frac{3}{4} V_0.$

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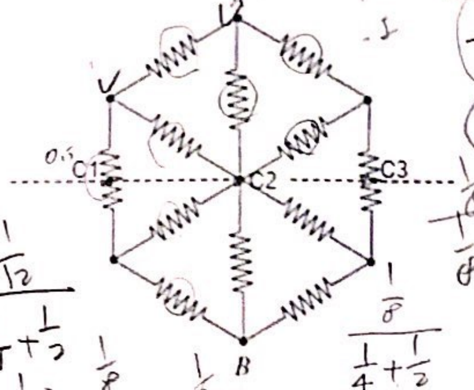
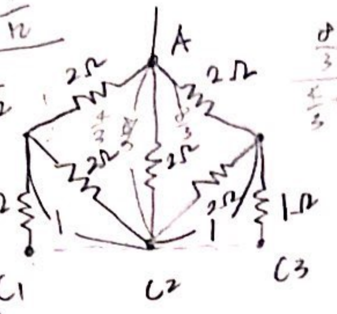
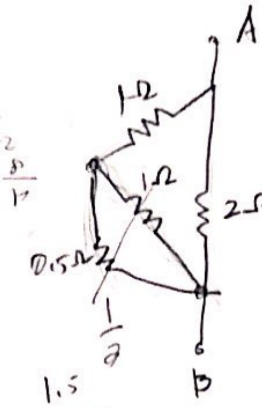
1-12. (point 10) Find the resistance between node A and B in the figure. All resistors equal 1Ω.

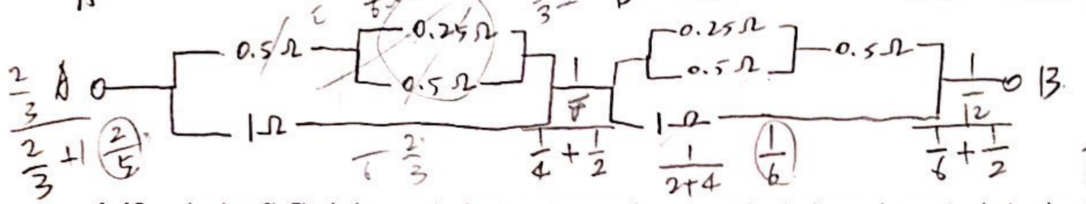
(Hint 1: Example 2.24 and 2.25 in the textbook. Hint 2 : Split the circuit by the dashed line. Then C1, C2, C3 have same voltage.)







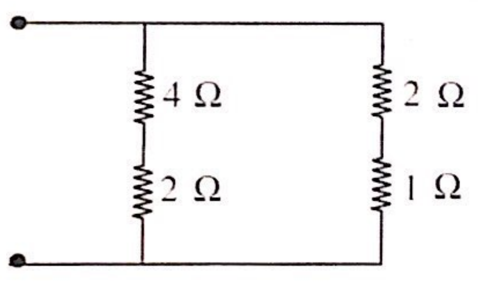
$\boxed{0.8\Omega}$

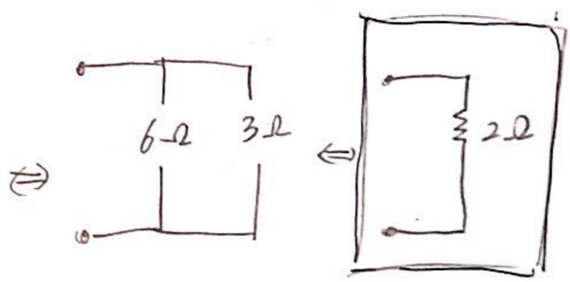


1-13. (point 6) Find the equivalent resistance between the indicated terminals in the figure.

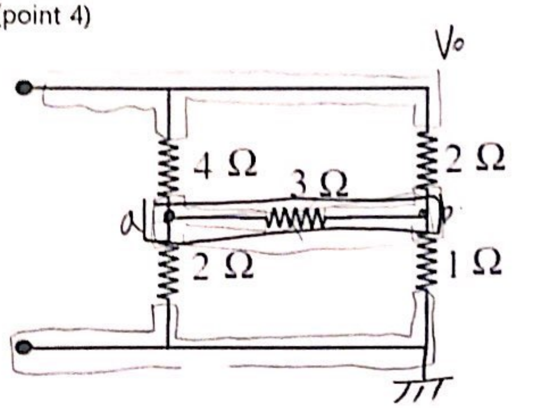
(Hint : Example 2.24 and 2.25 in the textbook.)

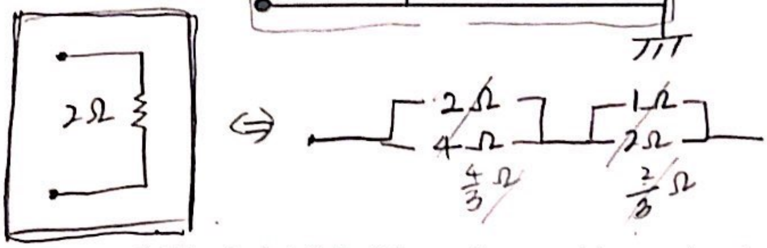
(a) (point 2)





(b) (point 4)





Node a : $\frac{a-V_0}{4} + \frac{a-b}{3} + \frac{a}{2} = 0$

$3a - 3V_0 + 4a - 4b + 6a = 0$

$13a = 3V_0 + 4b \cdots ①$

Node b : $\frac{b-V_0}{2} + \frac{b-a}{3} + b = 0$

$3b - 3V_0 + 2b - 2a + 6b = 0$

$11b = 3V_0 + 2a \cdots ②$

$13a - 11b = 4b - 2a$

$15a = 15b$

$26a = 6V_0 + 8b$

$26a = 143b - 39V_0$

$135b = 45V_0$

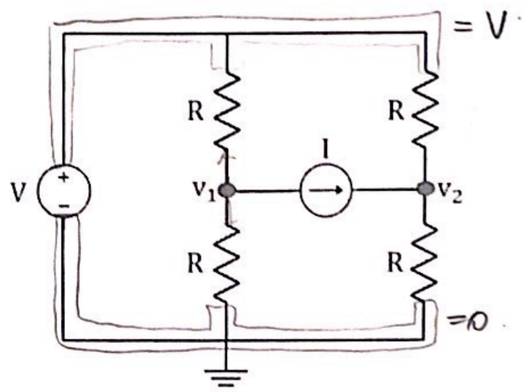
$b = \frac{1}{3}V_0$

$39a = 9V_0 + 4V_0$

$13V_0$

$a = \frac{1}{3}V_0$

1-14. (point 6) Find the node potential v_1 and v_2 in terms of V, I, R.



$$\boxed{\mathbf{v_1} = \frac{1}{2}(V - IR) \quad \mathbf{v_2} = \frac{1}{2}(V + IR)}$$

v_1 : $\frac{v_1 - V}{R} + I + \frac{v_1}{R} = 0$

by KCL: $v_1 - V + I \cdot R + v_1 = 0$

$v_1 = \frac{1}{2}V - \frac{1}{2}I \cdot R \cdots ①$

v_2 : $\frac{v_2 - V}{R} - I + \frac{v_2}{R} = 0$

$v_2 - V - RI + v_2 = 0$

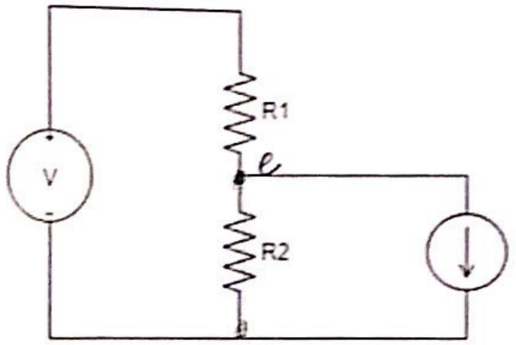
$v_2 = \frac{1}{2}V + \frac{1}{2}IR \cdots ②$

CamScanner로 스캔하기

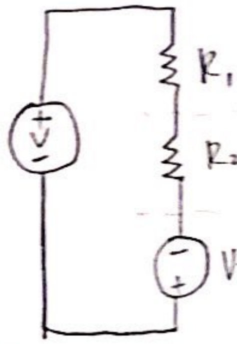
$$+\ V \ - \ \frac{(V-IR_1)^2 \cdot R_2^2}{(R_1+R_2)^2} \quad \therefore V = V + IR_2$$

1-15. (point 8) Answer the following questions.

$$\rightarrow i = \frac{V+IR_2}{R_1+R_2}$$



$\Longleftrightarrow$

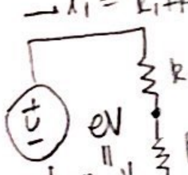


$$\overset{+}{\underset{-}{V}} = (V+IR_1)\cdot\frac{R_2}{R_1+R_2}$$

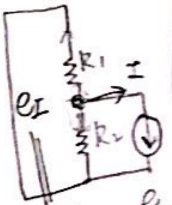
(a) Calculate the power consumption in R2. (Hint : Use superposition method to find a voltage drop between each end of R2.)

$$\rightarrow i_1 = \frac{V}{R_1+R_2}$$

i)



$$e_V = \boxed{\frac{R_2 \cdot V}{R_1+R_2}}$$



$$\boxed{\frac{(V-IR_1)^2}{(R_1+R_2)^2}\cdot R_2}$$

$$e = \frac{V-R_1R_2I}{R_1+R_2}$$

$$\frac{1}{R_2}\cdot\frac{(V-R_1\cdot R_2 I)^2}{(R_1+R_2)^2}$$

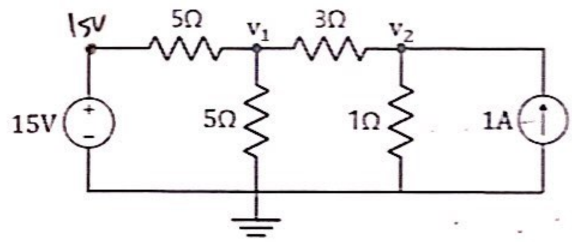
$$\frac{e}{R_1}+\frac{e}{R_2}+I=0 \qquad e\left(\frac{1}{R_1}+\frac{1}{R_2}\right) = -I$$

$$e_I = -\frac{R_1\cdot R_2}{R_1+R_2}I$$

(b) Is it possible to make R2 consume negative power by changing V and I?

$\boxed{\text{No.}}$ ∵ the only variable that include V & I is always positive value

1-16. (point 6) Find the node potential v_1, v_2 in the following figure using node analysis.



$$\text{at } V_1: \frac{V_1-15}{5}+\frac{V_1}{5}+\frac{V_1-V_2}{3}=0$$

$$3(V_1-15)+3V_1+5(V_1-V_2)=0$$

$$11V_1 = 5V_2+45 \ \cdots ①$$

$$\text{at } V_2: \frac{V_2-V_1}{3}+V_2-1=0.$$

$$V_2-V_1+3V_2-3=0.$$

$$V_1 = 4V_2-3 \ \cdots ②$$

$\mathbf{v_1} = \boxed{5V}$ $\mathbf{v_2} = \boxed{2V}$

$$\text{Node } V_1: \frac{V_1-15}{5}+\frac{V_1}{5}+\frac{V_1-V_2}{3}=0.$$

$$3(V_1-15)+3V_1+5(V_1-V_2)=0$$

$$\boxed{11V_1 = 5V_2+45}$$

$$\Rightarrow 44V_2-33 = 5V_2+45 \qquad ②\times 11 = ①: 44V_2-33 = 5V_2+45$$

$$39V_2 = 78.$$

$$39V_2 = 78.$$

$$V_2 = 2V \qquad \therefore V_1 = 5V \qquad \begin{pmatrix} V_2 = 2 \\ V_1 = 5 \end{pmatrix}$$

$$\text{Node } V_2: \frac{V_2-V_1}{3}+V_2-1=0 \qquad \times 11$$

$$V_2-V_1+3V_2-3=0$$

$$\boxed{V_1 = 4V_2-3}$$