MAE 140 - HWk 1

1.18 1.5-V AA battery delivers 40 kJ of energy
application draws 10mA continuously.
time the battery will last = ?

$P = V \cdot I \qquad P = \frac{dW}{dt}$

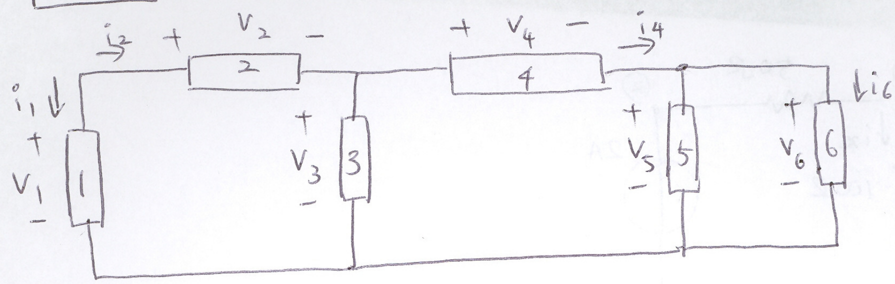
$P = 1.5(10mA)$
$= 15mW$

$E = 40kJ$

$P = \frac{dW}{dt} \cong \frac{\Delta W}{\Delta t} \Longrightarrow t = \frac{W}{P} = \frac{40kJ}{15mW} = 2.67 \times 10^6 \, s$

$\Longrightarrow \boxed{t = 2.67 \times 10^6 \, s}$

$\boxed{1.23}$



Analysis

	Device 1	Device 2	Device 3	Device 4	Device 5	Device 6
v	20V	?	?	?	?	?
i	−2A	?	?	1A	?	?
p	?	20W	10W	?	2.5W	2.5W

Using $p = vi$,

$P_1 = V_1 i_1 = (20V)(-2A) = -40W$ → Device 1 delivers power

Power balance : $P_1 + P_2 + P_3 + P_4 + P_5 + P_6 = 0$

$-40 + 20 + 10 + P_4 + 2.5 + 2.5 = 0$

$\therefore P_4 = 5W$ → $\boxed{\text{Device 4 absorbs power}}$

$V_4 = P_4 / i_4 = (5W)/(1A) = \boxed{5V}$

1.28) $W = \int_{0}^{Q} v\,dq$

$W \downarrow$ Energy stored in capacitor

$q(t) = 10^{-7} v(t)$ and $v(t) = 10(1 - e^{-5000t})$

$\Rightarrow q(t) = 10^{-7}(10(1 - e^{-5000t}))$

$= 10^{-6}(1 - e^{-5000t})$

Then $\frac{dq}{dt} = +5 \cdot 10^{-3} e^{-5000t} \Rightarrow dq = 5\times10^{-3} e^{-5000t} dt$

Substitute V(t) and dq in to energy equation

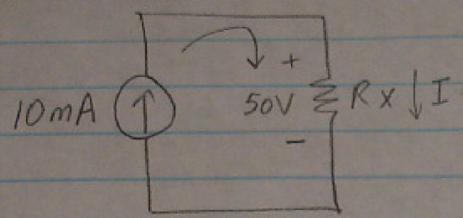
$$W = \int_{0}^{200\mu s} \underbrace{\left[10(1 - e^{-5000t})\right]}_{v(t)} \underbrace{\left[5\times10^{-3} \cdot e^{-5000t}\right] dt}_{dq}$$

Take the integral and consider that $200\,\mu s = 2\times10^{-4} s$

$$W = -10^{-5} e^{-5000t} + 0.5\times10^{-5} e^{-10000t} \Big|_{0}^{2\times10^{-4} s}$$

$$W = -3\times10^{-6} J + 5\times10^{-6} J = 2\times10^{-6} J$$

2.5) In figure, find Rx and the power delivered to the resistor



$V = I R_x$

$R_x = \dfrac{V}{I} = \dfrac{50V}{10mA} = 5k\Omega$

$P = V \cdot I = 50V(10mA)$

$\boxed{P = 500mW}$

$\boxed{2.8}$

R: $10\Omega \sim 100M\Omega$

maximum rating for voltage : $V_{max} = 500V$

" " " power : $P_{max} = \frac{1}{4}W$

Show that the voltage rating is the controlling limit for $R > 1M\Omega$ and the power rating is the controlling limit when $R < 1M\Omega$.

Analysis

For $R > 1M\Omega$,

$$\because P = \frac{V^2}{R},$$

maximum power occurs when V is at maximum and R is at minimum

$$\therefore P = \frac{V_{max}^2}{10^6\Omega} = \frac{(500V)^2}{(10^6\Omega)} = \frac{1}{4}W = \text{max. rating for power.}$$

$\therefore$ voltage rating is the controlling limit
(i.e. P will always be smaller than $\frac{1}{4}W$ if a smaller value for V and/or a larger value for R is used)

For $R < 1M\Omega$,

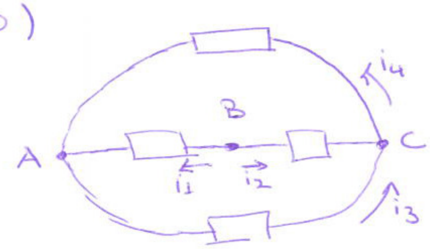
$$\because V = \sqrt{RP}$$

maximum voltage occurs maximum values for R and P are used.

$$\therefore V = \sqrt{(10^6\Omega)(\tfrac{1}{4}W)} = 500V = \text{max. rating for voltage}$$

$\therefore$ Power rating is the controlling limit (i.e. V will always be smaller if a smaller value for R and/or a smaller value for P is used).

2.10)



Let apply KCL

Node A: $i_1 + i_4 - i_3 = 0$

Node B: $-i_1 - i_2 = 0$

Node C: $i_3 + i_2 - i_4 = 0$

$i_2 = 2A$

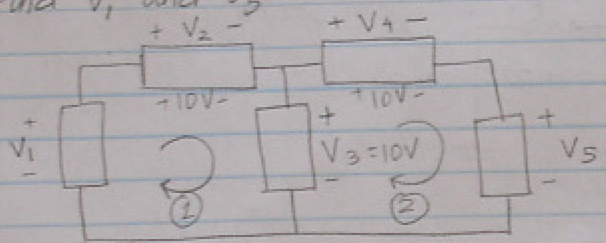
$i_3 = -5A$

From Node B $\quad \underline{i_1 = -i_2 = -2A}$

From Node C $\quad \underline{i_4 = i_3 + i_2 = -3A}$

Check Node A $\quad -2A - 3A - (-5A) = 0$ ✓

2.16 In the figure, $V_2 = 10V$, $V_3 = 10V$, and $V_4 = 10V$. Find V_1 and V_5



$V_2 = 10$

Loop 1 Applying KVL

$V_1 - V_2 - V_3 = 0$

$V_1 = V_2 + V_3$

$V_1 = 10V + 10V$

$\boxed{V_1 = 20V}$

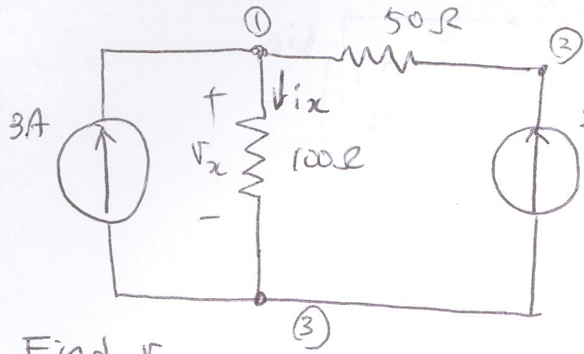
loop 2 Applying KVL

$V_3 - V_4 - V_5 = 0$

$10V - 10V = V_5$

$\boxed{V_5 = 0V}$

2.23



Find v_x.

Analysis

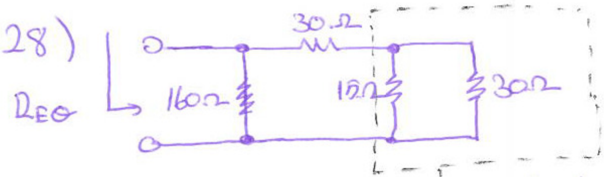
KCL at node 1:

$$3 + 2 = i_x$$

$$i_x = 5\,A$$

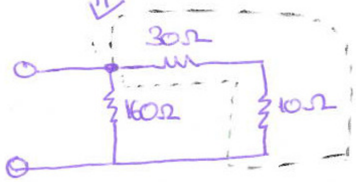
$$V_x = 100\,\Omega \cdot i_x = (100\,\Omega)(5\,A) = \underline{\underline{500\,V}}$$

2.28)



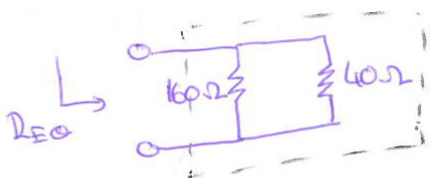
$$R_{EQ_1} = \left(\frac{1}{15} + \frac{1}{30}\right)^{-1} = 10\,\Omega \text{ (parallel)}$$

⇓



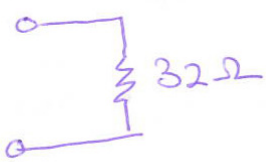
$$R_{EQ_2} = (30 + 10)\,\Omega = 40\,\Omega \text{ (series)}$$

⇓

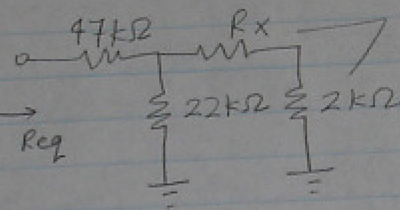


$$R_{EQ} = \left(\frac{1}{160} + \frac{1}{40}\right)^{-1} = \underline{\underline{32\,\Omega}} \text{ (Parallel)}$$

⇓



2.36 Select the value of R_x in figure so that $R_{eq} = 60k\Omega$



in series w/ each other

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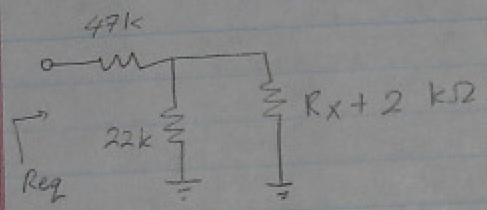

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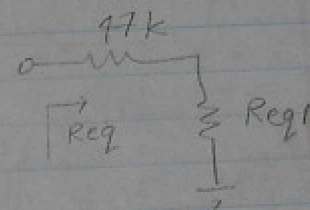

$$R_{eq1} = \frac{(22k)(R_x + 2k\Omega)}{22k + R_x + 2k}$$

... ($R_x + 2k\Omega$ and 22k are parallel to each other)

$$R_{eq} = 60k = R_{eq1} + 47k$$

$$13k = \frac{22k\,R_x + 44\times10^6\,\Omega}{R_x + 24k}$$

$$13k(R_x + 24k) = 22k\,R_x + 44\times10^6\,\Omega$$

$$13k\,R_x + 312\times10^6 = 22k\,R_x + 44\times10^6\,\Omega$$

$$268\times10^6\,\Omega = 9k\,R_x$$

$$R_x = 29.78\,k\Omega$$