MAE 140 fall 2014

Homework 1 solution

1.12 1.17 1.23 2.2 2.5 2.10 2.13 2.17 2.24 2.27

$\boxed{1.12}$ given: $q(t) = 1 - e^{-1000t}$ μC

Question: How long will it take the current to reach $200\,\mu A$?

$$i = \frac{dq}{dt} = \frac{d}{dt}\left(1 - e^{-1000t}\right) = 1000e^{-1000t} = 200$$

$$e^{-1000t} = \frac{1}{5}$$

using $a^N = b \iff \log_a b = N$ we obtain

$$-1000t = \log_e \frac{1}{5}$$

$$-1000t = \ln\frac{1}{5}$$

$$t = -\frac{\ln\frac{1}{5}}{1000} = \boxed{0.0016\ s}$$

$\boxed{1.17}$ given: $i = e^v - 10\,A$ (photocell)

For $v = -2$, 2 and 3 find the device power and state whether or not it is absorbing or delivering power

$$p = iv$$

for $v = -2$: $p = (e^{(-2)} - 10)(-2) =$ 19.73 W absorbing

for $v = 2$: $p = (e^{(+2)} - 10) \cdot 2 =$ − 5.22 W delivering

for $v = 3$: $p = (e^{(+3)} - 10) \cdot 3 =$ 30.26 W absorbing

1.23

Device	1	2	3	4	5	6
voltage v [V]	20			?		
current i [A]	-2			1		
power p [W]	?	20	10	?	2,5	2,5

$p_1 = v_1 \cdot i_1 = 20V \cdot (-2A) = -40\,W$

$\sum_{i=1}^{6} p_i = 0 \quad \rightarrow p_4 = 5W = \boxed{\text{absorbing}}$

$p = v \cdot i \quad \rightarrow v_4 = \frac{p_4}{i_4} = \frac{5W}{1A} = \boxed{5V}$

2.2 given: $V = 6.23V$; $i = 2.75mA$

$R = \frac{V}{i} = \frac{6.23V}{0.00275A} = \boxed{2265.5\,\Omega}$

$\rightarrow$ standard value: $\boxed{2200\Omega \pm 5\%}$

2.5 given: $V = 15V$; $p_x = 25mW$

$p = vi = \frac{V^2}{R} \quad \rightarrow R_x = \frac{V^2}{p_x} = \frac{15^2\,V^2}{0.025\,VA} = \boxed{9\,k\Omega}$

2.10 given: $R = 10\Omega \ldots 100\,M\Omega$

$V_{max} = 500V$; $P_{max} = 0.25\,W$

$$p = vi = \frac{v^2}{R} \quad \rightarrow \quad R = \frac{v^2}{p}$$

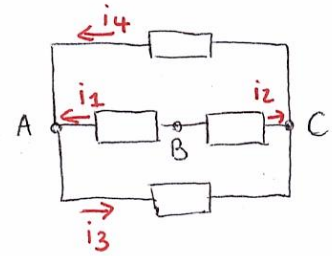
Substituting $v = v_{max} = 500V$ and $p = p_{max} = 0.25\,W$ we obtain

$$R = \frac{500^2}{0.25}\frac{V^2}{VA} = 10^6\frac{V}{A} = 1\,M\Omega$$

Since $R \sim v$ *and* $R \sim \frac{1}{p}$ it follows that

- Voltage is the limiting factor for $R > 10^6\Omega$
- Power is the limiting factor for $R < 10^6\Omega$

2.13



node B: $-i_1 - i_2 = 0$ so $\boxed{i_1 = 5\,A}$

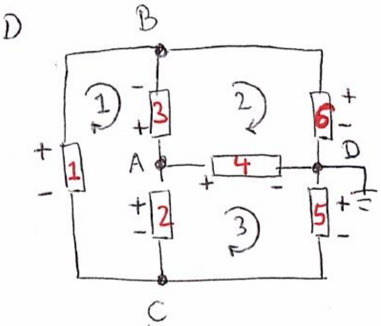
node A: $i_1 + i_4 - i_3 = 0$

$\rightarrow i_4 = i_3 - i_1 = 2A - 5A = \boxed{-3A}$

given: $i_2 = -5A$
$i_3 = 2A$

2.17 a) Identify nodes: Nodes A, B, C and D

Identify loops: elements 2-4-5
elements 3-4-6
elements 1-2-3
elements 1-5-6
elements 2-3-5-6

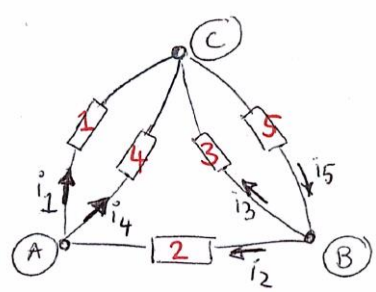


b) Elements in series: none
Elements in parallel: none

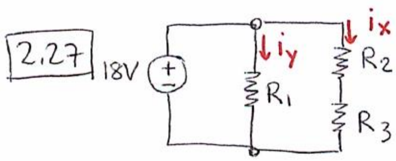
c) KCL: A $\quad -i_2 - i_3 - i_4 = 0$
B $\quad -i_1 + i_3 - i_6 = 0$
C $\quad i_1 + i_2 + i_5 = 0$
D $\quad i_4 - i_5 + i_6 = 0$

KVL: ① $-V_1 - V_3 + V_2 = 0$
② $V_3 + V_6 - V_4 = 0$
③ $-V_2 + V_4 + V_5 = 0$

2.24 A: $-i_1 + i_2 - i_4 = 0$
B: $-i_2 - i_3 + i_5 = 0$
C: $i_1 + i_3 + i_4 - i_5 = 0$



2.27



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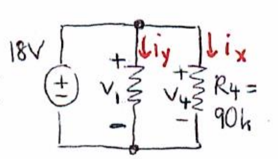

$R_1 = 33\,k\Omega$
$R_2 = 22\,k\Omega$
$R_3 = 68\,k\Omega$

Note that $V_1 = V_4 = 18V$

Thus $i_x = \frac{V_4}{R_4} = \frac{18V}{90k}$

$i_x = \boxed{0.2\,mA}$

Hence $v_x = R_3 i_x \boxed{= 13.8\,V}$

- Comparison with 2.26

$i_x = \frac{V}{R_{total}} = \frac{18V}{22k + 68k} = 0.2mA$

$V_x = 68k\Omega \cdot i_x = 13.8\,V$ $\boxed{\text{same!}}$

- $i_y \neq 0$ because the voltage across the 33kΩ resistor is 18V!

- Effect of 33 kΩ resistor: Increases the current going through the independent source.