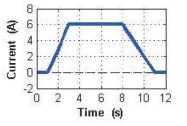
# BLM1612 - Circuit Theory

# Examples



## Example 01

- Given the following current graph through an element, what is the net charge that passes through the element between $t = 4$ and $t = 8$ seconds?




$$q = \int_{t_1}^{t_2} i dt = \int_4^8 6dt = 6t|_4^8 = 6(8-4) = 24\ \mathrm{C}$$

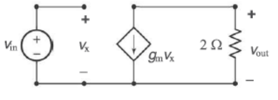
  – or for constant current

$$q = i \times \Delta t = 6(8-4) = 24\ \mathrm{C}$$



## Example 02

- In the circuit below, $v_{in}$=3sin($\omega t$) mV and $g_m$=10 A/V. Determine $v_{out}$.

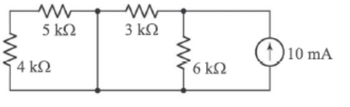



$$v_{out} = -g_m v_x \times R$$
$$v_{out} = -10 \times 3\sin(\omega t) \times 2$$
$$v_{out} = -60\sin(\omega t)\ \mathrm{mV}$$



## Example 03

- In the circuit below, determine the power absorbed by the 5 kΩ resistor.

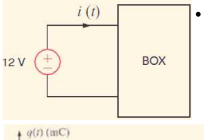



- Short circuit across 4 kΩ and 5 kΩ resistors.
  – No current through 5 kΩ resistor.
- Therefore

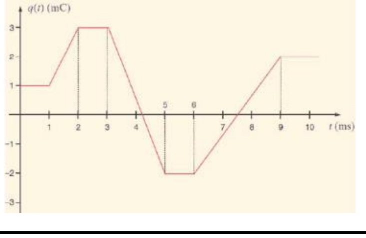
$$P_{abs} = 0\ \mathrm{W}$$



## Example 04…




- The charge that enters the BOX is given below. Calculate and sketch the current flowing into and the power absorbed by the BOX between 0 and 10 ms.




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

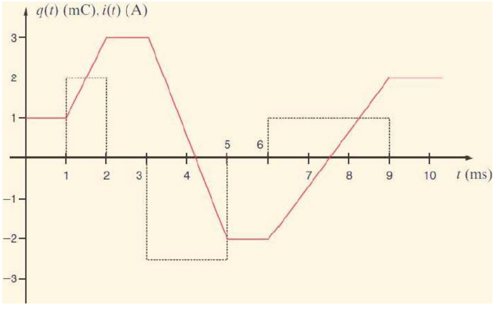


## …Example 04…

Recall that current is related to charge by $i(t) = \frac{dq(t)}{dt}$. The current is equal to the slope of the charge waveform.

| | |
|---|---|
| $i(t) = 0$ | $0 \le t \le 1$ ms |
| $i(t) = \frac{3\times10^{-3} - 1\times10^{-3}}{2\times10^{-3} - 1\times10^{-3}} = 2\mathrm{A}$ | $1 \le t \le 2$ ms |
| $i(t) = 0$ | $2 \le t \le 3$ ms |
| $i(t) = \frac{-2\times10^{-3} - 3\times10^{-3}}{5\times10^{-3} - 3\times10^{-3}} = -2.5\ \mathrm{A}$ | $3 \le t \le 5$ ms |
| $i(t) = 0$ | $5 \le t \le 6$ ms |
| $i(t) = \frac{2\times10^{-3} - (-2\times10^{-3})}{9\times10^{-3} - 6\times10^{-3}} = 1.33\ \mathrm{A}$ | $6 \le t \le 9$ ms |
| $i(t) = 0$ | $t \ge 9$ ms |

# …Example 04…

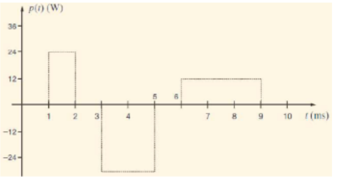





# …Example 04

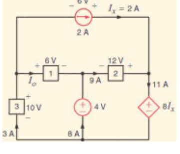
The power absorbed by the BOX is $12 \cdot i(t)$.

$$
\begin{aligned}
p(t) &= 12{*}0 = 0 && 0 \le t \le 1 \text{ ms}\\
p(t) &= 12{*}2 = 24 \text{ W} && 1 \le t \le 2 \text{ ms}\\
p(t) &= 12{*}0 = 0 && 2 \le t \le 3 \text{ ms}\\
p(t) &= 12{*}(-2.5) = -30 \text{ W} && 3 \le t \le 5 \text{ ms}\\
p(t) &= 12{*}0 = 0 && 5 \le t \le 6 \text{ ms}\\
p(t) &- 12{*}1.33 - 16 \text{ W} && 6 \le t \le 9 \text{ ms}\\
p(t) &= 12{*}0 = 0 && t \ge 9 \text{ ms}
\end{aligned}
$$






# Example 05




- Use Tellegen's theorem to find the current $I_O$ in the network below.

$$
\begin{aligned}
P_{2\,\text{A}} &= (6)(-2) = -12 \text{ W}\\
P_1 &= (6)(I_o) = 6I_o \text{ W}\\
P_2 &= (12)(-9) = -108 \text{ W}\\
P_3 &= (10)(-3) = -30 \text{ W}\\
P_{4\,\text{V}} &= (4)(-8) = -32 \text{ W}\\
P_{DS} &= (8I_x)(11) = (16)(11) = 176 \text{ W}
\end{aligned}
$$

Applying Tellegen's theorem yields

$$-12 + 6I_o - 108 - 30 - 32 + 176 = 0$$

or

$$6I_o + 176 = 12 + 108 + 30 + 32$$

Hence,

$$I_o = 1\text{A}$$