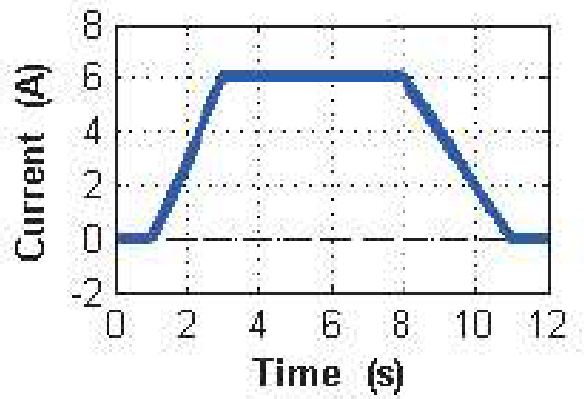
BLM1612 - Circuit Theory

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?



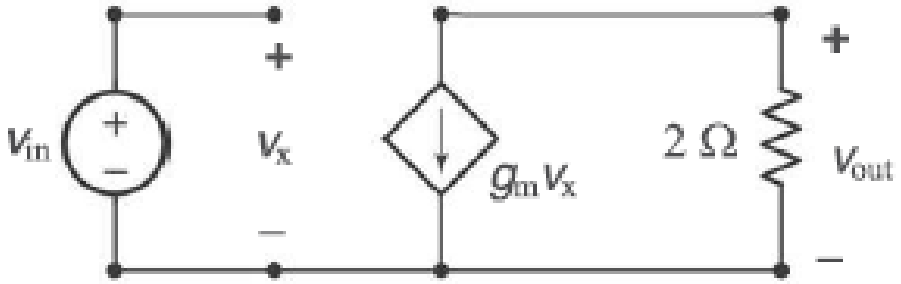
$$q = \int_{t_1}^{t_2} i dt = \int_4^8 6 dt = 6t|_4^8 = 6(8-4) = 24 \text{ C}$$

  - or for constant current

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

Example 02

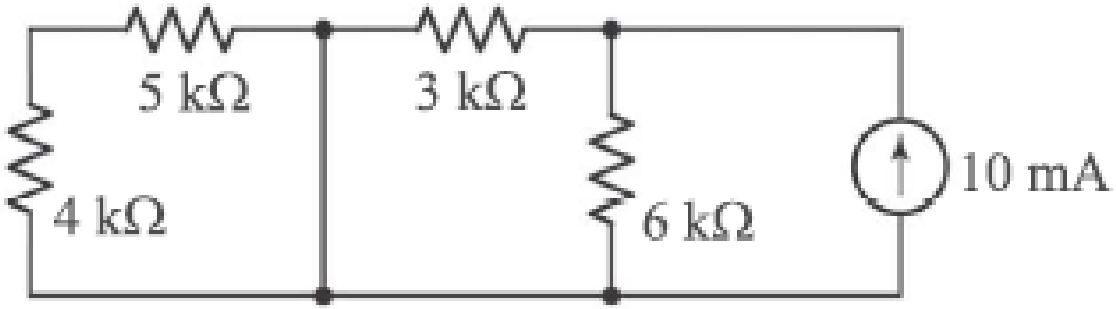
- In the circuit below, v_{in}=3sin(ωt) mV and g_m=10 A/V. Determine v_{out}.



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

Example 03

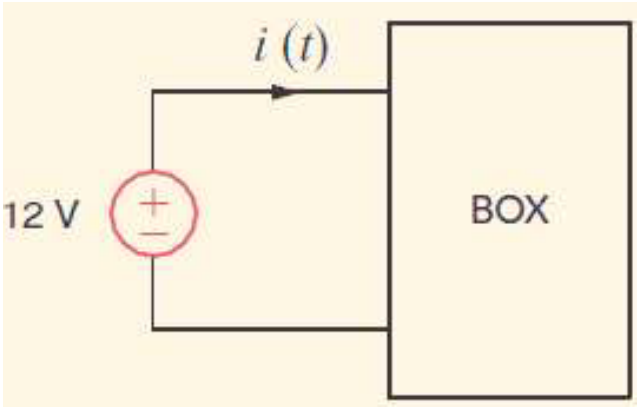
- In the circuit below, determine the power absorbed by the 5 kΩ resistor.



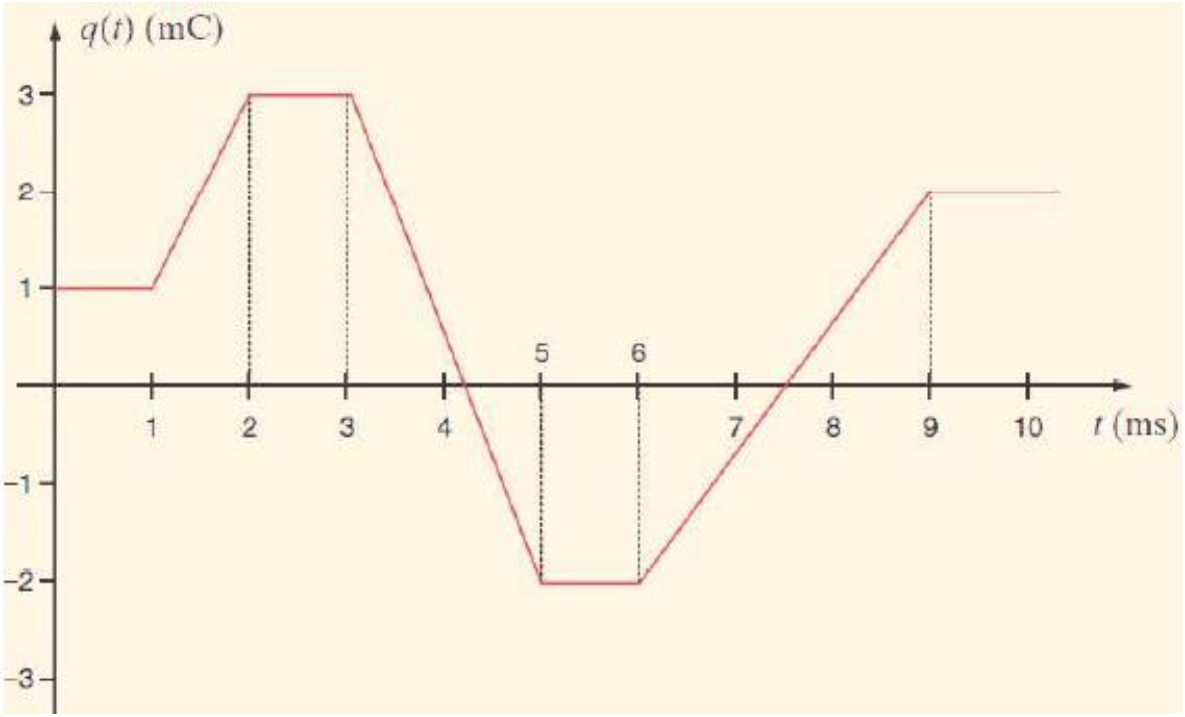
- Short circuit across 4 kΩ and 5 kΩ resistors.
  - No current through 5 kΩ resistor.
- Therefore

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

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 $i(t) = \dfrac{dq(t)}{dt}$. The current is equal to the slope of the charge waveform.

$$i(t) = 0 \qquad 0 \le t \le 1\ \text{ms}$$

$$i(t) = \frac{3 \times 10^{-3} - 1 \times 10^{-3}}{2 \times 10^{-3} - 1 \times 10^{-3}} = 2\text{A} \qquad 1 \le t \le 2\ \text{ms}$$

$$i(t) = 0 \qquad 2 \le t \le 3\ \text{ms}$$

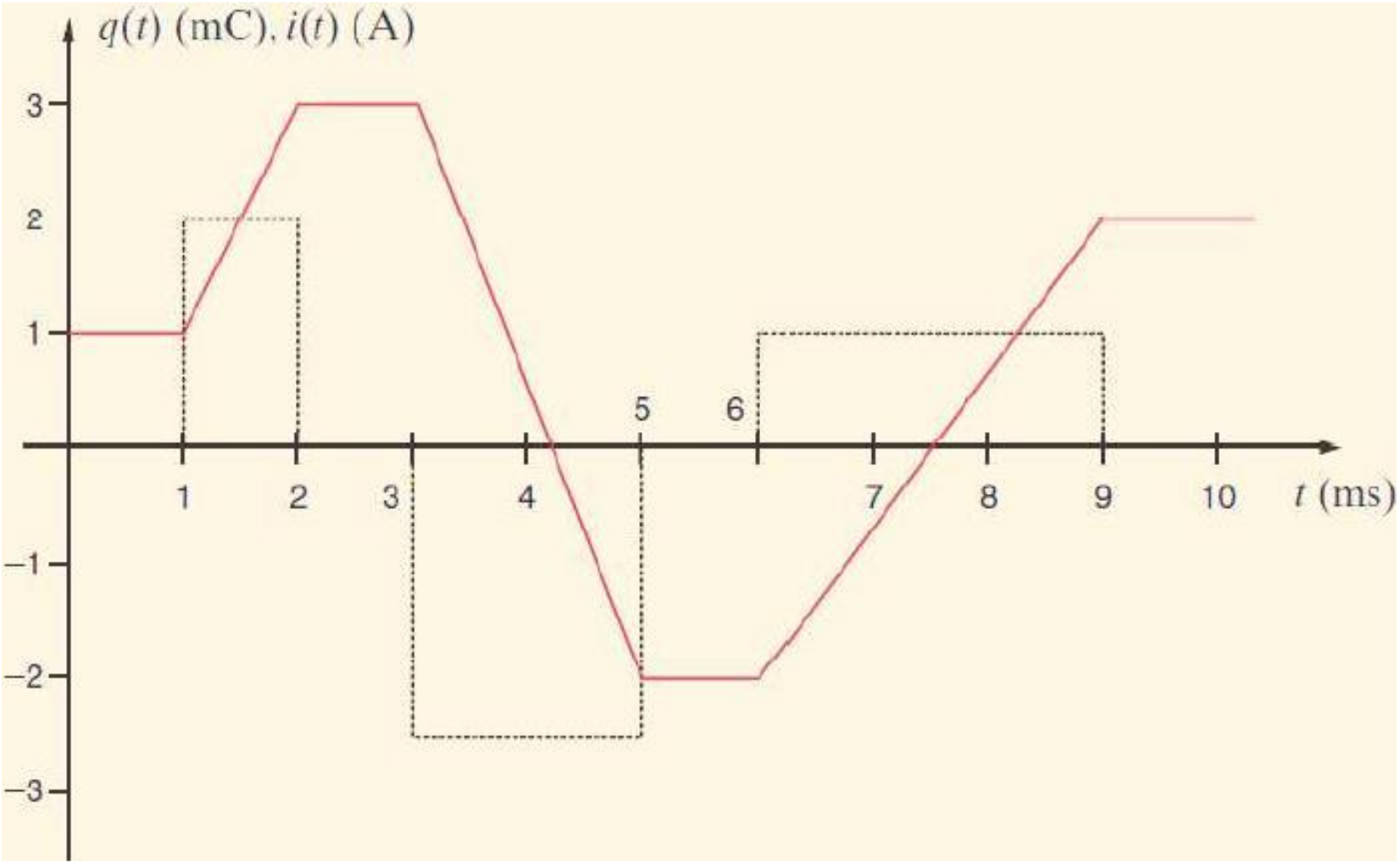
$$i(t) = \frac{-2 \times 10^{-3} - 3 \times 10^{-3}}{5 \times 10^{-3} - 3 \times 10^{-3}} = -2.5\ \text{A} \qquad 3 \le t \le 5\ \text{ms}$$

$$i(t) = 0 \qquad 5 \le t \le 6\ \text{ms}$$

$$i(t) = \frac{2 \times 10^{-3} - (-2 \times 10^{-3})}{9 \times 10^{-3} - 6 \times 10^{-3}} = 1.33\ \text{A} \qquad 6 \le t \le 9\ \text{ms}$$

$$i(t) = 0 \qquad t \ge 9\ \text{ms}$$

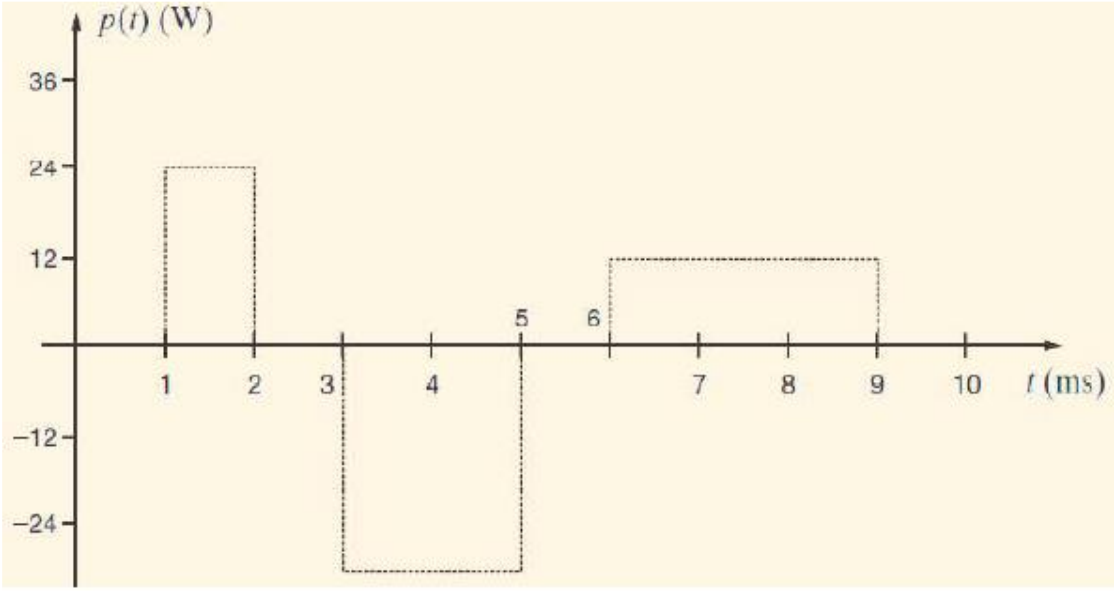
…Example 04…



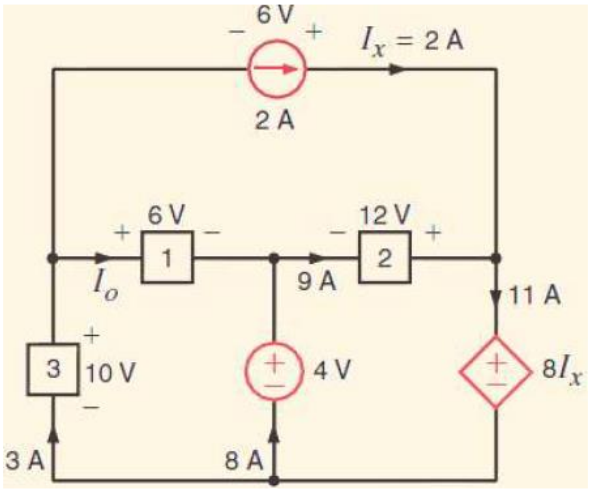
…Example 04

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

$p(t) = 12*0 = 0$	$0 \le t \le 1$ ms
$p(t) = 12*2 = 24$ W	$1 \le t \le 2$ ms
$p(t) = 12*0 = 0$	$2 \le t \le 3$ ms
$p(t) = 12*(-2.5) = -30$ W	$3 \le t \le 5$ ms
$p(t) = 12*0 = 0$	$5 \le t \le 6$ ms
$p(t) - 12*1.33 - 16$ W	$6 \le t \le 9$ ms
$p(t) = 12*0 = 0$	$t \ge 9$ ms



Example 05



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

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

Applying Tellegen's theorem yields

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

or

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

Hence,

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