1.

An ideal voltage source has a value of:

$$v(t) = 10e^{-t} \quad \text{V}$$

What is the value of this voltage source when:

(a) $t = 0\,\text{s}$, (b) $t = 1\,\text{s}$, (c) $t = 2\,\text{s}$, (d) $t = 3\,\text{s}$, (e) $t = 4\,\text{s}$

Solutions:

An ideal voltage source has a value of:

$$v(t) = 10e^{-t}$$

What is the value of this voltage source when:

(a) $t = 0s$, (b) $t = 1s$, (c) $t = 2s$, (d) $t = 3s$, (e) $t = 4s$

Solution

(a) $t = 0s$
Substituting $t = 0$ into $v(t) = 10e^{-t}$,

$$v(0) = 10e^{-0}$$
$$v(0) = 10 \times 1$$
$$v(0) = 10 \text{ V}$$

(b) $t = 1s$
Substituting $t = 1$ into $v(t) = 10e^{-t}$,

$$v(1) = 10e^{-1}$$
$$v(1) = 10 \times 0.3678...$$
$$v(1) = 3.68 \text{ V}$$

(c) $t = 2s$
Substituting $t = 2$ into $v(t) = 10e^{-t}$,

$$
\begin{aligned}
v(2) &= 10e^{-2} \\
v(2) &= 10 \times 0.1353... \\
v(2) &= 1.35 \text{ V}
\end{aligned}
$$

(d) $t = 3s$
Substituting $t = 3$ into $v(t) = 10e^{-t}$,

$$
\begin{aligned}
v(3) &= 10e^{-3} \\
v(3) &= 10 \times 0.0498... \\
v(3) &= 0.498 \text{ V}
\end{aligned}
$$

(e) $t = 4s$
Substituting $t = 4$ into $v(t) = 10e^{-t}$,

$$
\begin{aligned}
v(4) &= 10e^{-4} \\
v(4) &= 10 \times 0.0183... \\
v(4) &= 0.183 \text{ V}
\end{aligned}
$$

2.

The total charge in some material is described by the function:

$$q(t) = 4e^{-2t} \quad \text{C}$$

Find the current through this material.

Solution

Applying the definition of current:

$$\begin{aligned} i &= \frac{dq}{dt} \\ &= \frac{d}{dt} 4e^{-2t} \\ &= -8e^{-2t} \text{ A} \end{aligned}$$

3.

The total charge in some material is described by the function:

$$q(t) = 3\sin(\pi t) \quad \text{C}$$

Find the current through this material.

Solution

Applying the definition of current:

$$\begin{aligned} i &= \frac{dq}{dt} \\ &= \frac{d}{dt} 3\sin(\pi t) \\ &= 3\pi \cos(\pi t) \text{ A} \end{aligned}$$

4.

The total charge in some material is described by the function:

$$q(t) = 6\cos(2\pi t) \quad \text{C}$$

Find the current through this material.

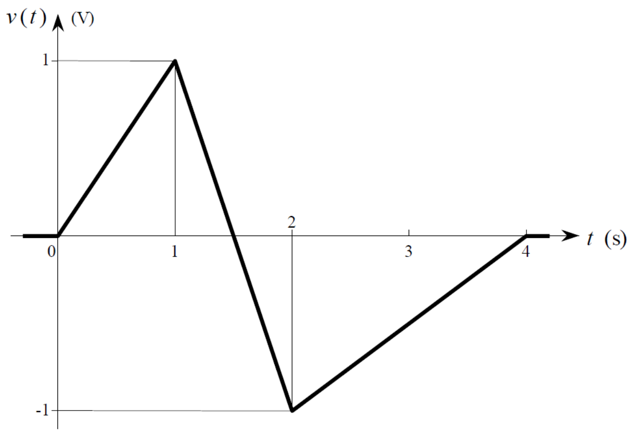
Solution

Applying the definition of current:

$$\begin{aligned} i &= \frac{dq}{dt} \\ &= \frac{d}{dt} 6\cos(2\pi t) \\ &= -12\pi \sin(2\pi t)\,\text{A} \end{aligned}$$

5.

An ideal voltage source is described by the function shown below:

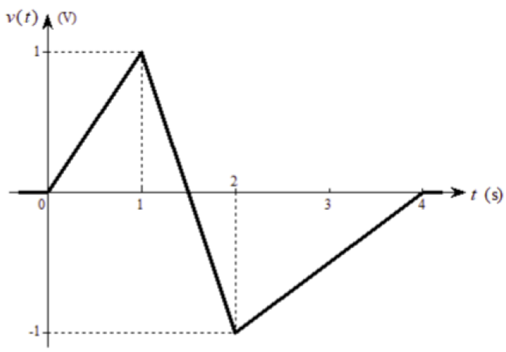


What is the value of this voltage source when:

(a) $t = 0\,\text{s}$, (b) $t = 1\,\text{s}$, (c) $t = 2\,\text{s}$, (d) $t = 3\,\text{s}$, (e) $t = 4\,\text{s}$

Solution:

An ideal voltage source is described by the function shown below:



What is the value of this voltage source when:

(a) $t = 0\,\text{s}$, (b) $t = 1\,\text{s}$, (c) $t = 2\,\text{s}$, (d) $t = 3\,\text{s}$, (e) $t = 4\,\text{s}$

The voltage produced by an ideal voltage source will be a function of time represented symbolically as $v(t)$. Therefore, to determine the value of a ideal voltage source at a point in time you must first determine the function, $v(t)$. For questions (a) through (c) and (e) the voltages at the required time intervals are marked on the graph for us. However, for question (d) we require further information regarding the function at the point where $t = 3s$.

(a) $v(0) = 0V$

(b) $v(1) = 1V$

(c) $v(2) = -1V$

(d) To determine the voltage at $t = 3s$ we must first determine the equation of the function that encompasses the 3 second time interval. From the graph we can see that this segment is a straight line between the points;

$$p_1 = (2, -1),\ p_2 = (4, 0)$$

The equation of the straight line can be determined by using these two points by;

$$g(t) = \frac{t - t_0}{T} \qquad (1)$$

Where: $T = \frac{1}{slope}$

$$v_{t_2 t_3}(t) = \frac{t-4}{\frac{4-2}{0-(-1)}} = \frac{t-4}{2} \qquad (2)$$

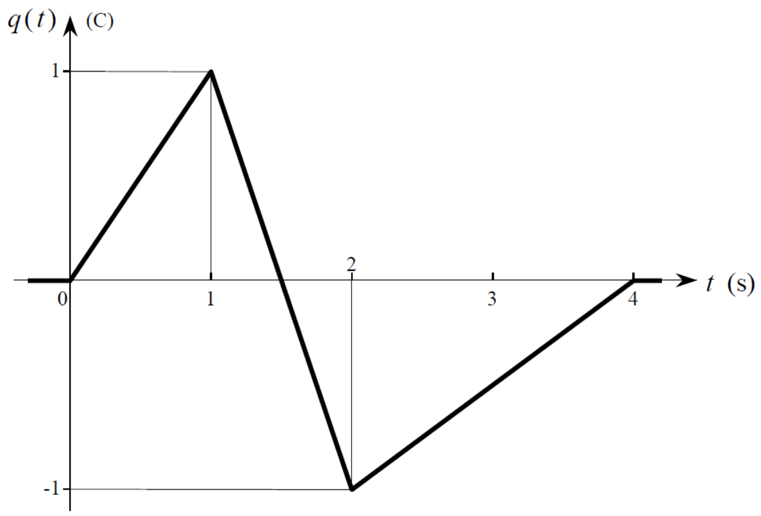
We can now use this equation to determine the value of the voltage source between 2s and 4s.

$$v_{t_2 t_3}(3) = \frac{3-4}{2} = -\frac{1}{2} \qquad (3)$$

(e) $v(4) = 0V$

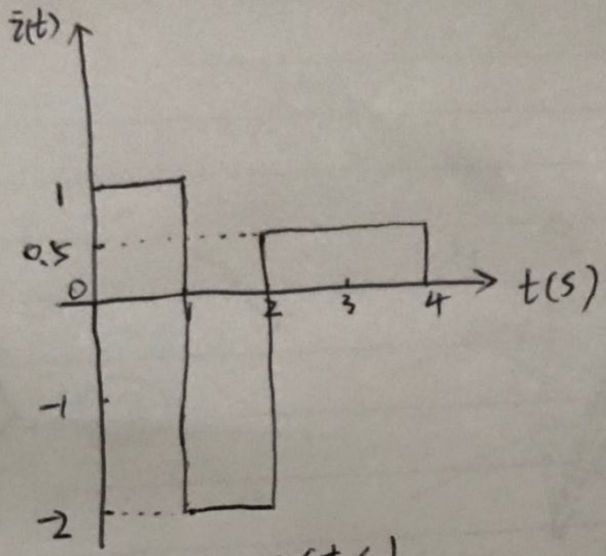
6.

The total charge $q(t)$ in some material is described by the function given below:



Sketch the current $i(t)$ through this material.

Solution:

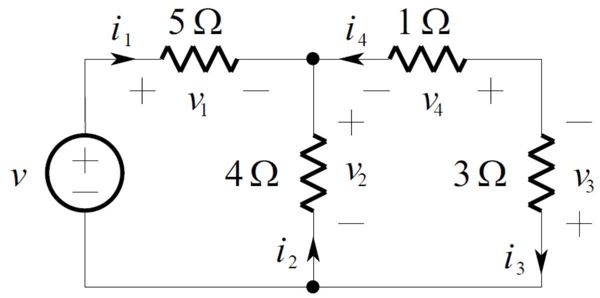


$$q(t)=\begin{cases} t, & 0<t<1 \\ -2t+3, & 1<t<2 \\ 0.5t-2, & 2<t<4 \end{cases}$$

$$\therefore\ i(t)=\frac{d\,q(t)}{dt}=\begin{cases} 1, & 0<t<1 \\ -2, & 1<t<2 \\ 0.5, & 2<t<4 \end{cases}$$

7.

Consider the circuit shown below:



(a) If $i_1 = 4\,\text{A}$, find v_1.

(b) If $i_2 = -2\,\text{A}$, find v_2.

(c) If $i_3 = 2\,\text{A}$, find v_3.

(d) If $i_4 = -2\,\text{A}$, find v_4.

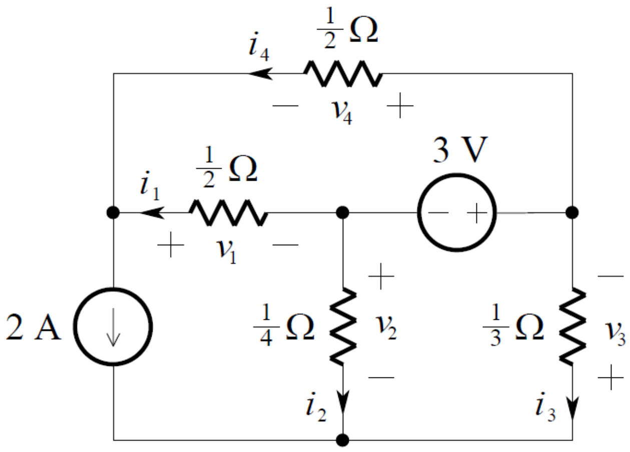
Solution:

Using Ohm's Law, V=I*R

(a) V1=4*5=20 v
(b) -V2=(-2)*4=-8v, V2= 8V
(c) -V3=2*3=6V, V3= -6V
(d) V4=(-2)*1=-2V

8.

Consider the circuit shown below:



(a) If $i_1 = -2$ A, find v_1.

(b) If $v_2 = -\frac{11}{7}$ V, find i_2.

(c) If $i_3 = \frac{30}{7}$ A, find v_3.

(d) If $v_4 = 2$ V, find i_4.

Solution:

$R_1 = 1/2\ \Omega$, (R at V_1)

$R_2 = 1/4\ \Omega$ (R at V_2)

$R_3 = 1/3\ \Omega$ (R at V_3)

$R_4 = 2\ \Omega$ (R at V_4)

a) If $i_1 = -2$ A, and $R_1 = 1/2\ \Omega$
Therefore using 'Ohms Law' we can determine the voltage at v_1:
$v = i \times R$ — Ohms Law
➔ $v_1 = -(i_1) \times R_1$ — Current is opposite direction to voltage so sign change (-) is needed
$v_1 = -(-2) \times (1/2)$ — Substitute in values for i_1 and R_1
$v_1 = 1$ V

b) If $v_2 = -11/7$ V, and $R_2 = 1/4\ \Omega$
Therefore, by rearranging 'Ohms Law' we can determine the current at i_2:
$v = i \times R$ ➔ $i = v / R$ — Ohms Law rearranged in terms of i
➔ $i_2 = v_2 / R_2$ — Current is in same direction as voltage
$i_2 = (-11/7) / (1/4)$ — Substitute in values of v_2 and R_2
$i_2 = -44/7$ A

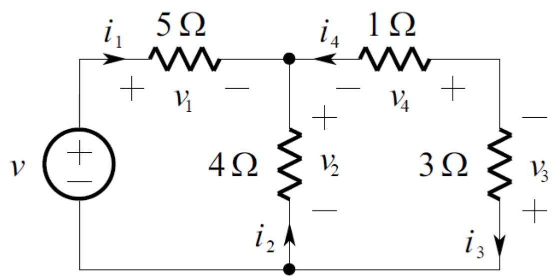
c) If i_3 = 30/7 A, and R_3 = 1/3 Ω
Therefore using 'Ohms Law' we can determine the voltage at v_3:
$v = i \times R$ Ohms Law
➔ $v_3 = -(i_3) \times R_3$ Current is opposite direction to voltage so sign change (-) is needed

v_3 = - (30/7) x (1/3) Substitute in values for i_3 and R_3
v_3 = -10/7 V

d) If v_4 = 2 V, and R_4 = 1/2 Ω
Therefore, by rearranging 'Ohms Law' we can determine the current at i_4:
$i = v / R$ from part b)
➔ $i_4 = v_4 / R_4$ Current is in same direction as voltage
i_4 = 2 / (1/2) Substitute in values of v_4 and R_4
i_4 = 4 A

9.

Consider the circuit shown below:



(a) Find $i_1(t)$ if $v_1(t) = 20\,\text{V}$.

(b) Find $i_2(t)$ if $v_2(t) = 3e^{-2t}\,\text{V}$.

(c) Find $v_3(t)$ if $i_3(t) = 6\sin(2t)\,\text{A}$.

(d) Find $v_4(t)$ if $i_4(t) = -e^{-t}\cos(5t)\,\text{A}$.

Solution:

(a) Noting that the current and voltage conform to the passive sign convention, we can apply Ohm's Law directly to give:

$$i_1(t) = \frac{v_1(t)}{R} = \frac{20}{5} = 4\,\text{A}$$

(b) Noting that the current and voltage **do not** conform to the passive sign convention, we will have to introduce a negative sign when applying Ohm's Law:

$$i_2(t) = -\frac{v_2(t)}{4} = -\frac{3}{4}e^{-2t}\,\text{A}.$$

(c) Noting that the current and voltage **do not** conform to the passive sign convention, we will have to introduce a negative sign when applying Ohm's Law:

$$v_3(t) = -Ri_3(t) = -3 \times 6\sin(2t) = -18\sin(2t)\,\text{V}$$

(d) Noting that the current and voltage conform to the passive sign convention, we can apply Ohm's Law directly to give:

$$v_4(t) = Ri_4(t) = 1 \times -e^{-t}\cos(5t) = -e^{-t}\cos(5t)\,\text{V}$$