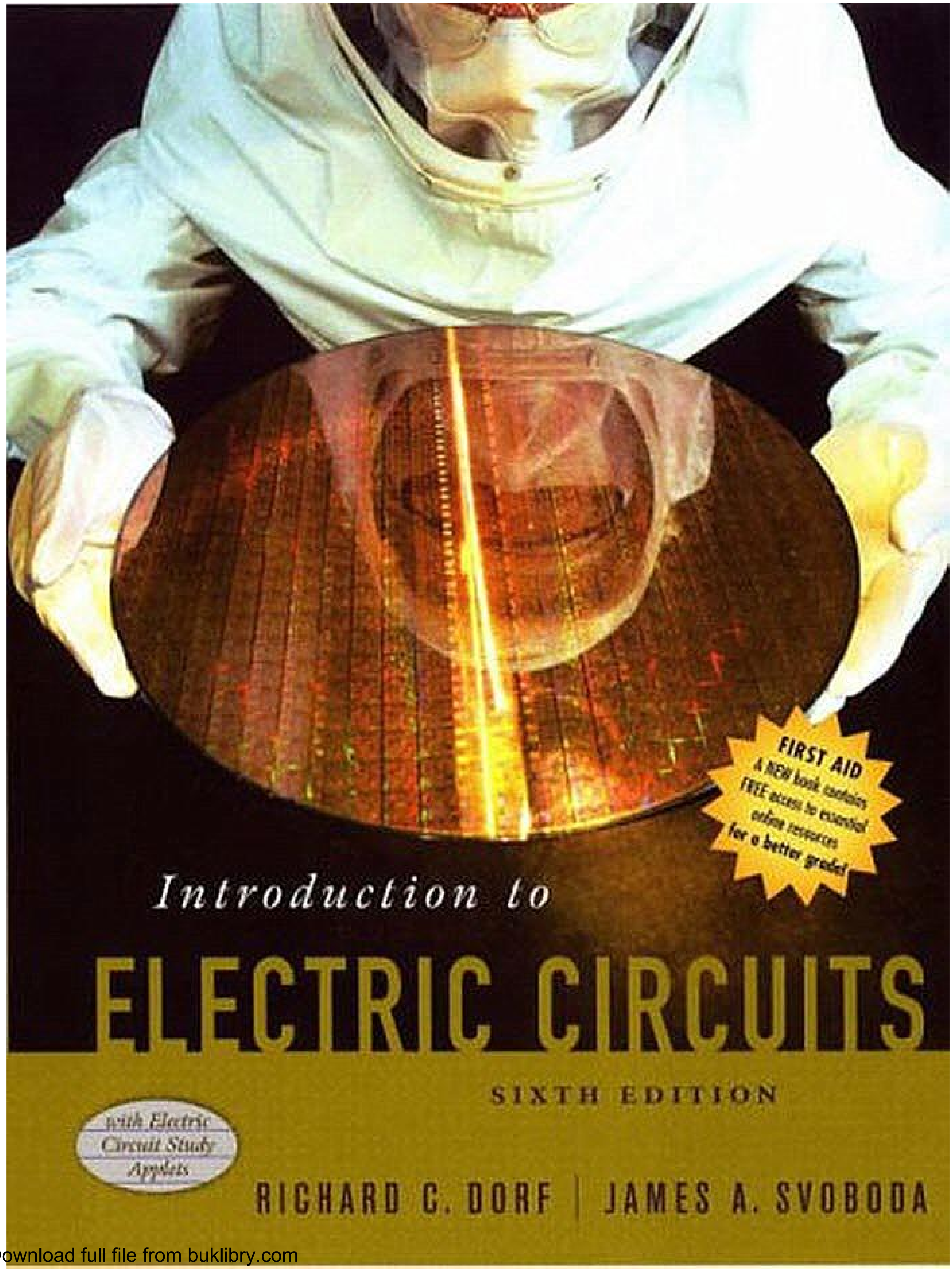
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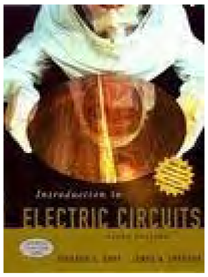
Introduction to
ELECTRIC CIRCUITS
SIXTH EDITION
with Electric
Circuit Study
Applets
RICHARD C. DORF | JAMES A. SVOBODA



Solution Manual

to accompany

Introduction to Electric Circuits, 6e

By R. C. Dorf and J. A. Svoboda

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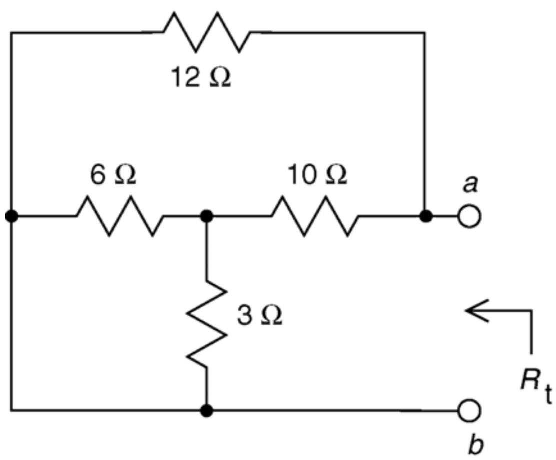
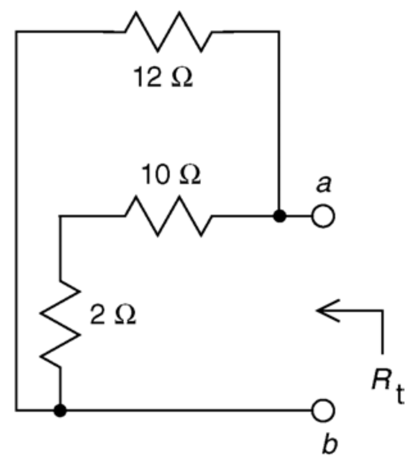
P5.5-4

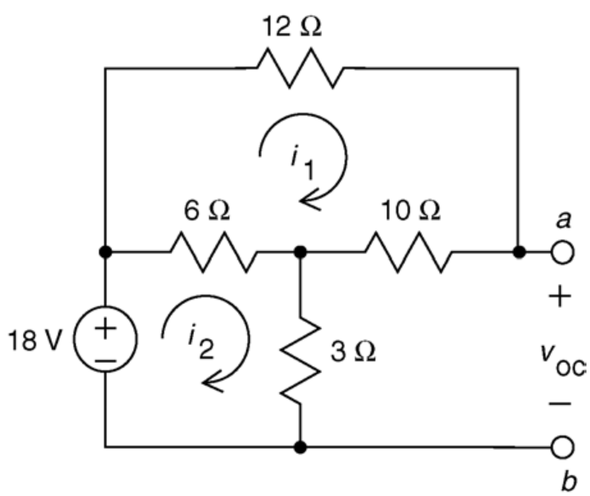
Find R_t:





$$R_t = \frac{12(10+2)}{12+(10+2)} = 6\ \Omega$$

Write mesh equations to find v_{oc}:



Mesh equations:

$$12\,i_1 + 10\,i_1 - 6\left(i_2 - i_1\right) = 0$$
$$6\left(i_2 - i_1\right) + 3\,i_2 - 18 = 0$$

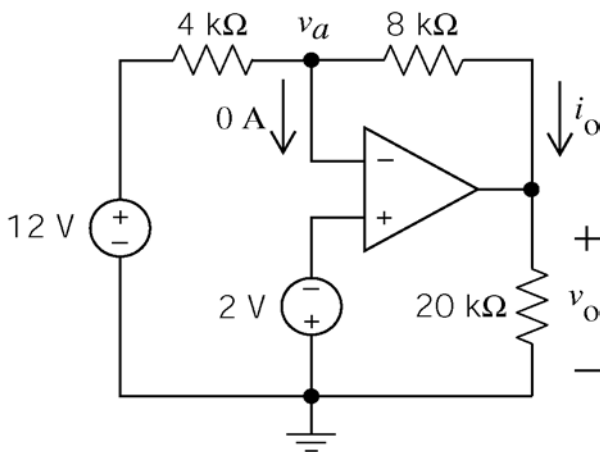
$$28\,i_1 = 6\,i_2$$
$$9\,i_2 - 6\,i_1 = 18$$

$$36\,i_1 = 18 \quad \Rightarrow \quad i_1 = \frac{1}{2}\ \text{A}$$
$$i_2 = \frac{14}{3}\left(\frac{1}{2}\right) = \frac{7}{3}\ \text{A}$$

Finally, $$v_{oc} = 3\,i_2 + 10\,i_1 = 3\left(\frac{7}{3}\right) + 10\left(\frac{1}{2}\right) = 12\ \text{V}$$

(checked using LNAP 8/15/02)

P6.4-3



The voltages at the input nodes of an ideal op amp are equal so $v_a = -2$ V.

Apply KCL at node *a*:

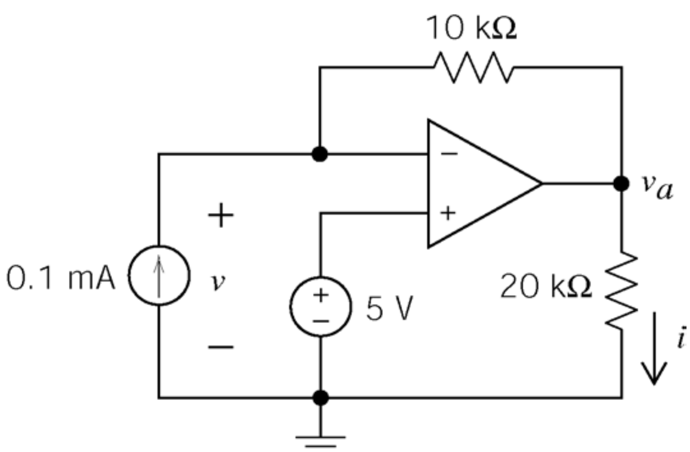
$$\frac{v_o - (-2)}{8000} + \frac{12 - (-2)}{4000} = 0 \quad \Rightarrow v_o = -30 \text{ V}$$

Apply Ohm's law to the 8 kΩ resistor

$$i_o = \frac{-2 - v_o}{8000} = 3.5 \text{ mA}$$

(checked using LNAP 8/16/02)

P6.4-4



The voltages at the input nodes of an ideal op amp are equal so $v = 5$ V.

Apply KCL at the inverting input node of the op amp:

$$-\left(\frac{v_a - 5}{10000}\right) - 0.1 \times 10^{-3} - 0 = 0 \quad \Rightarrow \quad v_a = 4 \text{ V}$$

Apply Ohm's law to the 20 kΩ resistor

$$i = \frac{v_a}{20000} = \frac{1}{5} \text{mA}$$

(checked using LNAP 8/16/02)

P6.4-5

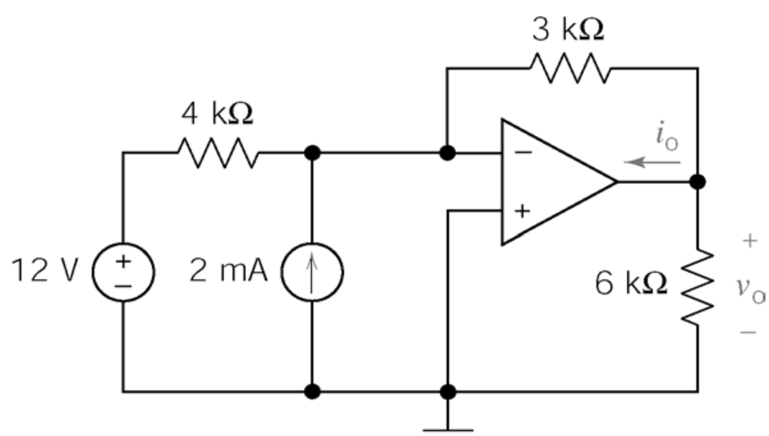
The voltages at the input nodes of an ideal op amp are equal so $v_a = 0$ V. Apply KCL at node *a*:

$$-\left(\frac{v_o - 0}{3000}\right) - \left(\frac{12 - 0}{4000}\right) - 2 \cdot 10^{-3} = 0$$

$$\Rightarrow v_o = -15 \text{ V}$$

Apply KCL at the output node of the op amp:

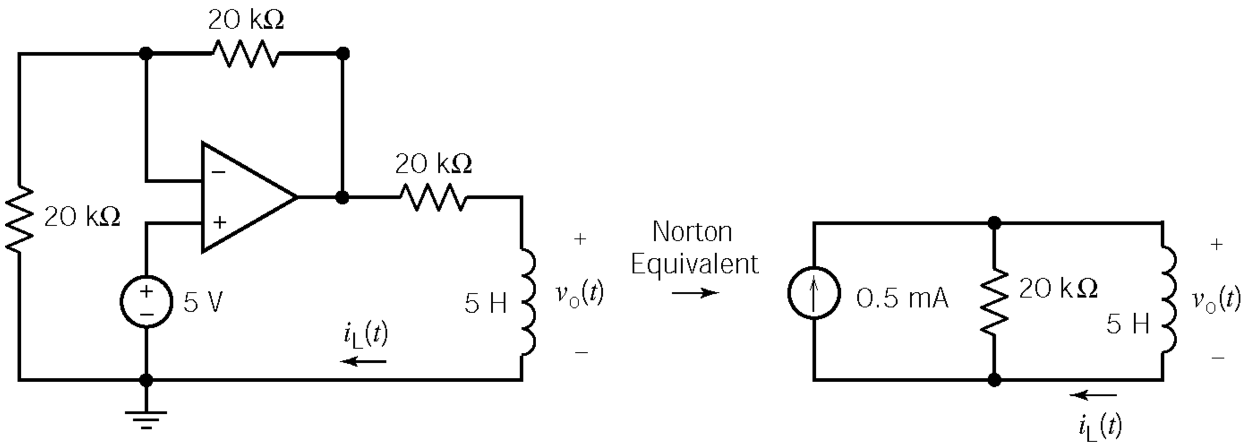
$$i_o + \frac{v_o}{6000} + \frac{v_o}{3000} = 0 \Rightarrow i_o = 7.5 \text{ mA}$$



(checked using LNAP 8/16/02)

P8.3-6

Before the switch opens, $v_o(t) = 5\text{ V} \Rightarrow v_o(0) = 5\text{ V}$. After the switch opens the part of the circuit connected to the capacitor can be replaced by it's Norton equivalent circuit to get:



Therefore $\tau = \dfrac{5}{20\times10^3} = 0.25\text{ ms}$.

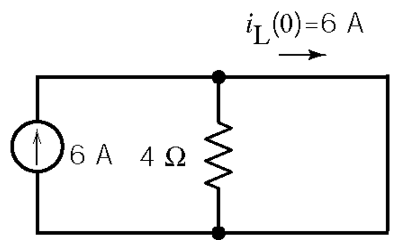
Next, $i_L(t) = i_{sc} + (i_L(0) - i_{sc})\, e^{-\frac{t}{\tau}} = 0.5 - 0.25\, e^{-4000t}\text{ mA}$ for $t > 0$

Finally, $v_o(t) = 5\dfrac{d}{dt} i_L(t) = 5\, e^{-4000t}\text{ V}$ for $t > 0$

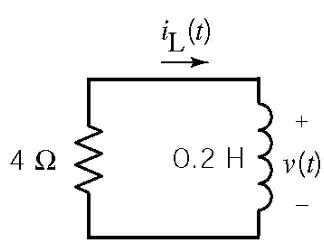
P8.3-7

At $t = 0^-$ (steady-state)

Since the input to this circuit is constant, the inductor will act like a short circuit when the circuit is at steady-state:



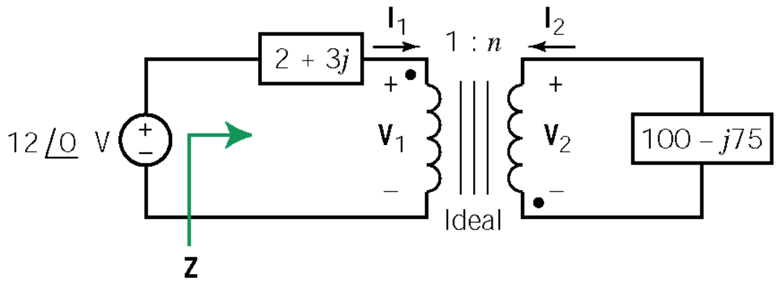
for t > 0



$$\underline{i_L(t) = i_L(0)\, e^{-(R/L)\,t} = 6\, e^{-20t}\text{ A}}$$

Section 11-10: The Ideal Transformer

P11.10-1



$$\mathbf{Z} = (2+j3) + \frac{(100-j75)}{5^2} = 6\ \Omega$$

$$\mathbf{I}_1 = \frac{12\angle 0°}{\mathbf{Z}} = \frac{12\angle 0°}{6} = 2\ \text{A}$$

$$\mathbf{V}_1 = \mathbf{I}_1\left(\frac{100-j75}{n^2}\right) = (2)\left(\frac{100-j75}{25}\right) = 10\angle -36.9°\ \text{V}$$

$$\mathbf{V}_2 = n\mathbf{V}_1 = 5\ (10\angle -36.9°) = 50\ \angle -36.9°\ \text{V}$$

$$\mathbf{I}_2 = \frac{\mathbf{I}_1}{n} = \frac{2}{5}\ \text{A}$$

P11.10-2

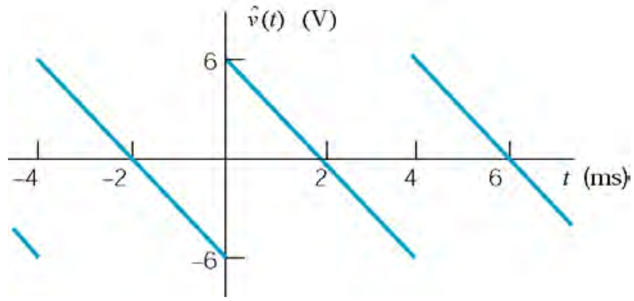
(a) $\mathbf{V}_0 = (5\times 10^{-3})(10,000) = 50\ \text{V}$

$$n = \frac{N_2}{N_1} = \frac{\mathbf{V}_0}{\mathbf{V}_1} = \frac{50}{10} = 5$$

(b) $R_{ab} = \frac{1}{n^2} R_2 = \frac{1}{25}(10\times 10^3) = 400\ \Omega$

(c) $\mathbf{I}_s = \frac{10}{R_{ab}} = \frac{10}{400} = 0.025\ \text{A} = 25\ \text{mA}$

P15.8-6



Rather than find the Fourier Series of $v(t)$ directly, consider the signal $\hat{v}(t)$ shown above. These two signals are related by

$$v(t) = \hat{v}(t-1) - 6$$

since $v(t)$ is delayed by 1 ms and shifted down by 6 V.

The Fourier series of $\hat{v}(t)$ is obtained as follows:

$$T = 4\text{ ms} \Rightarrow \omega_0 = \frac{2\pi\text{ radians}}{4\text{ ms}} = \frac{\pi}{2}\text{rad/ms}$$

$$\hat{a}_n = 0 \text{ because the average value of } \hat{v}(t) = 0$$

$$\hat{b}_n = \frac{1}{2}\int_0^4 (6-3t)\sin\left(n\frac{\pi}{2}t\right)dt \quad \text{because } \hat{v}(t) \text{ is an odd function.}$$

$$= 3\int_0^4 \sin\left(n\frac{\pi}{2}t\right)dt - \frac{3}{2}\int_0^4 t\sin\left(n\frac{\pi}{2}t\right)dt$$

$$= 3\left.\frac{-\cos\left(n\frac{\pi}{2}t\right)}{n\frac{\pi}{2}}\right|_0^4 - \frac{3}{2}\left[\left(\frac{1}{\frac{n^2\pi^2}{4}}\right)\sin\left(n\frac{\pi}{2}t\right) - \left(\frac{n\pi}{2}t\right)\cos\left(n\frac{\pi}{2}t\right)\right]_0^4$$

$$= \frac{6}{n\pi}\left(-1+\cos(2n\pi)\right) - \frac{6}{n^2\pi^2}\left(\left(\sin(2n\pi)-0\right) - \left(2n\pi - \cos(2\pi) - 0\right)\right) = \frac{12}{n\pi}$$

Finally, $$\hat{v}(t) = \sum_{n=1}^{\infty}\frac{12}{n\pi}\sin n\frac{\pi}{2}t$$

The Fourier series of $v(t)$ is obtained from the Fourier series of $\hat{v}(t)$ as follows:

$$v(t) = -6 + \sum_{n=1}^{\infty}\frac{12}{n\pi}\sin n\frac{\pi}{2}(t-1) = -6 + \sum_{n=1}^{\infty}\frac{12}{n\pi}\sin\left(n\frac{\pi}{2}t - n\frac{\pi}{2}\right)$$

where t is in ms. Equivalently,