EEE 201'e ait önemli konular:

1) $v(t) = i(t) R$

2) Kirchoff : K.G.K. $\left(\sum v_i(t) = 0\right)$

K.A.K. $\left(\sum i_i(t) = 0\right)$

3) Düğüm gerilim

Çevre Akım yöntemi ? ?

4) Thevenin eşdeğer devresi

$$R_{Th} = \frac{V_{ad}}{I_{kd}}$$

Bağımlı kaynak varsa (a-b noktalarına test gerilimi bağlanır – V_T

ondan geçen akım bulunur – I_T)

$R_{Th} = V_T / I_T$ olarak bulunur.

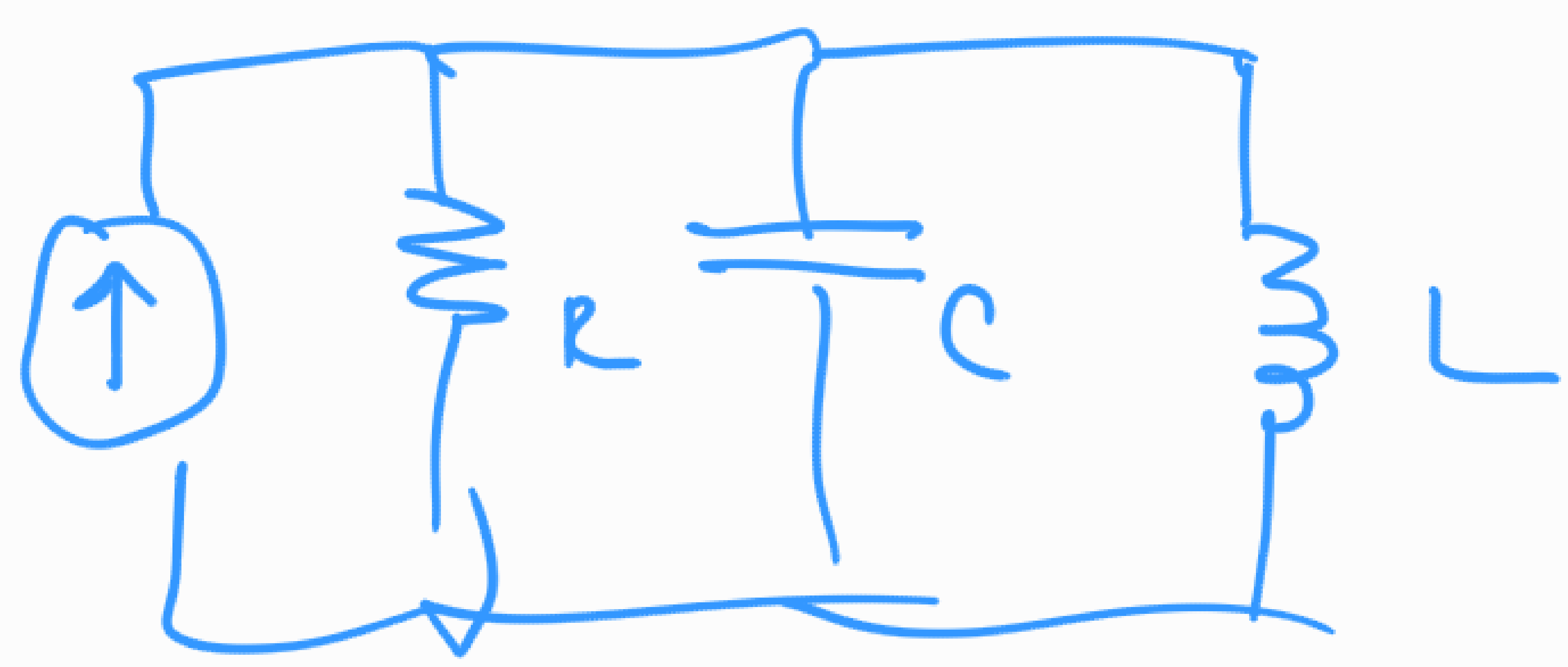
5) Maksimum güç transferi

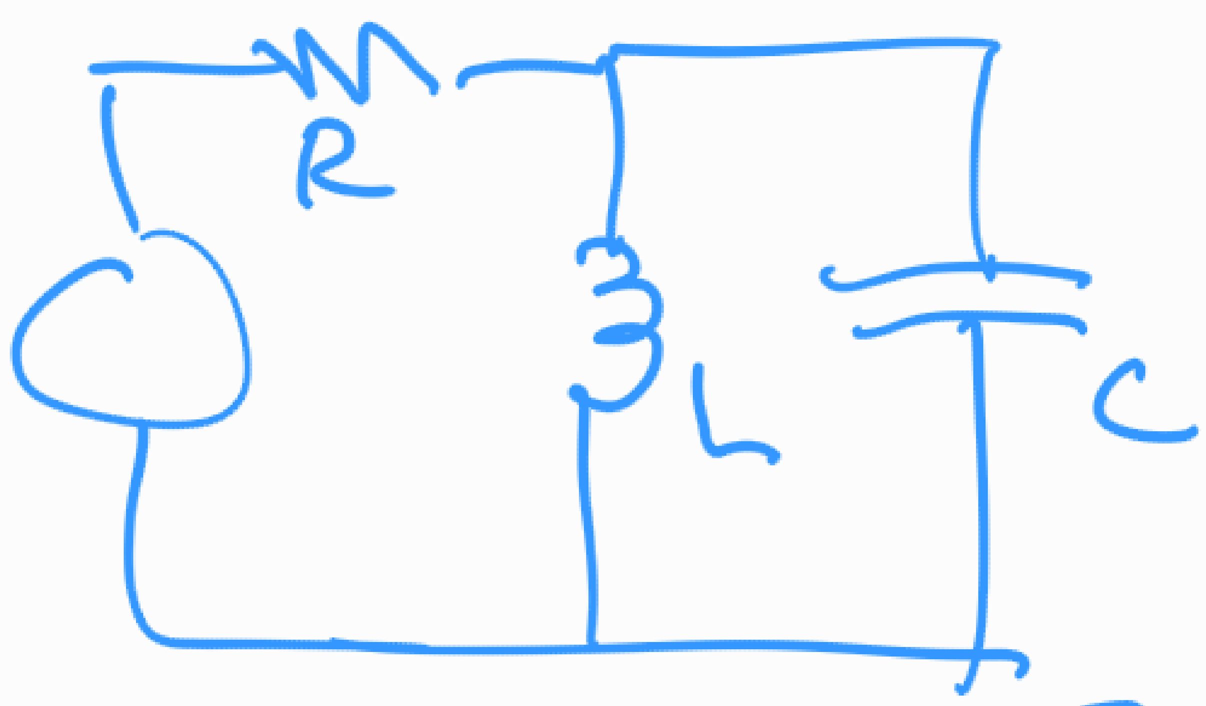
$R_L = R_{Th}$ $\quad V^2/R$, $I^2 R$

6) RL ve RC devreleri:

$v_L(t) = L \dfrac{di_L(t)}{dt}$ $\qquad i_C(t) = C \dfrac{dv_C(t)}{dt}$

7) İkinci dereceden devreler (RLC)





Bu devreleri açıklayan denklemler 2. derece dif. denklem.

Bunlar OPAMP da içerebilir

Doğal Tepki: (Natural Response)

Yükleme elemanlarının başlangıç yüklerinden doğan tepkidir.

Zorlanmış Tepki (Step Response, Forced R.)

Devredeki bağımsız güç kaynaklarına olan tepki

Başlangıç ve Son değerler:

- Kondansatör gerilimi ani değişikliğe uğramaz $v_c(0^-) = v_c(0^+)$
- İndüktör akımı ani değişikliğe uğramaz $i_L(0^-) = i_L(0^+)$
- Kondansatör (DC girdi için) uzun vadede açık devreye yakınsar.
  $i_c = C\frac{dv_c}{dt}$ (sıfır akım)
- İndüktör (DC girdi için) uzun vadede kısa devreye yakınsar.

The switch in Fig. 8.2 has been closed for a long time. It is open at $t = 0$. Find: (a) $i(0^+)$, $v(0^+)$, (b) $di(0^+)/dt$, $dv(0^+)/dt$, (c) $i(\infty)$, $v(\infty)$.

Solution:

(a) If the switch is closed a long time before $t = 0$, it means that the circuit has reached dc steady state at $t = 0$. At dc steady state, the inductor acts like a short circuit, while the capacitor acts like an open circuit, so we have the circuit in Fig. 8.3(a) at $t = 0^-$. Thus,

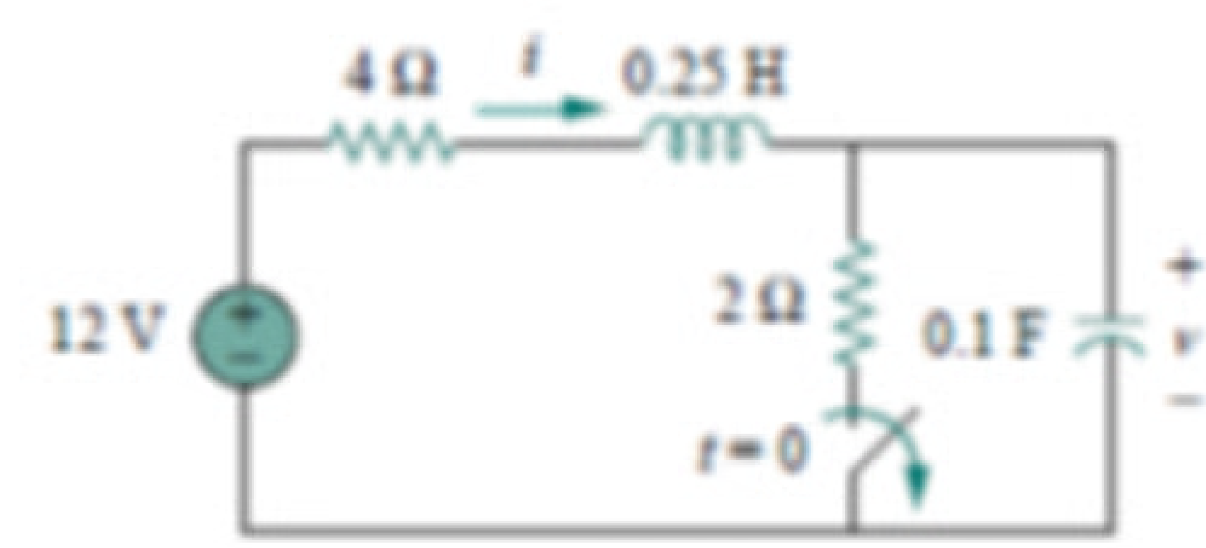
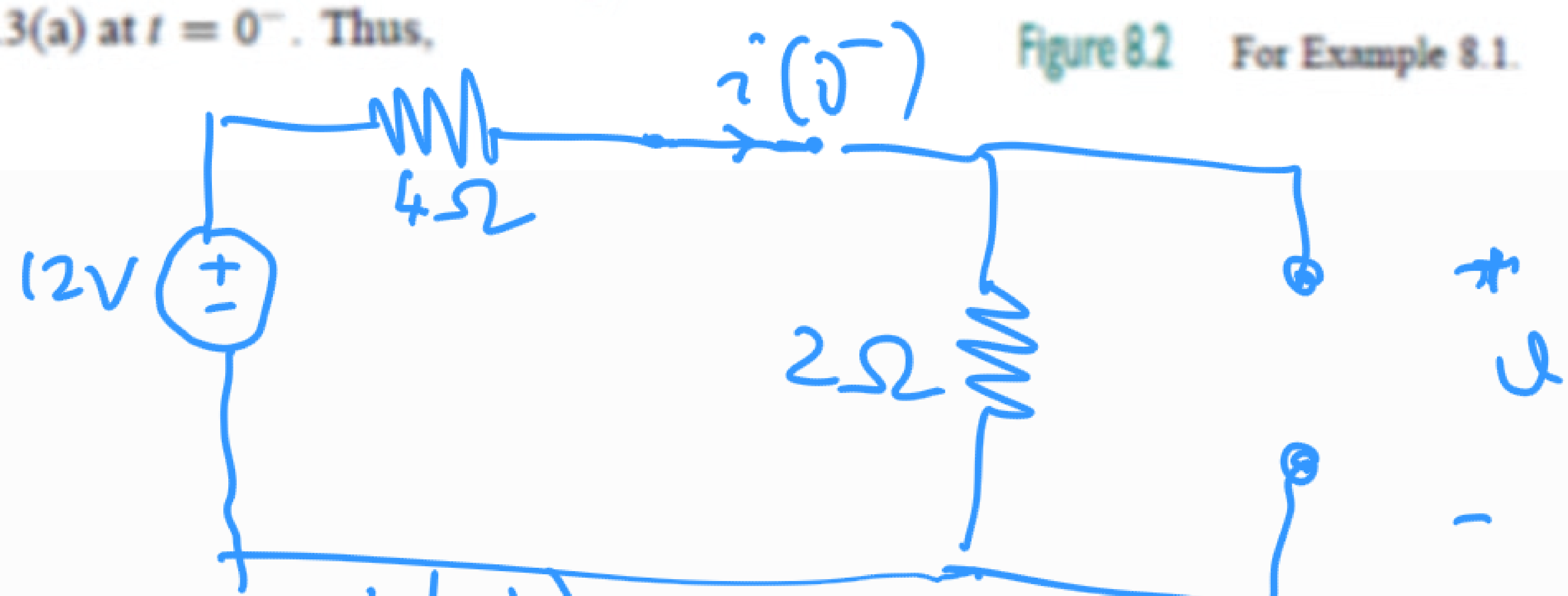


Figure 8.2 For Example 8.1.

$t = 0^-$



a) $i(0^-) = 2A = i(0^+)$

$v(0^-) = 4V = v(0^+)$

b)

$t = 0^+$

$$\underbrace{v_L(0^+)} = L\,\frac{di(0^+)}{\underbrace{dt}}$$

$$v_L(0^+) = 12 - \underbrace{i(0^+)}_{2}\,4\Omega - 4V = 0$$

$$\boxed{\frac{di(0^+)}{dt} = 0}$$

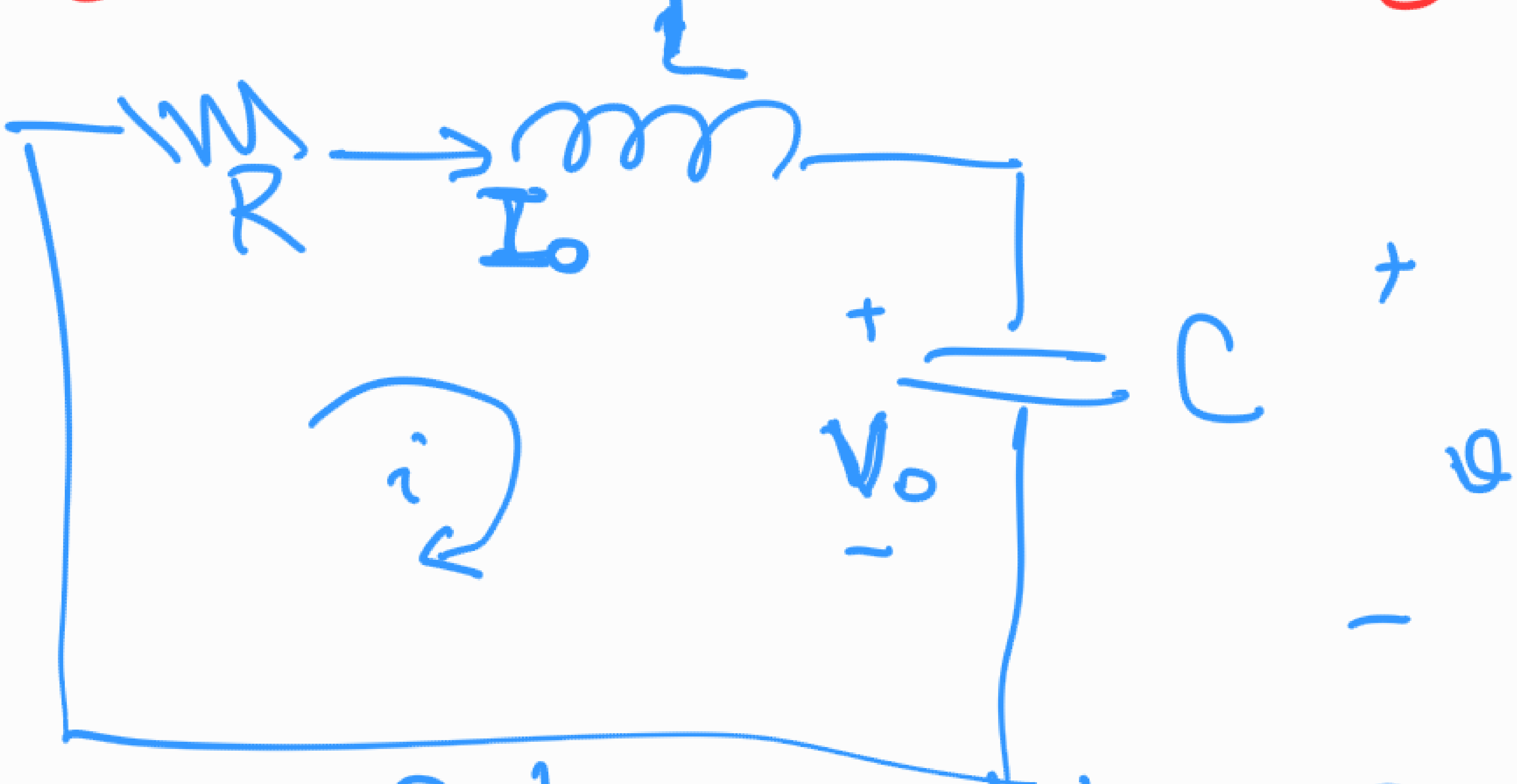
$$\underbrace{i_C(0^+)}_{2A} = C\,\frac{dv(0^+)}{dt} \Rightarrow \boxed{\frac{dv(0^+)}{dt} = \frac{2}{C} = 20}$$

c)

$i(\infty) = 0$ A

$v(\infty) = 12$ V

8.3 Seri RLC Devresinde Doğal Tepki



$$i = C\,\frac{dv}{dt} \qquad \frac{di}{dt} = C\,\frac{d^2v}{dt^2}$$

$$iR + L\,\frac{di}{dt} + v = 0$$

$$iR + LC\,\frac{d^2v}{dt^2} + v = 0$$

$$\boxed{RC\frac{dv}{dt} + LC\frac{d^2v}{dt^2} + v = 0}$$

$$\boxed{\frac{d^2v}{dt^2} + \frac{R}{L}\frac{dv}{dt} + \frac{v}{LC} = 0}$$

$$\boxed{\frac{d^2v}{dt^2} + 2\alpha\frac{dv}{dt} + v\,\omega_0^2 = 0}$$

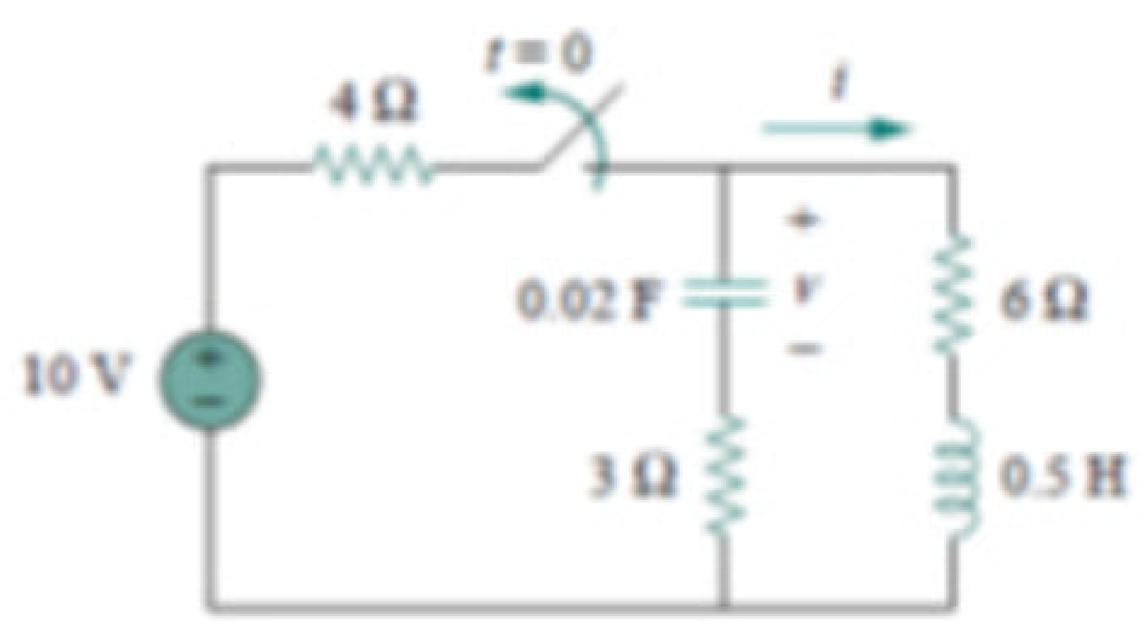
$$\alpha = \frac{R}{2L} \qquad \omega_0 = \sqrt{\frac{1}{LC}}$$

• $\alpha > \omega_0$	Aşırı sönümlü	$v(t) = A_1e^{s_1t} + A_2e^{s_2t}$ $s_{1,2} = -\alpha \pm \sqrt{\alpha^2-\omega_0^2}$
• $\alpha = \omega_0$	Kritik sönümlü	$v(t) = (A_1t + A_2)e^{-\alpha t}$ $s_1 = s_2 = -\alpha$
• $\alpha < \omega_0$	Eksik sönümlü	$v(t) = e^{-\alpha t}(B_1\cos\omega_d t + B_2\sin\omega_d t)$ $\omega_d = \sqrt{\omega_0^2-\alpha^2}$

$$v(t) = A_1e^{s_1t} + A_2e^{s_2t}$$

Tek olası çözüm formatı.

EXAMPLE 8.4



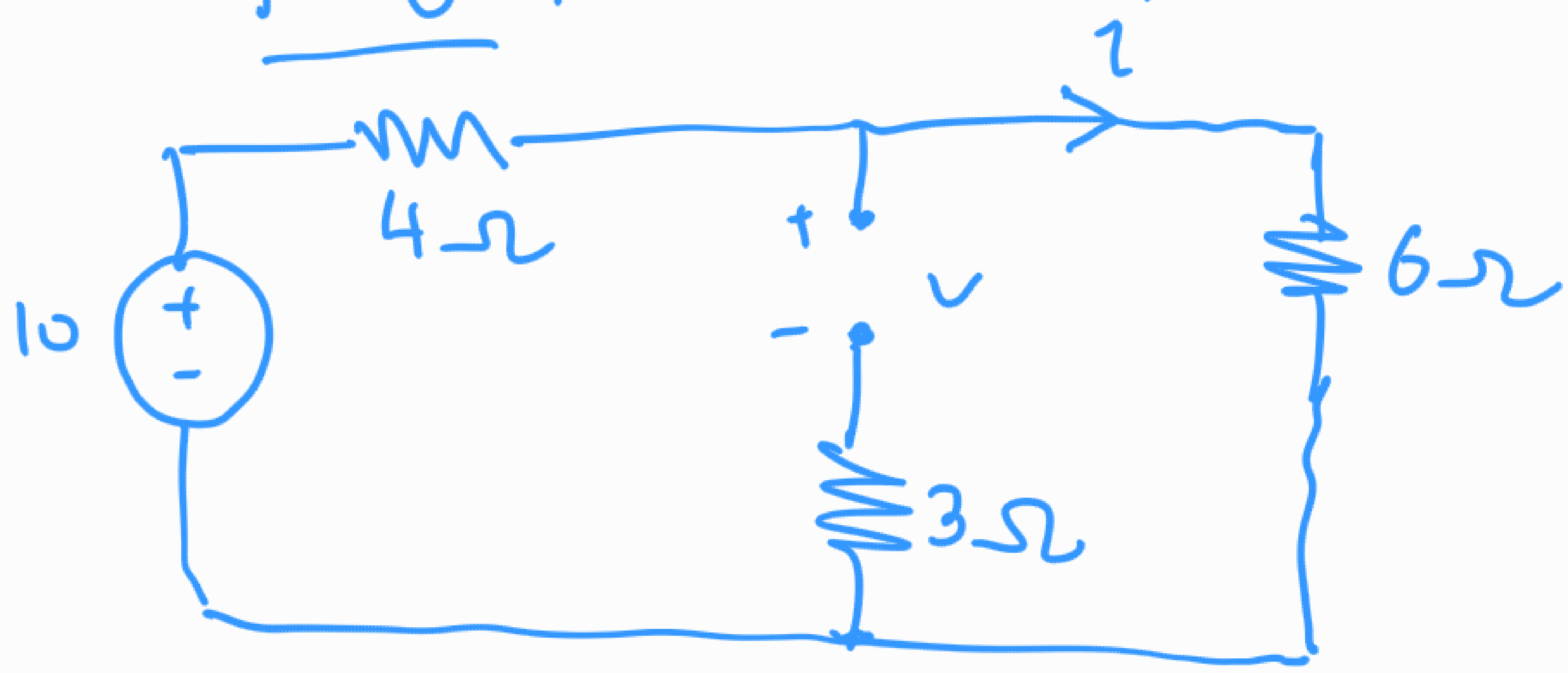
Find $i(t)$ in the circuit in Fig. 8.10. Assume that the circuit has reached steady state at $t = 0^-$.

Solution:

For $t < 0$, the switch is closed. The capacitor acts like an open circuit while the inductor acts like a shunted circuit. The equivalent circuit is shown in Fig. 8.11(a). Thus, at $t = 0$,

$$i(0) = \frac{10}{\quad} = 1\text{ A}, \qquad v(0) = 6i(0) = 6\text{ V}$$

$t = 0^-$:



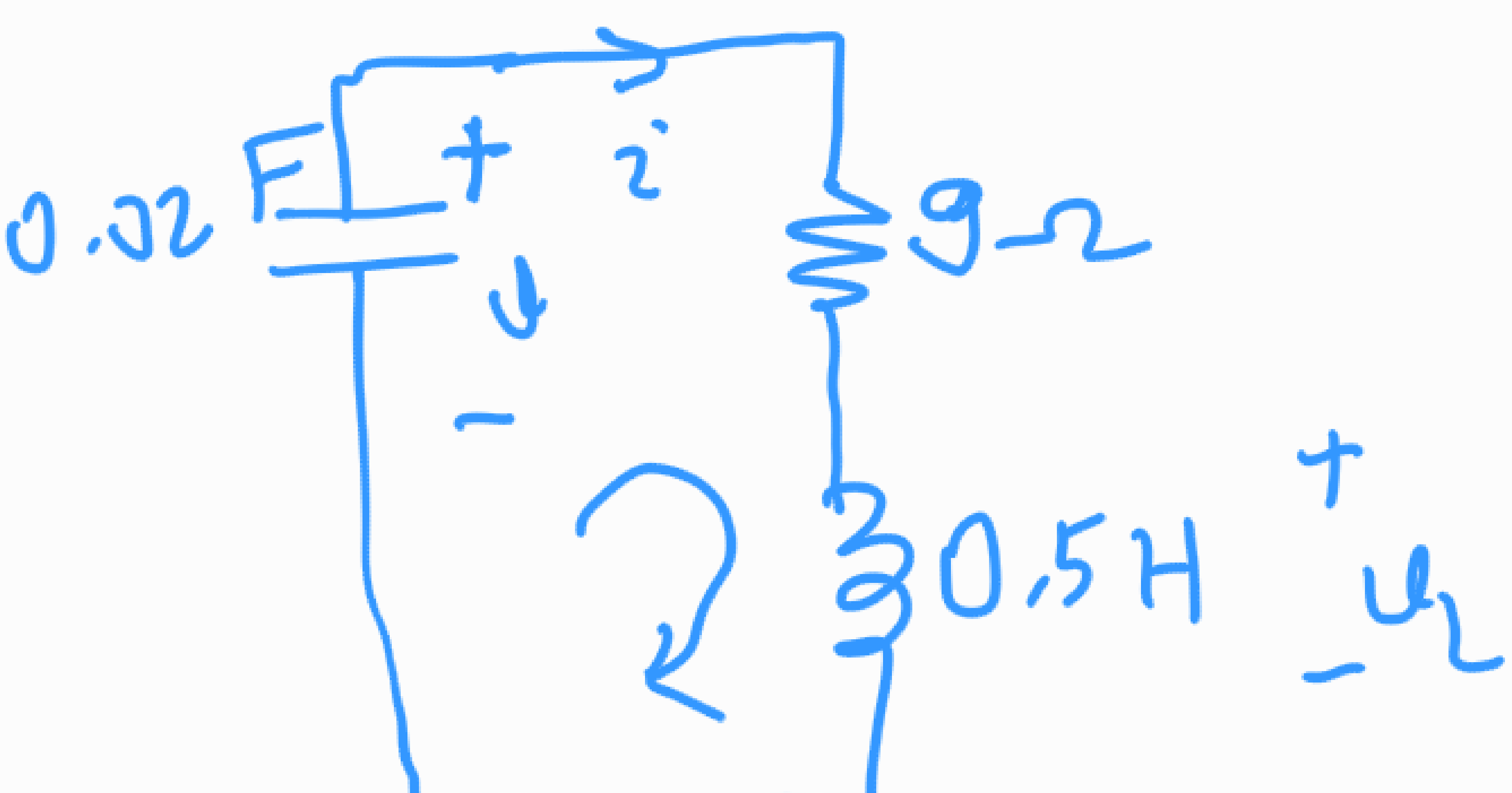
$i(0^-) = 1A = i(0^+)$

$v(0^-) = 6V = v(0^+)$

$I_0 = 1A$

$V_0 = 6V$

$t > 0$:



$$\alpha = \frac{R}{2L} = 9$$

$$\omega_0 = \sqrt{\frac{1}{LC}} = \sqrt{\frac{1}{0.02 \times 0.5}} = 10$$

$\alpha < \omega_0 \longrightarrow$ Eksik sönümlü

$$i(t) = e^{-\alpha t}\left(\overset{?}{B_1} \cos\omega_d t + \overset{?}{B_2} \sin\omega_d t\right)$$

$$\alpha = 9 \qquad \omega_d = \sqrt{10^2 - 9^2} = \sqrt{19}$$

$$i(t) = e^{-9t}\left(B_1 \cos(\sqrt{19}\,t) + B_2 \sin(\sqrt{19}\,t)\right)$$

$$i(0) = I_0 = 1 = B_1 \checkmark$$

$$-V_0 + 9I_0 + v_L(0) = 0$$

$$-6 + 9 + v_L(0) = 0 \Rightarrow \boxed{v_L(0) = -3}$$

$$v_L(t) = L\frac{di(t)}{dt}$$

$$v_L(0) = L\frac{di(0)}{dt}$$

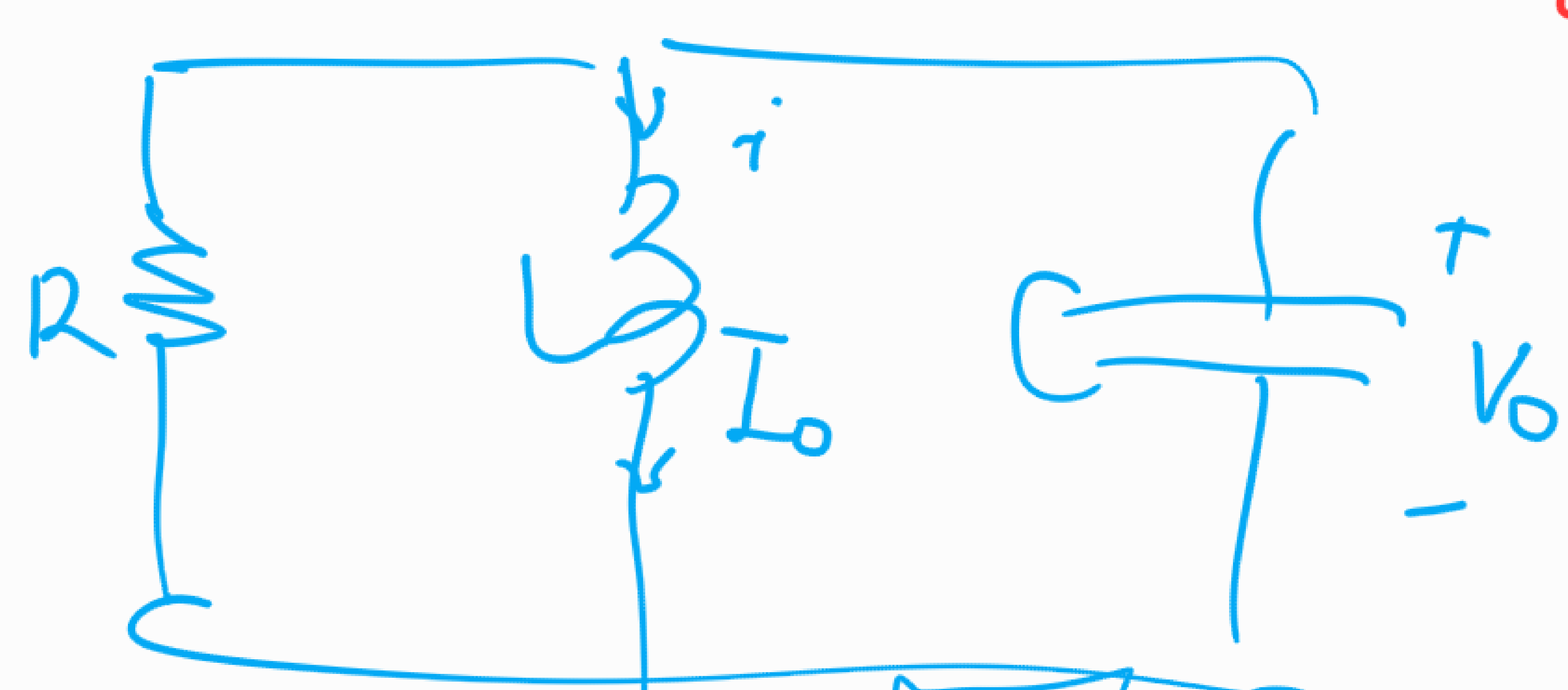
$$-3 = 0.5\Big[-9e^{-9t}\left(\cos(\sqrt{19}t) + B_2\sin(\sqrt{19}t)\right) + e^{-9t}\left(-\sqrt{19}\sin(\sqrt{19}t) + \sqrt{19}B_2\cos(\sqrt{19}t)\right)\Big]_{t=0}$$

$$-3 = 0.5\left[-9 + \sqrt{19}B_2\right]$$

$$-6 = -9 + \sqrt{19}B_2 \Rightarrow \frac{3}{\sqrt{19}} = B_2 = 0.6882$$

$$i(t) = e^{-9t}\left(\cos(\sqrt{19}t) + 0.6882\sin(\sqrt{19}t)\right) \checkmark$$

8.4 Paralel RLC Devresinde Doğal Tepki



+
v
-

$\alpha = \frac{1}{2RC}$ $\quad \omega_0 = \sqrt{\frac{1}{LC}}$ olmak üzere

diğer kurallar aynıdır.

8-5 Seri RLC Devresinde Zorlanmış Tepki

Devrede bağımsız bir güç kaynağı vardır. Devre bu kaynağın zorladığı duruma yakınsar.

$v(t) = v(\infty) +$ Doğal tepki tipinde çözüm.

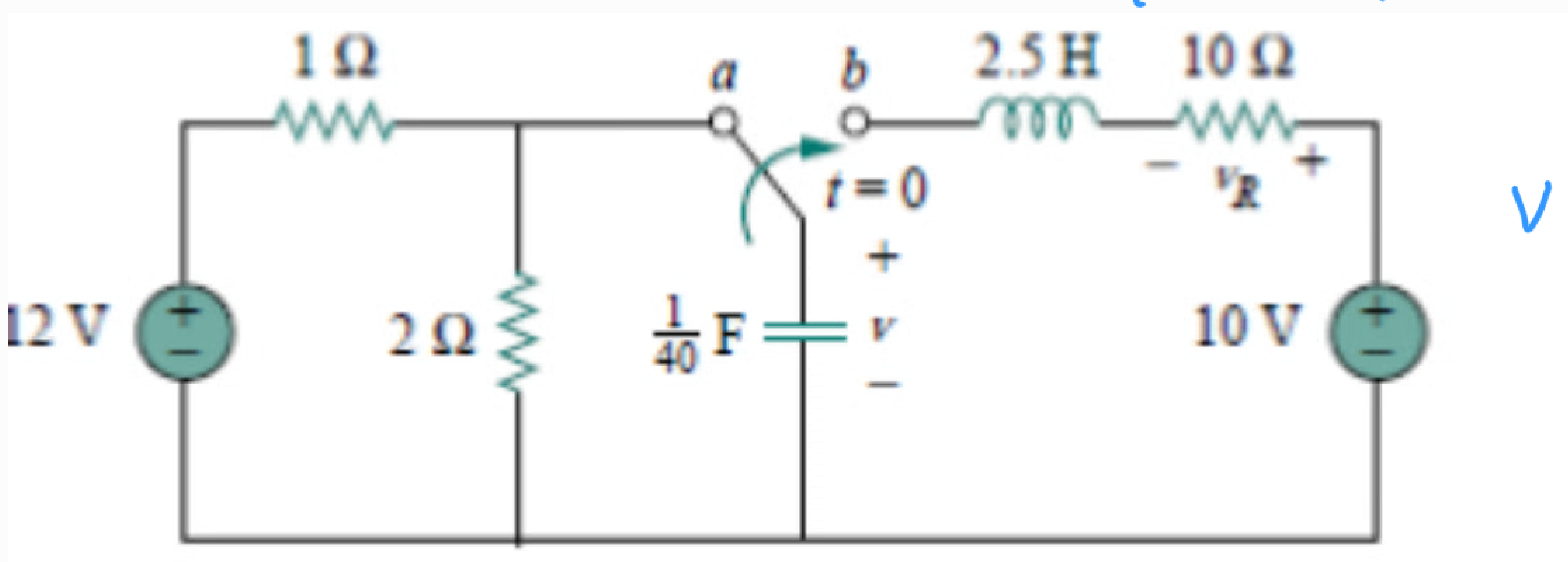
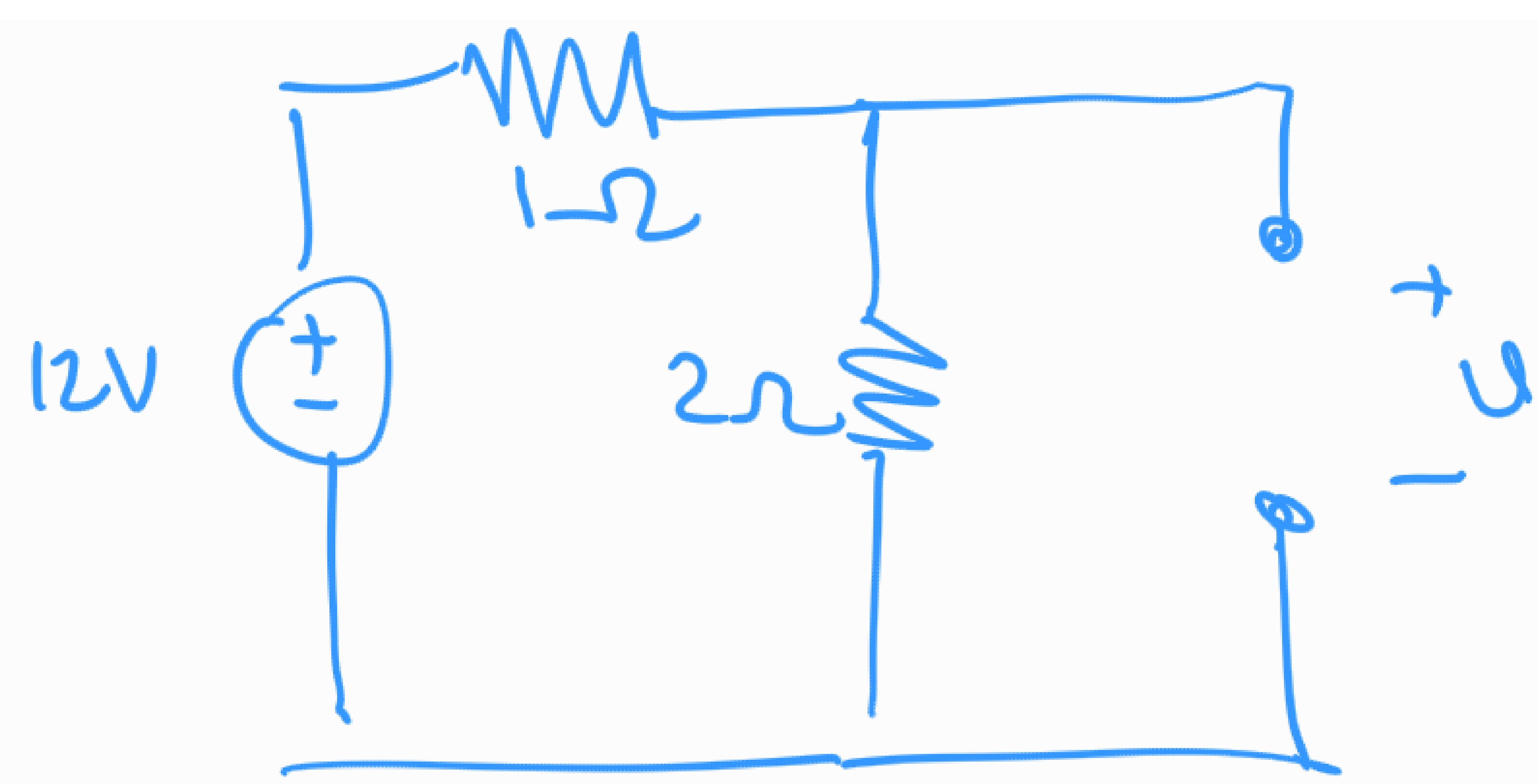


Figure 8.21 For Practice Prob. 8.7.

$v(t) = ?$

$t \geq 0$

$t = 0^-$:

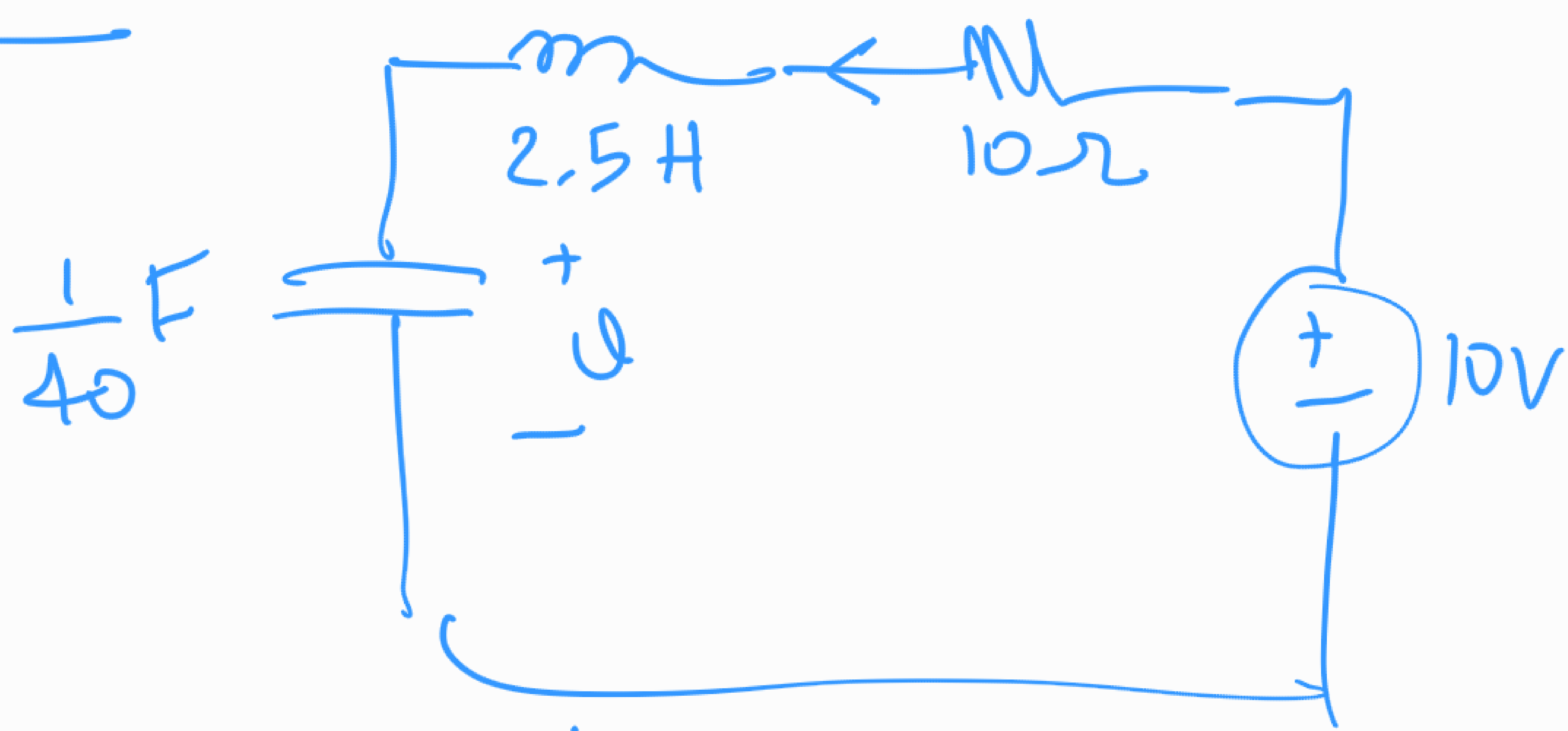


$v(0^-) = 8V = v(0^+) = 8\ V$

$t \to \infty$:

$v(\infty) = 10\ V$

$t \geq 0:$



$$\alpha = \frac{R}{2L} = \frac{10}{2 \times 2{,}5} = 2 \qquad w_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{2.5/40}} = \frac{\sqrt{40}}{\sqrt{2{,}5}} = \sqrt{16} = 4$$

$\alpha < w_0 \longrightarrow$ Eksik Sönümlü

$$v(t) = 10 + e^{-2t}\left[B_1 \cos w_d t + B_2 \sin w_d t\right]$$

$$w_d = \sqrt{4^2 - 2^2} = \sqrt{12}$$

$$v(0) = 8 = 10 + B_1 \rightarrow \boxed{B_1 = -2}$$

$i(0^+) = 0$ (akım geçmiyor, ilk başta)

$$i(0^+) = \cancel{\frac{1}{40}} \frac{d(v(0^+))}{dt} = 0$$

$$\underset{t=0\text{'da}}{0} = -2e^{-2t}\left[B_1 \cos w_d t + B_2 \sin w_d t\right] + e^{-2t}\left[-B_1 w_d \sin w_d t + B_2 w_d \cos w_d t\right]$$

$$0 = -2B_1 + B_2 w_d$$
$$= -2(-2) + B_2\sqrt{12}$$
$$B_2 = \frac{-4}{\sqrt{12}} = \frac{-2}{\sqrt{3}}$$
$$v(t) = 10 + e^{-2t}\left[-2\cos(\sqrt{12}t) - \frac{2}{\sqrt{3}}\sin(\sqrt{12}t)\right]$$

8.6 Paralel RLC Devresinde Zorlanmış Tepki

Benzer şekilde

$v(t) = V_s +$ Doğal Tepki Tipinde Çözüm

$$\alpha = \frac{1}{2RC} \qquad \omega_0 = \frac{1}{\sqrt{LC}}$$

8.8. İkinci Dereceden OPAMP Devreleri

1) Opamp girişindeki gerilimler birbirine eşittir
2) OPAMP'a giren akımlar sıfırdır.

In the op amp circuit of Fig. 8.33, find $v_o(t)$ for $t > 0$ when $v_s = 10u(t)$ mV. Let $R_1 = R_2 = 10\ \text{k}\Omega$, $C_1 = 20\ \mu\text{F}$, and $C_2 = 100\ \mu\text{F}$.

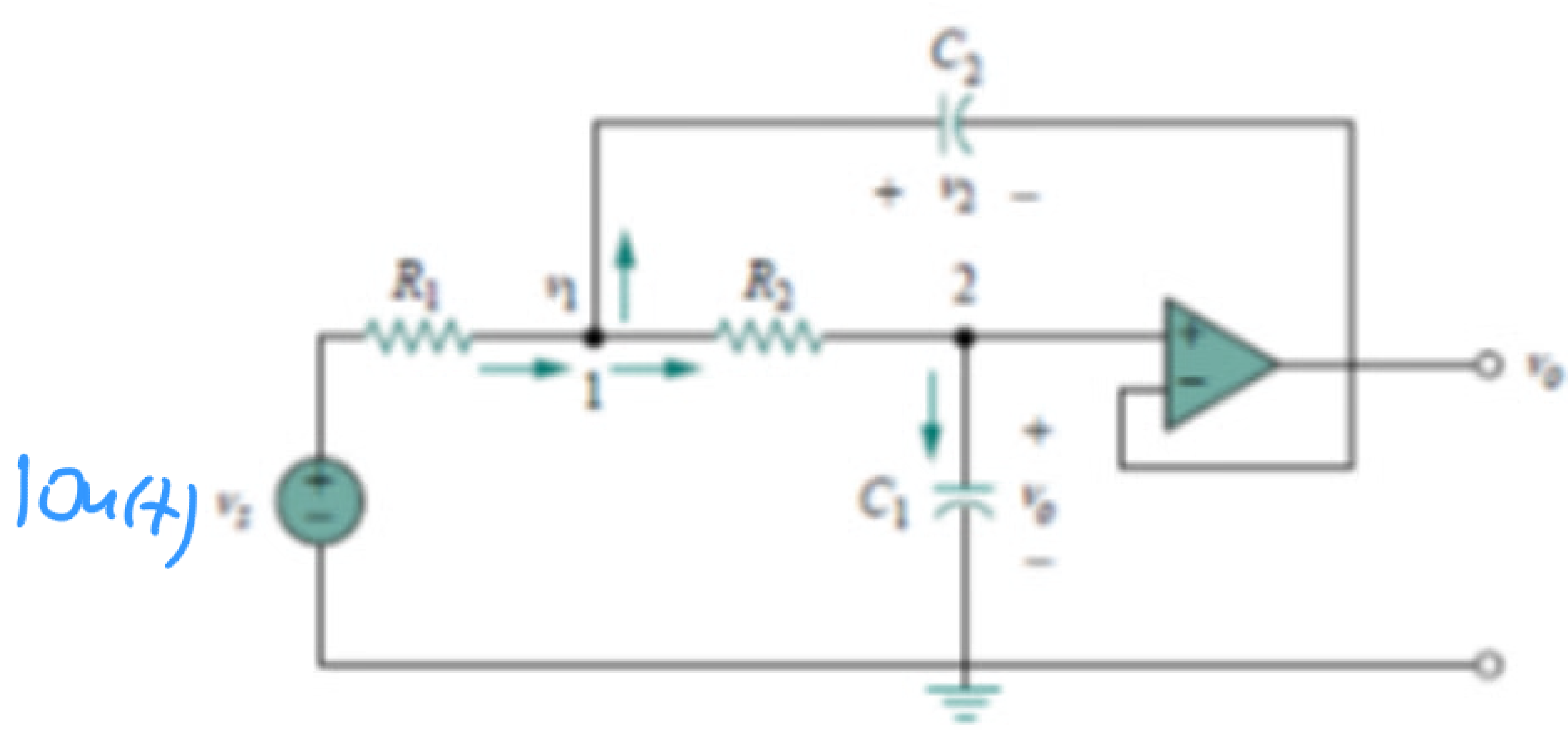
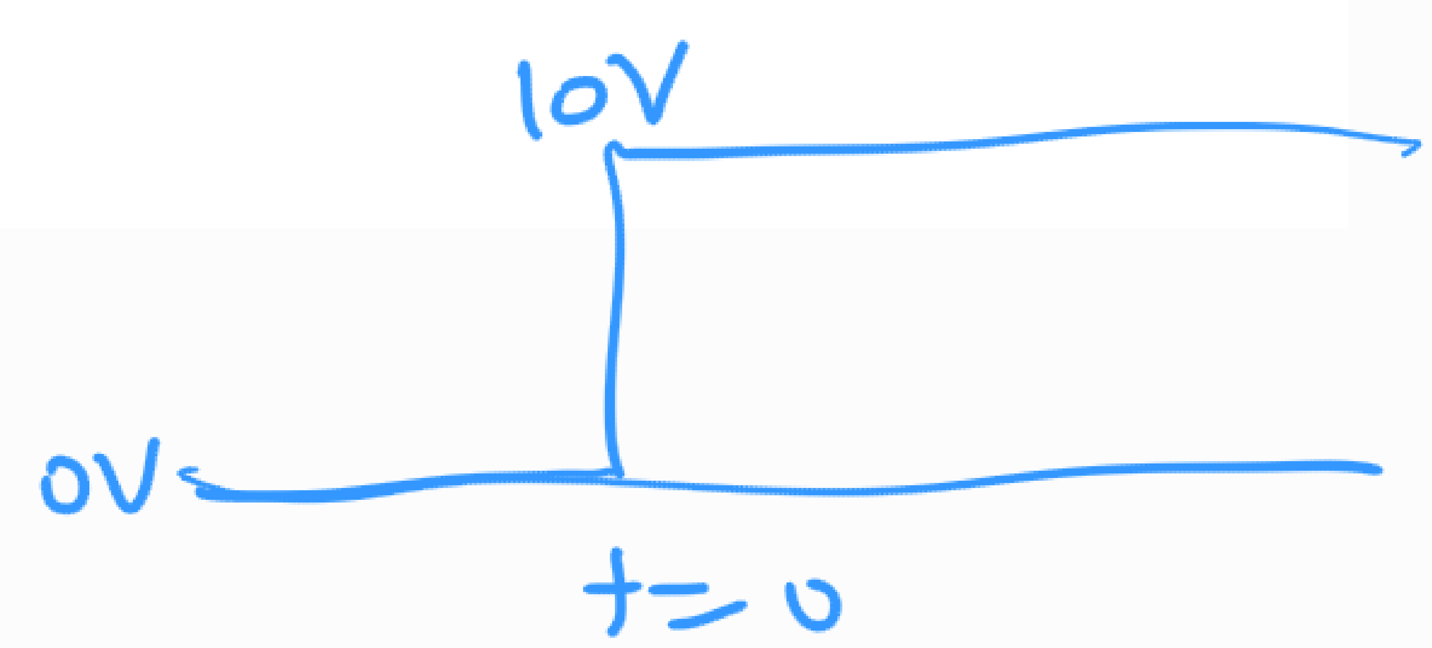
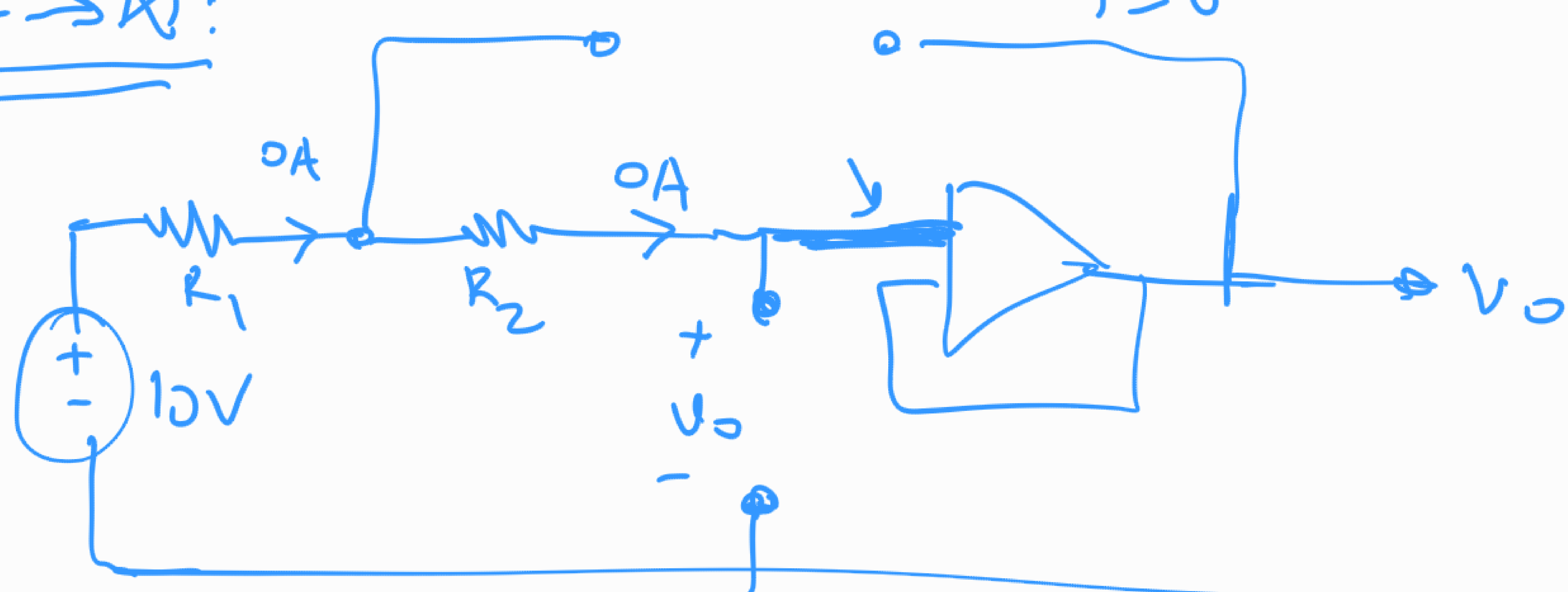


Figure 8.33 For Example 8.11.



10 u(t) ?

$t \to \infty$:



$$\lim_{t \to \infty} V_o(t) = 10V$$

v(t) = 10 + Doğal tepki tipinde çözüm.

In the op amp circuit of Fig. 8.33, find $v_o(t)$ for $t > 0$ when $v_s = 10u(t)$ mV. Let $R_1 = R_2 = 10\text{ k}\Omega$, $C_1 = 20\ \mu\text{F}$, and $C_2 = 100\ \mu\text{F}$.

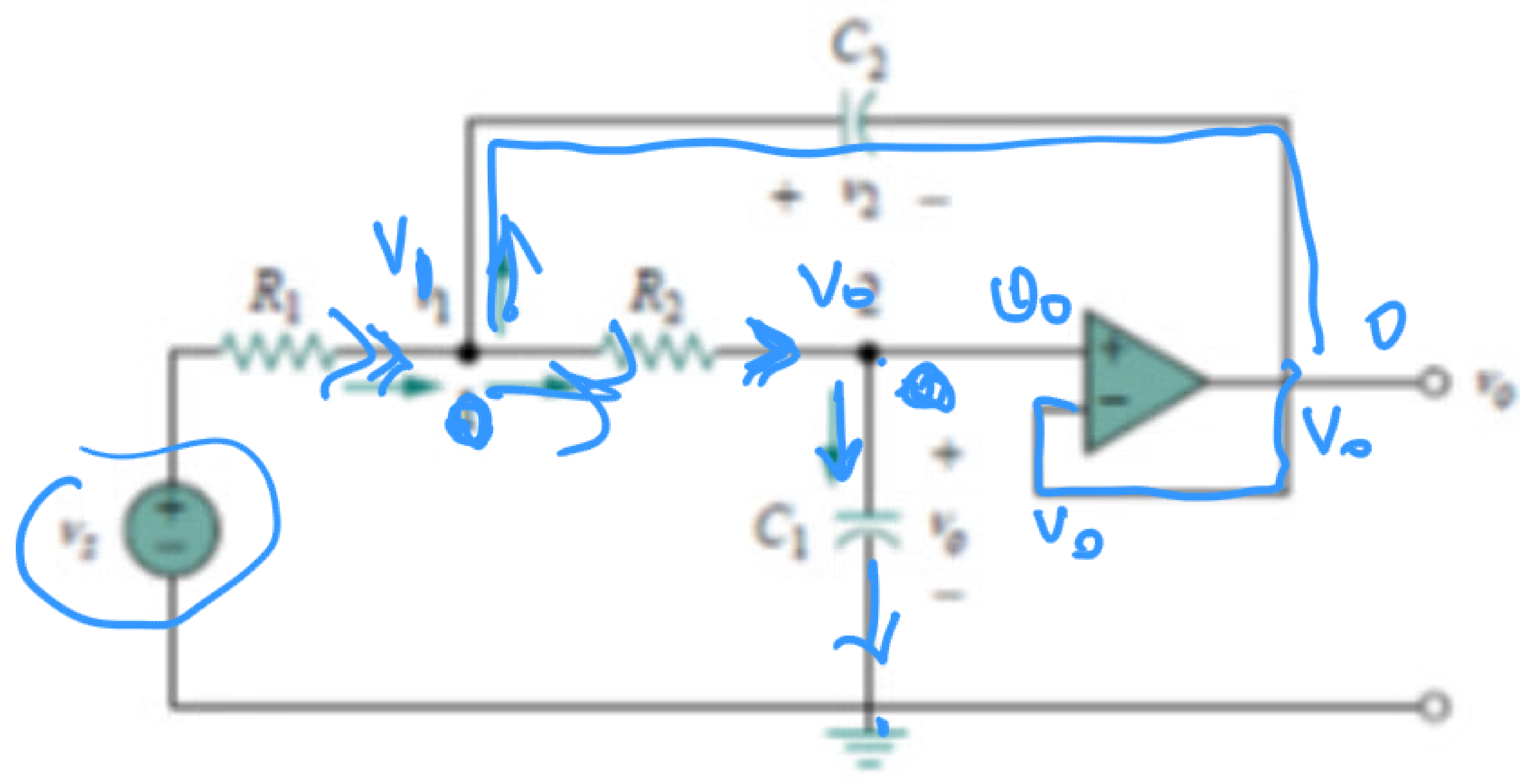


Figure 8.33 For Example 8.11.

(1) $$\frac{10-v_1}{R_1} = C_2\frac{d(v_1-v_o)}{dt} + \frac{v_1-v_o}{R_2}$$

(2) $$\frac{v_1-v_o}{R_2} = C_1\frac{dv_o}{dt}$$

(1) $$\frac{10-v_1}{R_1} = C_2\frac{d(v_1-v_o)}{dt} + C_1\frac{dv_o}{dt}$$

(2) $$\cancel{\frac{1}{R_2}}\frac{d(v_1-v_o)}{dt} = R_2C_1\frac{d^2v_o}{dt^2}$$

(1) $$\frac{10-v_1}{\ } = R_1R_2C_1C_2\frac{d^2v_o}{dt^2} + R_1C_1\frac{dv_o}{dt}$$

$$v_1 = 10 - R_1R_2C_1C_2\frac{d^2v_o}{dt^2} - R_1C_1\frac{dv_o}{dt}$$

(2)

$$v_1 = v_o + R_1C_2\frac{dv_o}{dt}$$

$$10 - R_1R_2C_1C_2\frac{d^2v_o}{dt^2} - R_1C_1\frac{dv_o}{dt} = v_o + R_1C_2\frac{dv_o}{dt}$$

$$10 = R_1R_2C_1C_2\underline{\frac{d^2v_o}{dt^2}} + (R_1C_1 + R_1C_2)\frac{dv_o}{dt} + v_o$$

$$\frac{10}{R_1R_2C_1C_2} = \frac{d^2v_o}{dt^2} + \underbrace{\frac{R_1C_1+R_1C_2}{R_1R_2C_1C_2}}_{2\alpha}\frac{dv_o}{dt} + \underbrace{\frac{v_o}{R_1R_2C_1C_2}}_{w_o^2}$$

$$\alpha = \frac{R_1C_1+R_1C_2}{2R_1R_2C_1C_2} = \frac{10^4(120)\times10^{-6}}{2\times10^8 \; 2\times10^{-9}} = \frac{1.2}{4\times0.1} = 3$$

$$w_o = \frac{1}{\sqrt{10^8\times2\times10^{-9}}} = \sqrt{5}$$

$\alpha > w_o$

Aşırı sönümlü

$$v_o(t) = 10 +$$

$$s_{1,2} = -3 \pm \sqrt{9-5} = -3 \pm 2 = (-1, -5)$$

$$v_o(t) = 10 + A_1 e^{-t} + A_2 e^{-5t}$$

$$v_o(0) \boxed{= 0 = A_1 + A_2}$$

$$i_{c_1}(0^+) = 0 = C_2 \frac{dv_o(0^+)}{dt}$$

$$\frac{dv_o(0^+)}{dt} = -A_1 e^{-t} - 5A_2 e^{-5t}\Big|_{t=0} = 0$$

$$\boxed{-A_1 - 5A_2 = 0}$$

$-4A$