Tutorial - 1-02-f

Question 1 (10-23)

For the network of Fig. 10.83:

a. Find the mathematical expression for the voltage across the capacitor after the switch is thrown into position 1.

b. Repeat part (a) for the current i_C.

c. Find the mathematical expressions for the voltage v_C and current i_C if the switch is thrown into position 2 at a time equal to five time constants of the charging circuit.

d. Plot the waveforms of v_C and i_C for a period of time extending from $t = 0$ to $t = 30\ \mu s$.

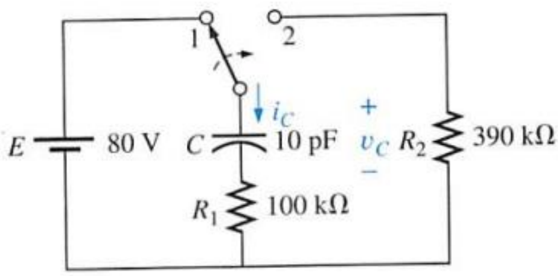


FIG. 10.83
Problem 23.

Question 2 (10-27)

***27.** The capacitor of Fig. 10.87 is initially charged to 12 V with the polarity shown.

a. Find the mathematical expressions for the voltage v_C and the current i_C when the switch is closed.

b. Sketch the waveforms for v_C and i_C.

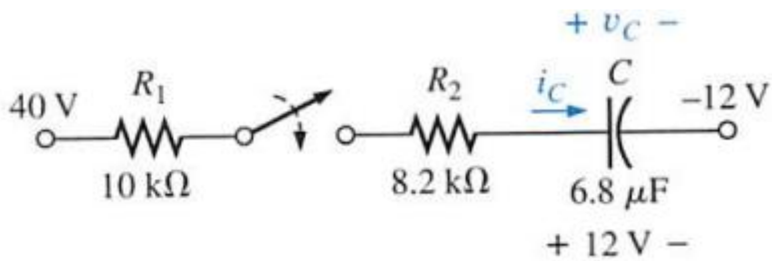


FIG. 10.87
Problem 27.

Question 3 (10-41)

41. Find the waveform for the average current if the voltage across a 0.06-μF capacitor is as shown in Fig. 10.99.

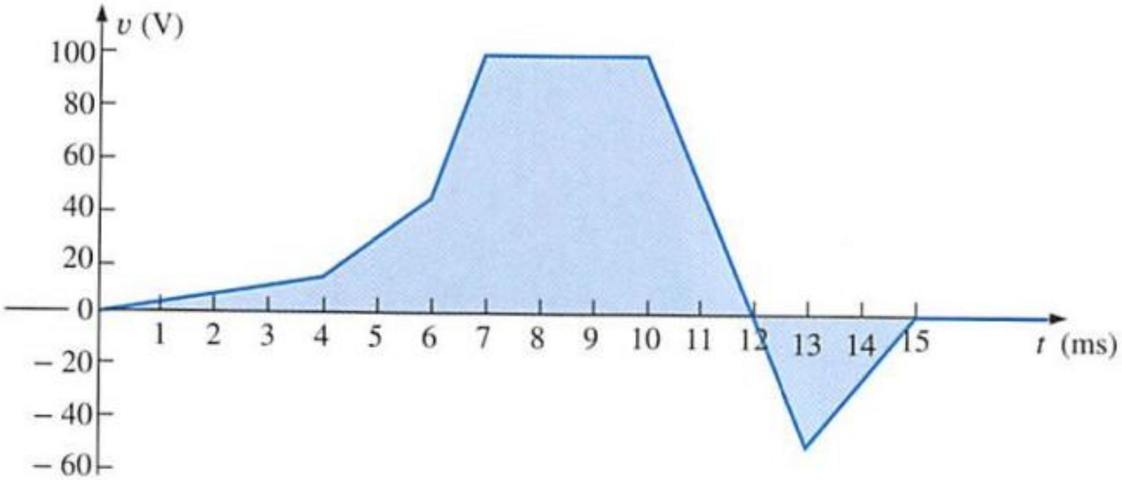


FIG. 10.99
Problem 41.

Question 4 (12-10)

10. Sketch the waveform for the voltage induced across a 0.2-H coil if the current through the coil is as shown in Fig. 12.65.

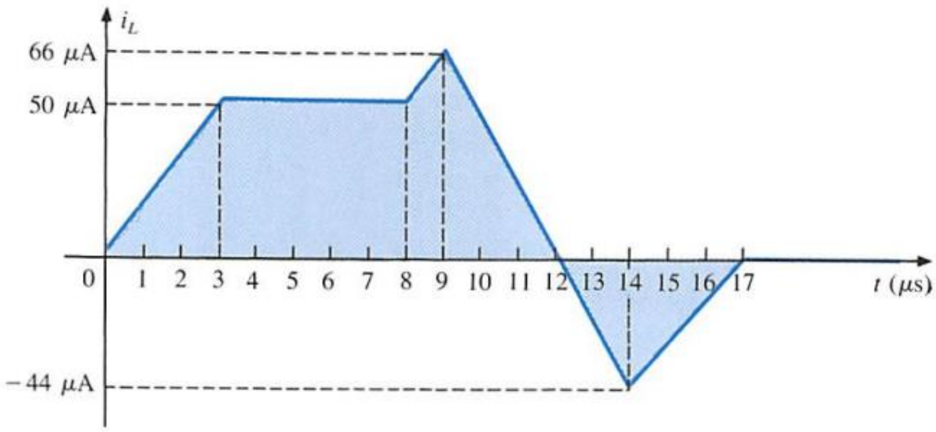


FIG. 12.65
Problem 10.

Question 5 (12-15)

***15.** For the network of Fig. 12.70:

a. Write the mathematical expression for the current i_L and the voltage v_L following the closing of the switch.

b. Determine the mathematical expressions for i_L and v_L if the switch is opened after a period of five time constants has passed.

c. Sketch the waveforms of i_L and v_L for the time periods defined by parts (a) and (b).

d. Sketch the waveform for the voltage across R_2 for the same period of time encompassed by i_L and v_L. Take careful note of the defined polarities and directions of Fig. 12.70.

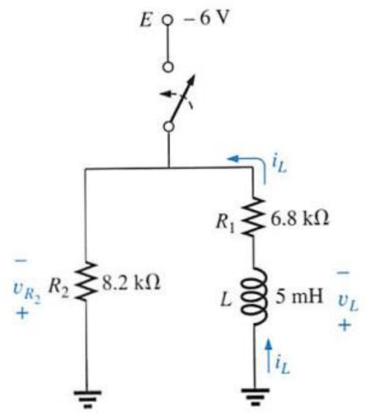


FIG. 12.70
Problem 15.

Solution

Question 1

23. a. $\tau = R_1C = (10^5\ \Omega)(10\ \text{pF}) = 1\ \mu s$

$v_C = 80(1 - e^{-t/1\times10^{-6}})$

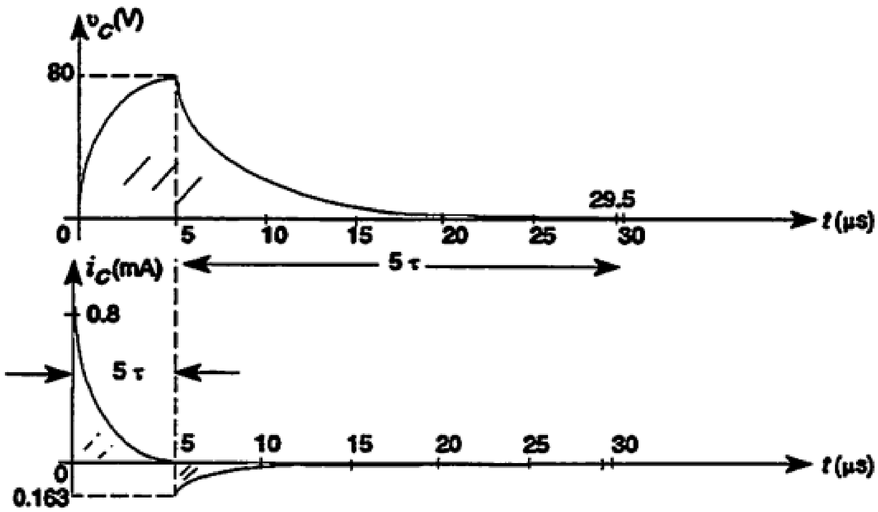
b. $i_C = \dfrac{80\ \text{V}}{100\ \text{k}\Omega}e^{-t/\tau} = 0.8 \times 10^{-3}e^{-t/1\times10^{-6}}$

c. $\tau' = R'C = (490\ \text{k}\Omega)(10\ \text{pF}) = 4.9\ \mu s$

$v_C = 80e^{-t/\tau'} = 80e^{-t/4.9\times10^{-6}}$

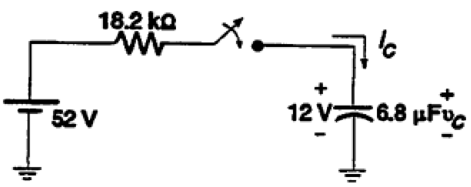
$i_C = \dfrac{80\ \text{V}}{490\ \text{k}\Omega}e^{-t/\tau'} = 0.163 \times 10^{-3}e^{-t/4.9\times10^{-6}}$

d.



Question 2

27. a.



$\tau = RC = (18.2\ \text{k}\Omega)(6.8\ \mu\text{F}) = 123.8\ \text{ms}$

$v_C = V_f + (V_i - V_f)e^{-t/\tau}$

$= 52\ \text{V} + (12\ \text{V} - 52\ \text{V})e^{-t/123.8\ \text{ms}}$

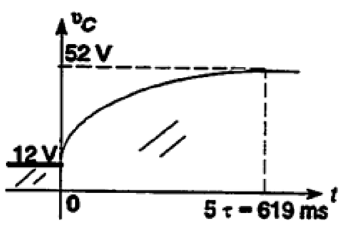
$v_C = 52\ \text{V} - 40\ \text{V}e^{-t/123.8\ \text{ms}}$

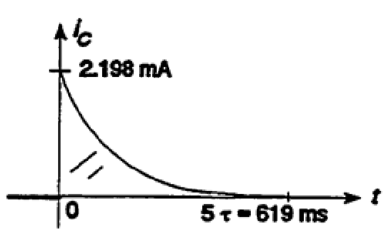
$v_R(0+) = 52\ \text{V} - 12\ \text{V} = 40\ \text{V}$

$i_C = \dfrac{40\ \text{V}}{18.2\ \text{k}\Omega}e^{-t/123.8\ \text{ms}}$

$= 2.198\ \text{mA}e^{-t/123.8\ \text{ms}}$

b.





Question 3

41. $i_C = C\frac{\Delta V}{\Delta t}$: $i_C = 0.06 \times 10^{-6}\frac{\Delta V}{\Delta t}$

0 – 4 ms: $i_C = 0.06 \times 10^{-6}\left[\frac{20\text{ V}}{4\text{ ms}}\right] = 0.3\text{ mA}$

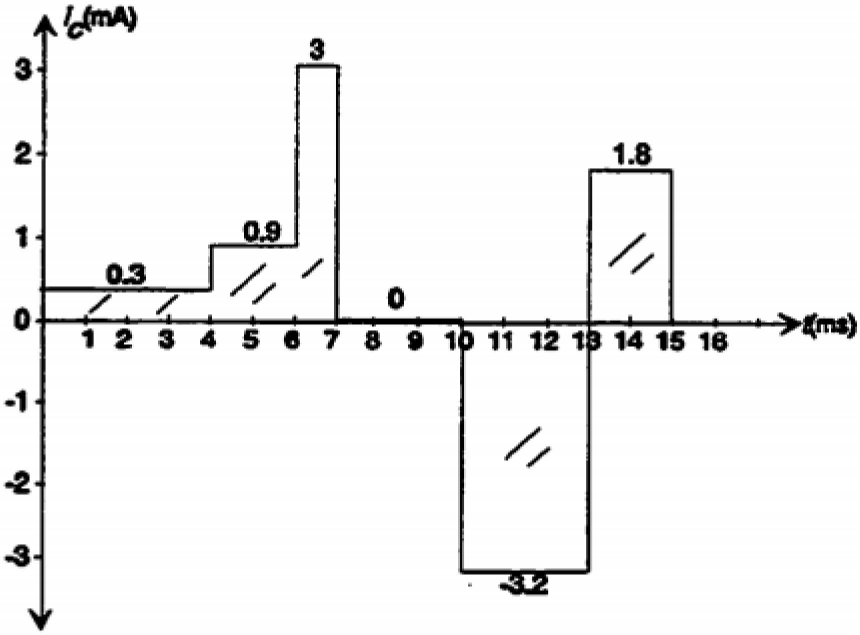
4 – 6 ms: $i_C = 0.06 \times 10^{-6}\left[\frac{30\text{ V}}{2\text{ ms}}\right] = 0.9\text{ mA}$

6 – 7 ms: $i_C = 0.06 \times 10^{-6}\left[\frac{50\text{ V}}{1\text{ ms}}\right] = 3\text{ mA}$

7 – 10 ms: $i_C = 0\text{ mA}$

10 – 13 ms: $i_C = -0.06 \times 10^{-6}\left[\frac{160\text{ V}}{3\text{ ms}}\right] = -3.2\text{ mA}$

13 – 15 ms: $i_C = 0.06 \times 10^{-6}\left[\frac{60\text{ V}}{2\text{ ms}}\right] = 1.8\text{ mA}$



Question 4

10. $e = L\frac{\Delta i}{\Delta t} = (0.2\text{ H})\frac{\Delta i}{\Delta t}$

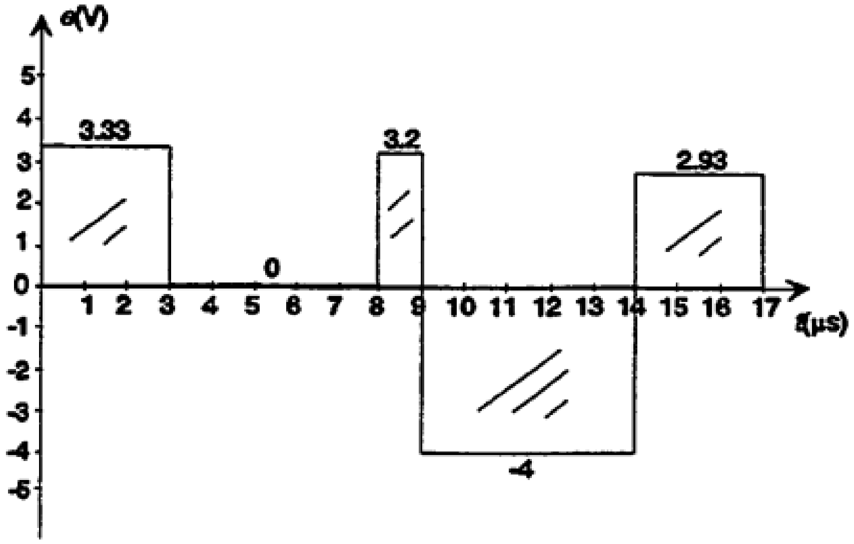
$$0 - 3\ \mu s: e = (0.2\text{ H})\left[\frac{50\ \mu A}{3\ \mu s}\right] = 3.33\text{ V}$$

$$3 - 8\ \mu s: e = (0.2\text{ H})(0) = 0\text{ V}$$

$$8 - 9\ \mu s: e = (0.2\text{ H})\left[\frac{16\ \mu A}{1\ \mu s}\right] = 3.2\text{ V}$$

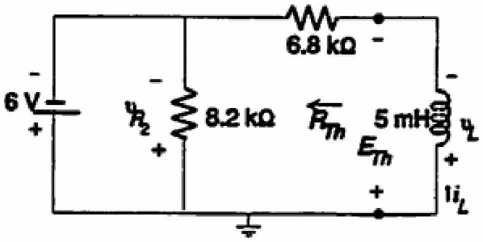
$$9 - 14\ \mu s: e = -(0.2\text{ H})\left[\frac{100\ \mu A}{5\ \mu s}\right] = -4\text{ V}$$

$$14 - 17\ \mu s: e = (0.2\text{ H})\left[\frac{44\ \mu A}{3\ \mu s}\right] = 2.93\text{ V}$$

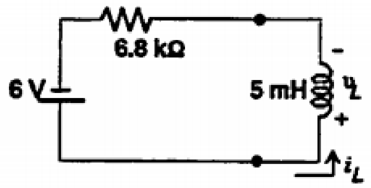


Question 5

15. a.



$R_{Th} = 6.8\ \text{k}\Omega$
$E_{Th} = 6\ \text{V}$

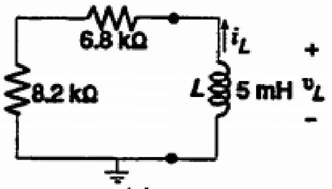


$$\tau = \frac{L}{R} = \frac{5\ \text{mH}}{6.8\ \text{k}\Omega} = 0.735\ \mu\text{s}$$

$$i_L = \frac{E}{R}(1 - e^{-t/\tau}) = \frac{6\ \text{V}}{6.8\ \text{k}\Omega}(1 - e^{-t/\tau}) = 0.882 \times 10^{-3}(1 - e^{-t/0.735\ \mu\text{s}})$$

$$v_L = Ee^{-t/\tau} = 6e^{-t/0.735\ \mu\text{s}}$$

b. Assume steady state and $I_L = 0.882$ mA



$$\tau' = \frac{L}{R} = \frac{5\ \text{mH}}{15\ \text{k}\Omega} = 0.333\ \mu\text{s}$$

$$i_L = I_m e^{-t/\tau'} = 0.882 \times 10^{-3} e^{-t/0.333\ \mu\text{s}}$$

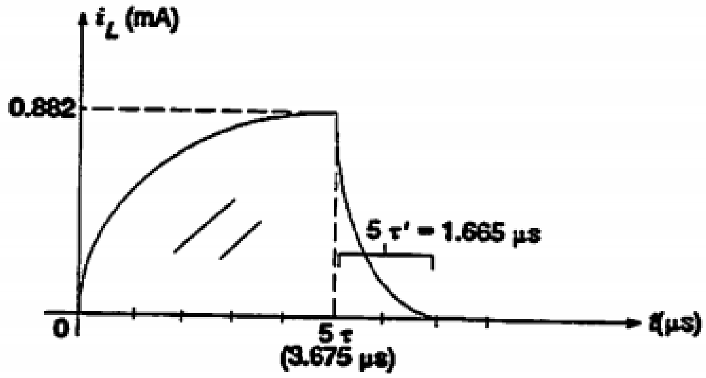
$$v_L = -V_m e^{-t/\tau'}$$

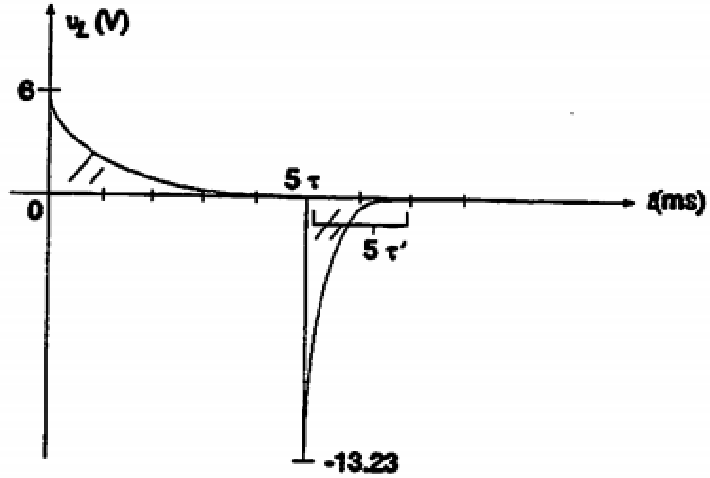
↑ compared to defined polarity of Fig. 12.62.

$$V_m = I_m R = (0.882\ \text{mA})(15\ \text{k}\Omega) = 13.23\ \text{V}$$

$$v_L = -13.23\ e^{-t/0.333\ \mu\text{s}}$$

c.





d. For polarity of Fig. 12.62:

$$V_{R_2\ max} = I_m R_2 = (0.882\ mA)(8.2\ k\Omega) = 7.23\ V$$