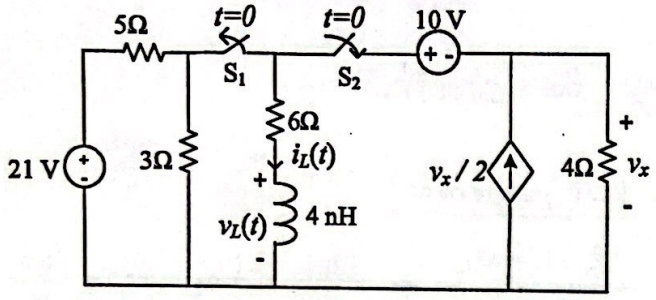
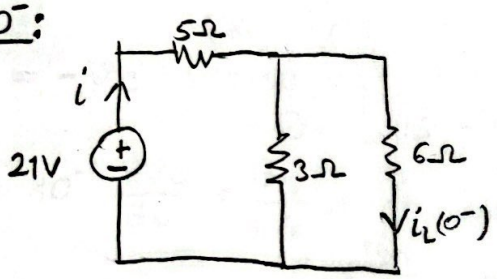
Question 2 (40 pts)

In the circuit below, switch S_1 is opened at t=0 while switch S_2 is closed at t=0. Assume DC steady state conditions are established at $t=0^-$.



a) Find inductor current $i_L(t)$ at $t=0^+$.
b) Find the energy stored in the inductor as $t \to \infty$.
c) Find $i_L(t)$ for t>0.
d) Find $v_x(t)$ for t>0.

$t=0^-$:

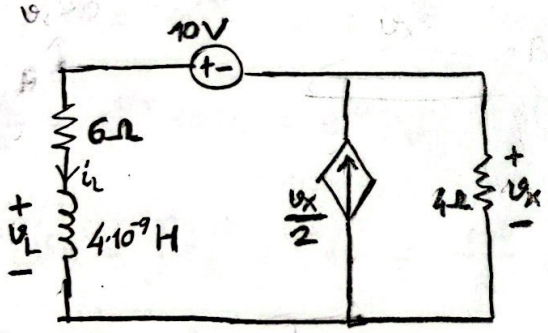


$$R_{eq} = \frac{6\cdot 3}{6+3} + 5 = 7\,\Omega$$

$$i = \frac{21}{7} = 3\,A$$

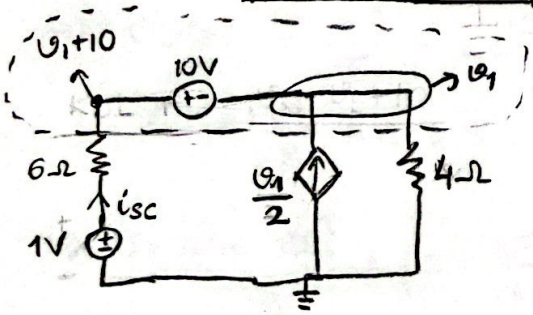
$$i_L(0^-) = 3 \cdot \frac{1}{3} = 1\,A.$$

$t=0^+$:



$$i_L(0^+) = i_L(0^-) = 1\,A$$
(current of inductor is always continuous).

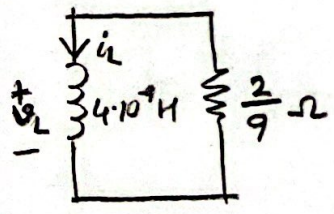
Apply Thevenin:



→ KCL supernode: $\frac{v_1+10-1}{6} + \frac{-v_1}{2} + \frac{v_1}{4} = 0.$
(2) (6) (3)

$$\Rightarrow v_1 = 18\,V \Rightarrow i_{sc} = -\frac{v_1+9}{6} = -4.5\,A$$

$$\Rightarrow R_{Th} = \left|\frac{1}{-4.5}\right| = \frac{2}{9}\,\Omega.$$ Therefore, the Thevenin equivalent circuit is:



KVL: $v_L + \frac{2}{9} i_L = 0 \Rightarrow 4\cdot 10^{-9}\frac{di_L}{dt} + \frac{2}{9} i_L = 0$

$$\Rightarrow \frac{di_L}{dt} + \frac{10^9}{18} i_L = 0 \Rightarrow \int \frac{di_L}{i_L} = \int \frac{-10^9}{18}\,dt$$

$$\Rightarrow \ln i_L = \frac{-10^9}{18} t + C$$

(Continues at the next page.)