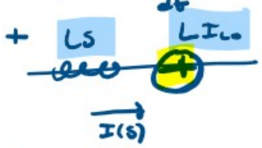
2nd Order Circuits

April 23, 2020 11:12 AM

Laplace domain:

Inductor:

$v(t) = L\frac{di(t)}{dt} \rightarrow V(s) = sLI(s) - Li_L(0)$

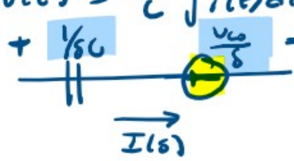


→ source helps current

Capacitor:

$\int i(t)dt \rightarrow \frac{I(s)}{s} + \frac{\int_{-\infty}^{0} i_c(t)dt}{s}$

$v(t) = \frac{1}{C}\int i(t)dt \rightarrow V(s) = \frac{I(s)}{sC} + \frac{v_c(0)}{sC}$



→ source opposes current

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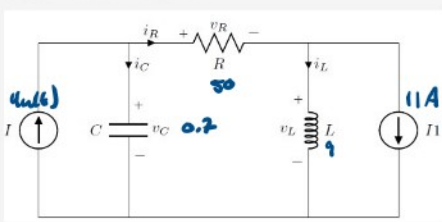
(8 points)
For the circuit shown below, let $I = 4u(t)A$, $C = 0.7F$, $R = 50\Omega$, $L = 9H$ and $I1 = 11A$. Find:

(a) $i_L(0^+), v_C(0^+), v_R(0^+)$

(b) $\frac{di_L(0^+)}{dt}, \frac{dv_C(0^+)}{dt}, \frac{dv_R(0^+)}{dt}$

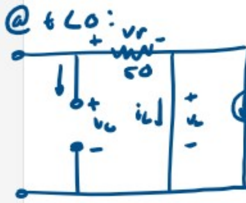
(c) $i_L(\infty), v_C(\infty), v_R(\infty)$



Note: In this problem, you may only submit numerical answers. (i.e. If 4 is the correct answer, 4 will be marked as correct, but 2+2 will be marked as incorrect.)

$i_L(0^+)$	A	$\frac{di_L(0^+)}{dt}$	A/S	$i_L(\infty)$	A
$v_C(0^+)$	V	$\frac{dv_C(0^+)}{dt}$	V/S	$v_C(\infty)$	V
$v_R(0^+)$	V	$\frac{dv_R(0^+)}{dt}$	V/S	$v_R(\infty)$	V

a) @ $t<0$:

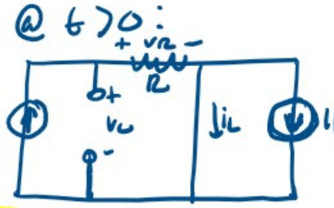


$i_L(0^+) = i_L(0^-) = -11A$

$v_c(0^+) = v_c(0^-) = 0$ V

$v_R(0^+) = v_R(0^-) = 0$ V

@ $t>0$:



Capacitor

$i = C\frac{dv}{dt}$

$v = \frac{1}{C}\int_{-\infty}^{t} i\,dt$

$v_c(0^+) = v_c(0^-)$

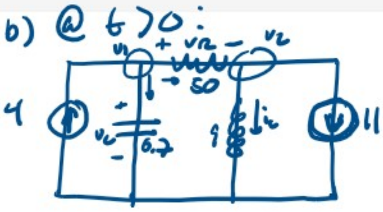
Inductor

$v = L\frac{di}{dt}$

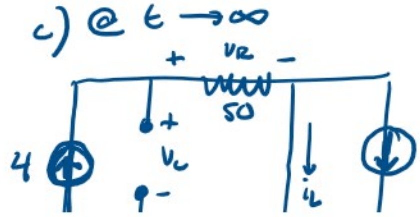
$i = \frac{1}{L}\int_{-\infty}^{t} v\,dt$

$i_L(0^+) = i_L(0^-)$

b) @ $t>0$:



c) @ $t \rightarrow \infty$



KCL1: $4 = i_C + i_R$

$$4 = C\frac{dv_C}{dt} + \frac{v_R}{R}$$

$$\frac{dv_C(0^+)}{dt} = \frac{4}{0.7}$$

$$\boxed{= 5.71429 \text{ V/s}}$$

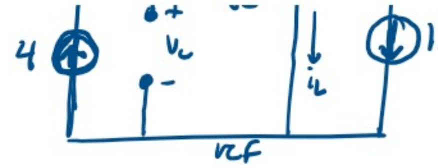
KCL2: $L\frac{di_L}{dt} = v_L - 0$

$$\frac{di_L(0^+)}{dt} = \frac{v_L(0^+)}{9}$$

$$\boxed{= 0 \text{ A/s}}$$

KCL3: $Ri_R = v_L$

$$v_R(0^+) \boxed{= 0 \text{ V/s}}$$



$$v_R(\infty) = 4 \cdot 50$$

$$\boxed{= 200 \text{ V}}$$

$$v_C(\infty) = v_R(\infty) \boxed{= 200\text{V}}$$

$$i_L(\infty) = 4 - 11$$

$$\boxed{= -7 \text{ A}}$$