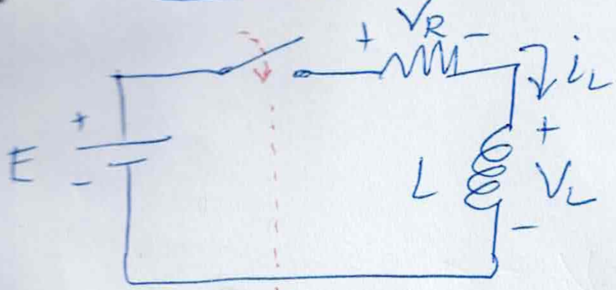
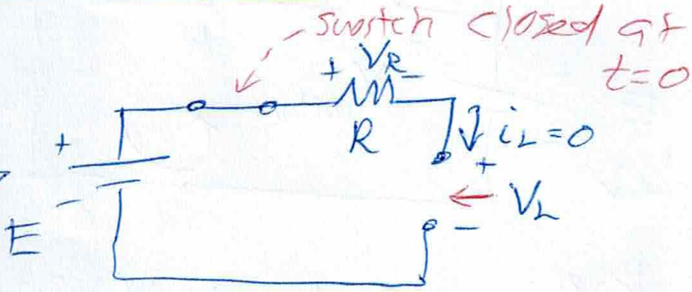
At $t=0$ (initial conditions)



$\Rightarrow$



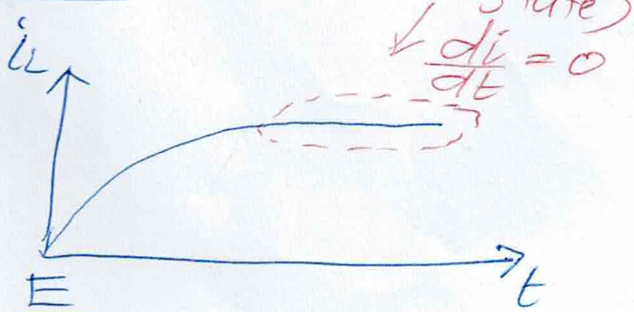
Just before switch is closed ----> No current i_L flows into inductor, so inductor L acts as an open circuit

$V_L = E$

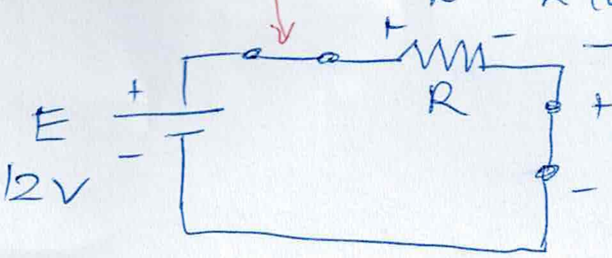
At $t = \infty$ (steady state)

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

$V_L = L(0) = 0$



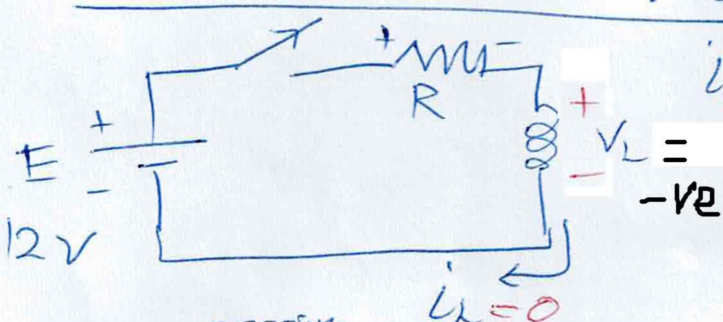
switch closed at $t = \infty$

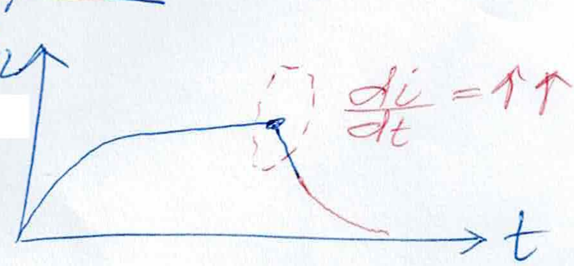


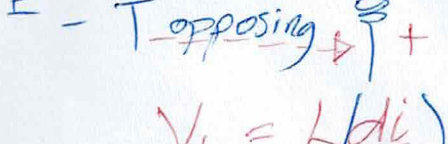
$i_L = \frac{E}{R}$

$V_L = 0$

At $t = \infty$, switch is opened

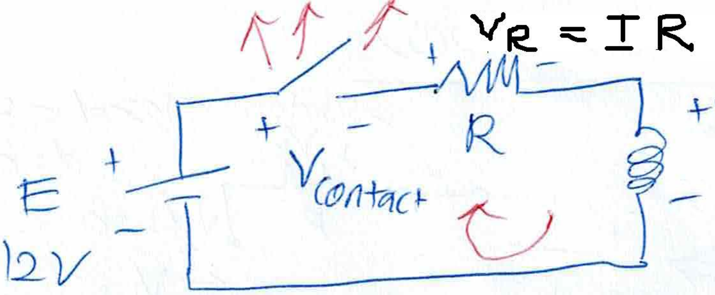






Faraday's Law $\Rightarrow$ induced V_L opposing sudden change of i_L

$V_L = L\left(\frac{di}{dt}\right)$ $V_L \uparrow\uparrow$ because $\frac{di}{dt} \uparrow\uparrow$



$V_R = IR = (0A)(R) = 0$

V_L = negative

KVL $\quad -12 + V_{contact} + (-V_L) = 0$

$$V_{contact} = V_L + 12$$

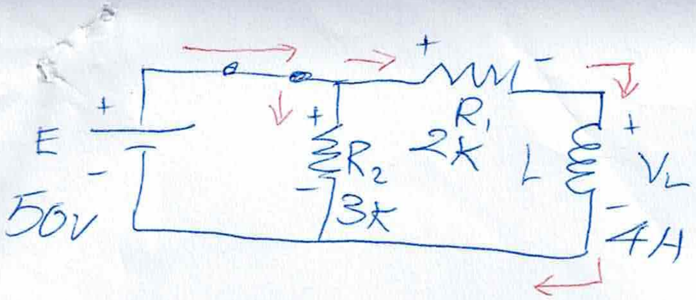
↑↑ ↑↑

spark plug ignition coil

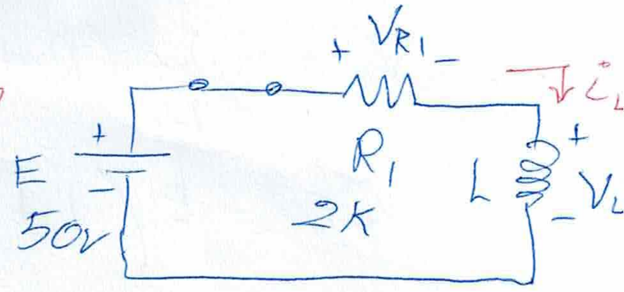
1A → 0A in 10^{-6} seconds

example $\quad V_L = L\left(\frac{di}{dt}\right) \quad$ if $\frac{di}{dt} = \frac{1}{10^{-6}}$

$V_L \approx 10MV \ (10 \times 10^6 V)$



Thevenin



at $t = \infty$ (steady state) (switch is closed)

$$\tau_1 = \frac{L}{R_1} = \frac{4H}{2k} = 2ms$$

$$i_L = \frac{E}{R_1}\left(1 - e^{-\frac{t}{2ms}}\right) = \frac{50V}{2k}\left(1 - e^{-\frac{t}{2ms}}\right)$$

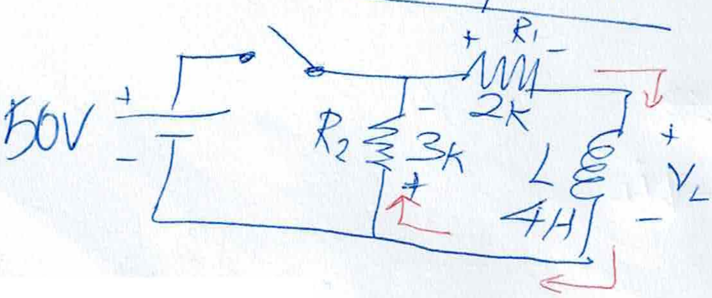
$$i_L = 25mA\left(1 - e^{-\frac{t}{2ms}}\right)$$

$$V_L = E\left(e^{-\frac{t}{2ms}}\right) = 50v\, e^{-\frac{t}{2ms}}$$

$$V_{R_1} = i_L R_1 = (2k)(25mA)\left(1 - e^{-\frac{t}{2ms}}\right)$$

$$V_{R_1} = (50V)\left(1 - e^{-\frac{t}{2ms}}\right)$$

Switch is opened



$$\tau_2 = \frac{L}{R_1 + R_2} = \frac{4H}{2k + 3k} = 0.8\ ms$$

(KVL) $V_{R2} + V_{R1} + V_L = 0$

$$V_L = -(V_{R1} + V_{R2})$$

$$V_L = -i_L(R_1 + R_2)$$

A change in current induces voltage in L (negative V_L)

Just before switched is opened, $i_L = 25mA\left(1 - e^{\frac{-\infty}{2ms}}\right)$

(at $t = \infty$ steady state)

$i_L = 25mA$

or $i_L = \frac{E}{R_1}$

$$V_L = -\frac{E}{R_1}(R_1 + R_2)$$

$$V_L = -E\left(1 + \frac{R_2}{R_1}\right)$$

$$V_L = -50\left(1 + \frac{3k}{2k}\right) = -125\,V$$

Faraday's Law
Induced voltage opposing sudden change of i_L
(negative)

$i_L = 25\,mA$

(KVL)

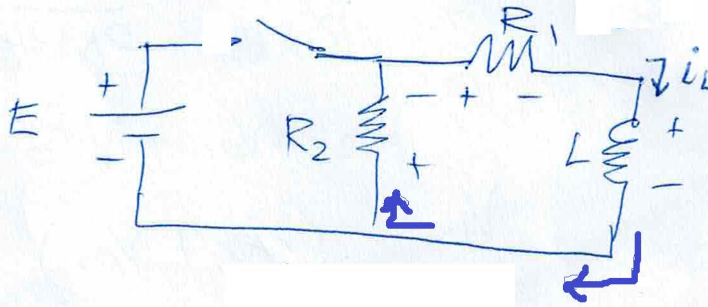
$$V_{R2} + V_{R1} + V_L = 0$$

$$V_{R_1} = (I_L)R_1 = (25mA)(2K) = 50V$$

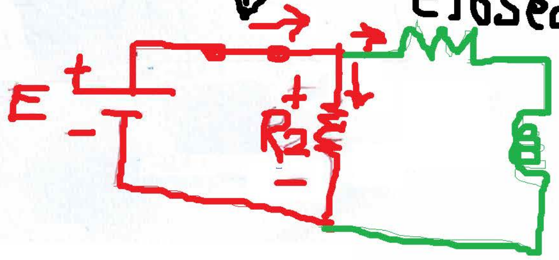
$$V_{L_1} = -125V$$

$$V_{R_2} + 50V - 125V = 0$$

$$V_{R2} = 75V$$



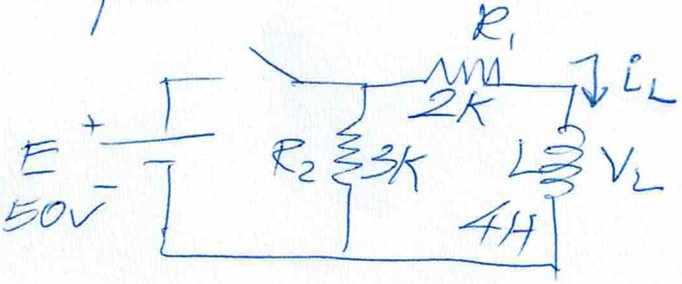
Previous (When the switch is closed)



Here $V_{R_2} = -75V$

because current ↑ is opposite to previous current ↓

When switch is opened



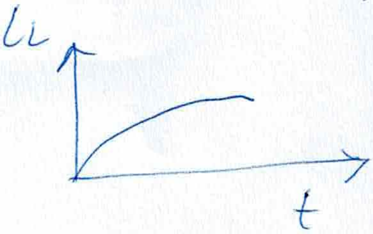
$$\tau_2 = \frac{L}{R_1 + R_2} = \frac{4H}{2K + 3K} = 0.8ms$$

$$V_L = -125V\left(e^{-\frac{t}{0.8ms}}\right)$$

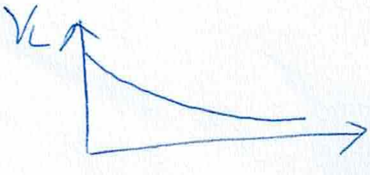
$$I_L = 25mA\left(e^{-\frac{t}{0.8ms}}\right)$$

Switch closed

$(t = \infty)$

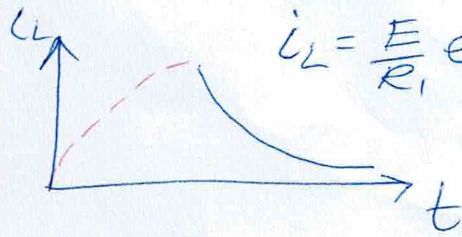


$$i_L = \frac{E}{R_1}\left(1 - e^{-\frac{t}{\tau_1}}\right)$$

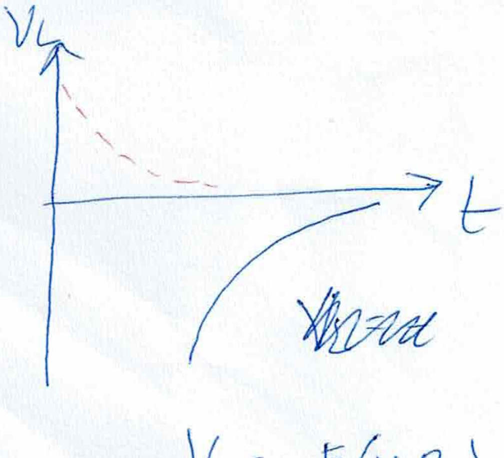


$$V_L = E\left(e^{-\frac{t}{\tau_1}}\right)$$

switch opened



$$i_L = \frac{E}{R_1} e^{-\frac{t}{\tau_2}}$$



$$V_L = -E\left(1 + \frac{R_2}{R_1}\right) e^{-\frac{t}{\tau_2}}$$