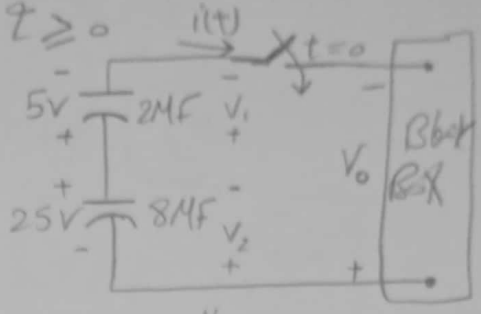
# Handwritten Assignment #2

**1** resulting current is $800e^{-25t}$ mA @ $t \geq 0$

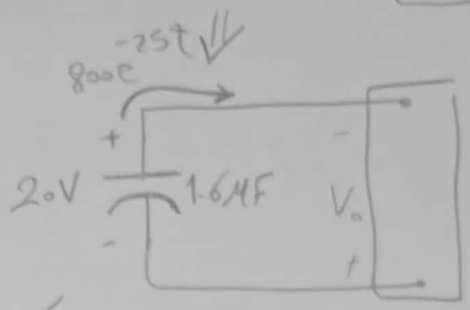



@ equivalent capacitor:

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{(2*8)*10^{-12}}{(2+8)*10^{-6}} = \boxed{1.6\,\mu F}$$

$$i = C\frac{dv}{dt} \rightarrow i\,dt = C\,dv \rightarrow \int dv = \frac{1}{C}\int i\,dt$$

$$\therefore V_o = \frac{1}{C}\int i(\tau)\,d\tau + V_o(t_o) \qquad \boxed{V_o(t_o) = -20}$$




$$V_o = \frac{1}{1.6*10^{-6}}\int_0^t (800e^{-25\tau}*10^{-6})\,d\tau - 20$$

$$= \frac{800}{1.6(-25)}e^{-25\tau}\Big|_0^t - 20 = (-20e^{-25t} - (-20)) - 20$$

$$\therefore \boxed{V_o(t) = -20e^{-25t}\ V} \quad @\ t \geq 0 \qquad \#①$$

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(b) $V_1(t) = ?$

$$V_1(t) = \frac{1}{C_1}\int i(\tau)\,d\tau + V_o(t_o) \qquad \boxed{V_o(t_o) = 5V}$$

$$= \frac{1}{2*10^{-6}}\int_0^t (800e^{-25\tau}*10^{-6})\,d\tau + 5 = \frac{800}{2*-25}e^{-25\tau}\Big|_0^t + 5 = (-16e^{-25t} - (-16)) +$$

$$= \boxed{21 - 16e^{-25t}\ V} \quad @\ t \geq 0 \qquad \#②$$

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(c) $V_2(t) = ?$

Similar as (b) $\rightarrow V_2(t) = \frac{800}{8*-25}e^{-25\tau}\Big|_0^t - 25 = (-4e^{-25t} - (-4)) - 25$

$$= \boxed{-4e^{-25t} - 21\ V} \quad @\ t \geq 0 \qquad \#③$$

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(d) energy to black box $= ?$ $\quad 0 \leq t \leq \infty$

$$P = vi = -(-20e^{-25t})(800*10^{-6}e^{-25t}) = \boxed{16*10^{-3}e^{-50t}\ \text{watt}}$$

$$W = \int P\,dt = \int_0^\infty 16*10^{-3}e^{-50t}\,dt = \frac{16*10^{-3}}{-50}e^{-50t}\Big|_0^\infty = -3.2*10^{-4}(0-1)$$

$$= \boxed{320\,\mu J} \qquad \#④$$

(e) Energy initially Stored in Series Capacitors = ?

$$W_{initial} = \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_1^2 = \frac{1}{2}\left[(2*10^{-6})(5)^2 + (8*10^{-6})(25)^2\right] = 2525\,\mu J$$

$W_{initial} = 2525\,\mu J$ #(5)

(f) $W_{Trapped} = (-W_{delivered}) + W_{initial} = 2525 - 320 = 2205\,\mu J$

$W_{Trapped} = 2205\,\mu J$ #(6)

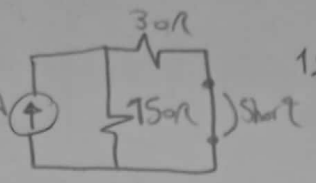
(g) $W_{Trapped} = \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_2^2 = \frac{1}{2}\left[(2*10^{-6})(21)^2 + (8*10^{-6})(-21)^2\right] = 2205$

$W_{Trapped} = 2205\,\mu J$ #(7)

→ which agree with answers obtained in (f)

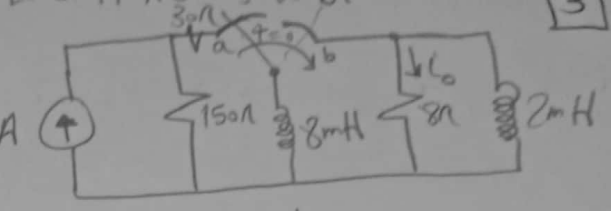
[2] switch is @ a for a long time & @ t=0 it moves to b. [3]

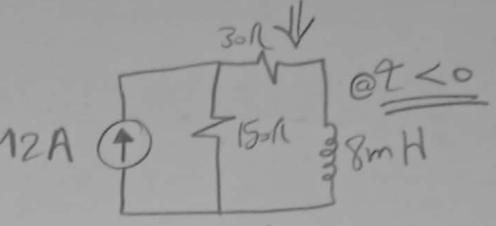
@ $i(t)=?$ @ $t \geq 0$




$\therefore i_{R_2}(0^-) = \frac{15}{18}(12) = 10A$ (using current divider)

$\therefore i_L(0^-) = 10A$

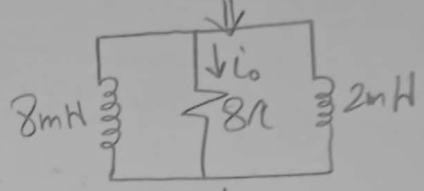


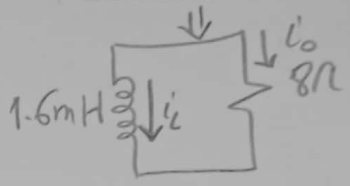

$\Rightarrow$ After switch moves to b

$L_{eq} = \frac{8*2*10^{-6}}{(8+2)*10^{-3}} = 1.6\,mH$

$T = \frac{L}{R} = \frac{1.6*10^{-3}}{8} = 200*10^{-6}$




$i_o(t) = I_o e^{-t/T} = -10\,e^{\frac{-t}{200*10^{-6}}} = -10\,e^{-5000t}\ A$




$\therefore i_o(t) = -10\,e^{-5000t}\ A$ #①

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(b) energy$_{8\Omega} = \frac{1}{2} L i^2 = \frac{1}{2}(1.6*10^{-3})(10)^2 = 80\,mJ$ #②

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(c) $\frac{95}{100} * \text{energy}_{8\Omega} = \frac{95}{100} * 80*10^{-3} = \frac{19}{250}$ , $W = \int_0^{t_o} i_o^2(t).R\,dt$

$\frac{19}{250} = \int_0^{t_o} 8(100\,e^{-10,000t})\,dt$

$R.H.S = 800 \int_0^{t_o} e^{-10,000t}\,dt = \frac{800}{-10,000} e^{-10,000t}\Big|_0^{t_o} = -8*10^{-2}(+e^{-10,000t_o} - 1)$

$\therefore \frac{19}{250} = 76*10^{-3} = -8*10^{-2}(-1 + e^{-10,000t_o})$

$\therefore e^{-10,000t_o} = 0.05 \rightarrow t_o = 299.57\,\mu s$

$\frac{t_o}{T} = \frac{299.57*10^{-6}}{200*10^{-6}} = 1.498$ So $t_o \approx 1.498T$ #③

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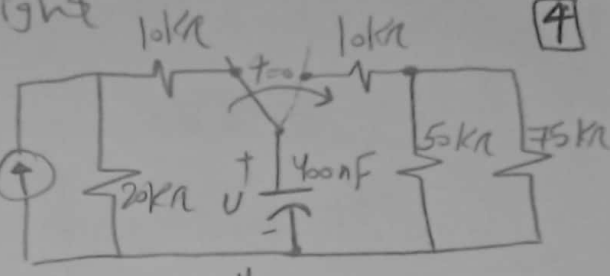
③ Switch on left for $t<0$ & $t=0$ switch to right

④

@ $V_{initial}=?$

$V(0^-) = (10 * 10^{-3})(20 * 10^3) = \boxed{200\,V}$ #①

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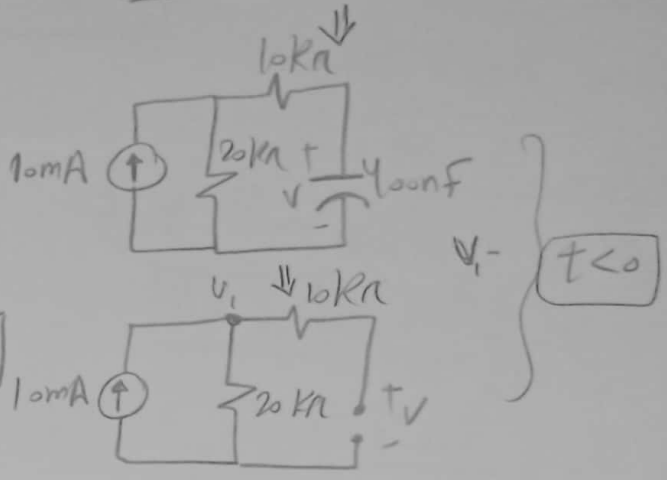
⑥ $W_{initial} = \frac{1}{2}CV^2 = \frac{1}{2}(400 * 10^{-9})(200)^2$

$W_{initial} = \boxed{8\,mJ}$ #②

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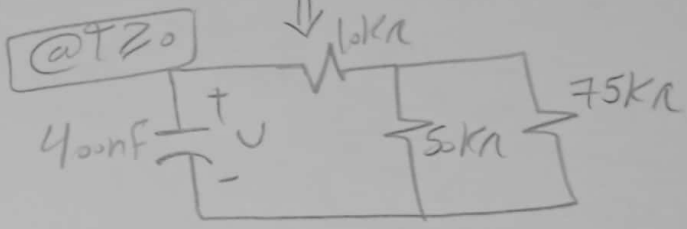
⑤ $\tau = CR_{eq} = (40 * 10^3)(400 * 10^{-9}) = \boxed{0.016}$

$R_{50,75} = \frac{(50 * 75)10^6}{(50+75)10^3} = \boxed{30k\Omega}$

$R_{eq} = 30 + 10 = \boxed{40k\Omega}$

$\therefore \tau = \boxed{16\,ms}$ #③

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⑦ $V(t) = ?$ for $t \geq 0$

$V = V_0 e^{-t/\tau} = 200\,e^{\frac{-t}{0.016}} = \boxed{200\,e^{-62.5t}\,V}$ for $t \geq 0$ #④

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