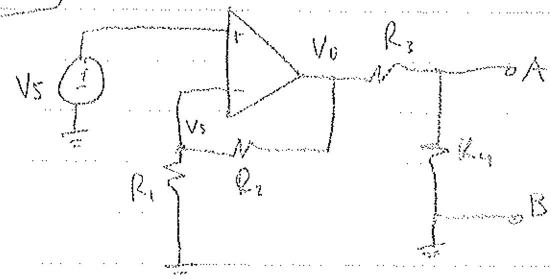
HW # 23 Solution

6.30



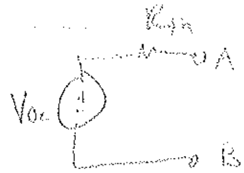
KCL: $\frac{V_S}{R_1} + \frac{V_S - V_O}{R_2} = 0 \rightarrow V_O = V_S\left(\frac{R_2}{R_1}+1\right)$

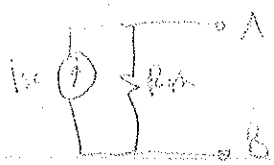
$$V_{AB} = V_{OC} = V_O\left(\frac{R_4}{R_3+R_4}\right) = \boxed{V_S\left(\frac{R_2}{R_1}+1\right)\left(\frac{R_4}{R_3+R_4}\right)}$$

$$i_{SC} = V_O/R_3 = \boxed{\frac{V_S}{R_3}\left(R_2/R_1+1\right)}$$

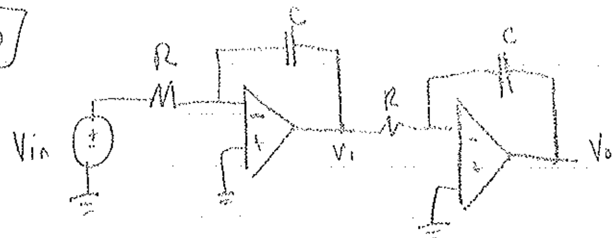
$$R_{th} = V_{OC}/i_{SC} = \frac{\left(\frac{R_2+R_1}{R_1}\right)\left(\frac{R_4}{R_3+R_4}\right)R_3}{\left(\frac{R_2+R_1}{R_1}\right)}$$

$$\boxed{= \frac{R_3 R_4}{R_3+R_4}}$$





8.38



$R = 10k$

$C = 10\mu F$

$V_{in} = 10 \sin 50t \; u(t) \; mV$

$$\frac{-V_{in}}{R} + C\frac{dV_1}{dt} = 0$$

$$V_1 = \frac{1}{C}\int_0^t V_{in}/R \; d\tau = \frac{1}{10\mu \, 10k}\int_0^t \frac{10}{1000} \sin 50\tau \; d\tau$$

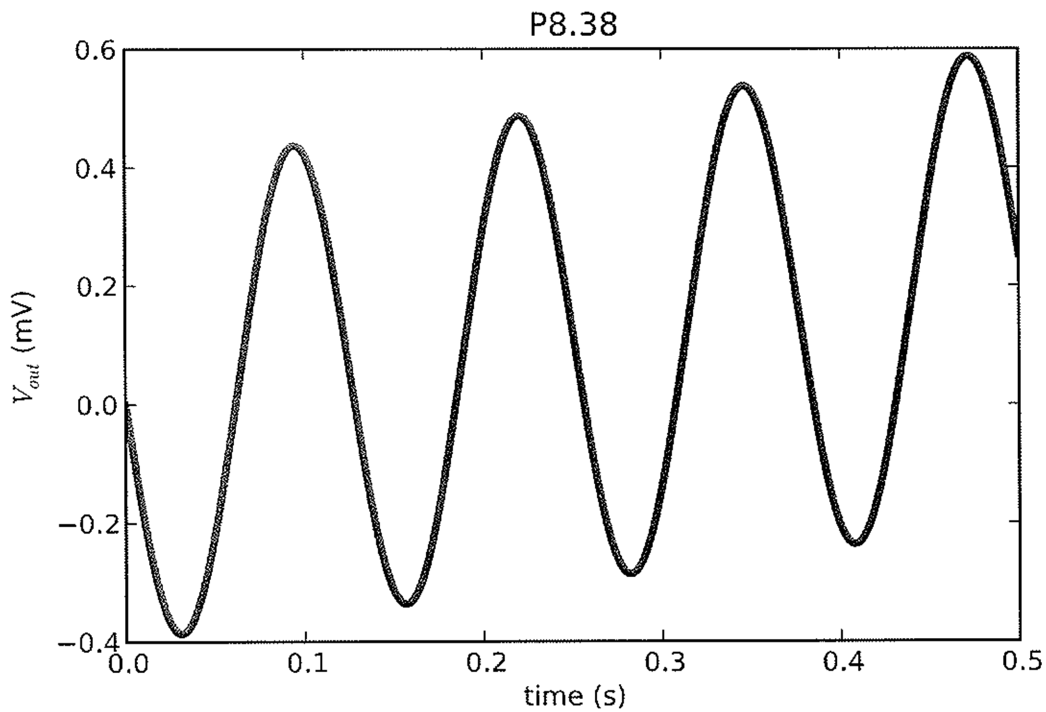
$$= -\frac{0.1}{50}\left(\cos 50t - \cancel{\cos} \; 0\right)$$

$$V_0 = \frac{1}{RC}\int_0^t V_1 \, dt = \frac{1}{10\mu \, 10k}\int_0^t (-.002 \cos 50\tau - 1) \, d\tau$$

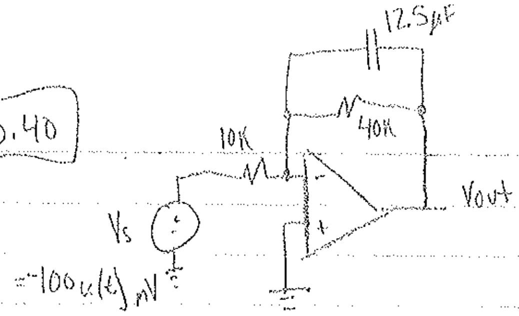
$$= \frac{10(-.002)}{50}\left(\sin 50t - t\right)$$

$$\boxed{= -0.4\left(\sin 50t - t\right) \; mV}$$

SEE PLOT ATTACHED.


P8.38
0.6
0.4
0.2
0.0
−0.2
−0.4
V_{out} (mV)
0.0
0.1
0.2
0.3
0.4
0.5
time (s)

8.40



a) $V_c(0^-) = 0 = V_c(0^+)$.

Vout will follow general RC solution:

$$V_c(t) = V_c(\infty) + (V_c(0) - V_c(\infty))\, e^{-t/\tau}$$

$\tau = RC$, where $R = 40K$, because with sources off, 10K has ground on both sides (shorted out). $\tau = (40K)(12.5\mu) = \underline{.5 \text{ sec}}$

Without capacitor ($t = \infty$), it's inverting, $V_o = -V_s\left(\frac{40}{10}\right) = -4V_s = \underline{+400 mV}$

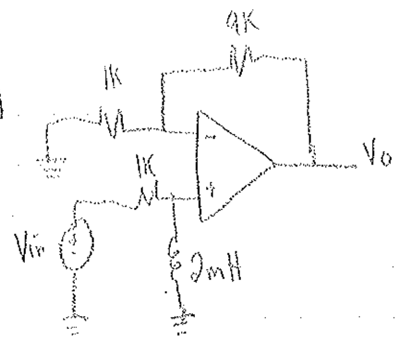
so $\boxed{V_c(t) = +400 - 400e^{-2t} \text{ mV}}$

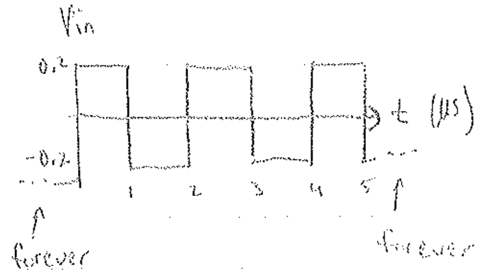
b) Now $V_c(0^-) = 50mV = V_c(0^+)$
everything else is the same,

$$V_c(t) = -400 + (50 - 400)e^{-2t}$$

$$\boxed{= +400 - 350e^{-2t} \text{ mV}}$$

#4





Looking at just the RL part: $i_L(\infty) = V_{in}/R = 0.2/1000 = \underline{0.2\ mA}$

$i_L(0)$ depends on where i_L is before each switch, because it hasn't been at -0.2 v for "a long time", we have to find it by plugging in:

$$i_L(1\mu s) = i_L(\infty) + \left(i_L(1\mu s) - i_L(\infty)\right) e^{-t/\tau}.$$

$\tau = L/R = 2mH/1000\ \Omega = 2\mu s.$

$$i_L(1) = 0.2mA + \left[i_L(1) - 0.2mA\right] e^{-1/\tau}$$

$$i_L(1)\left(1 + e^{-1/\tau}\right) = 0.2mA - 0.2mA\, e^{-1/\tau}$$

$$i_L(1) = 0.049\ mA \qquad = i_L(3) = i_L(5) \ldots$$

$$i_L(0) = -i_L(1) = \underline{-0.049\,mA.} \quad \approx \underline{0.05}$$

so $i_L(t) = \begin{cases} 0.2 - 0.25\ e^{-(t-T_i)/\tau} & mA \quad \text{Rising transitions} \\ -0.2 + 0.25\ e^{-(t-T_i)/\tau} & mA \quad \text{Falling transitions.} \end{cases}$

and $V_+ = L\, di_L/dt$

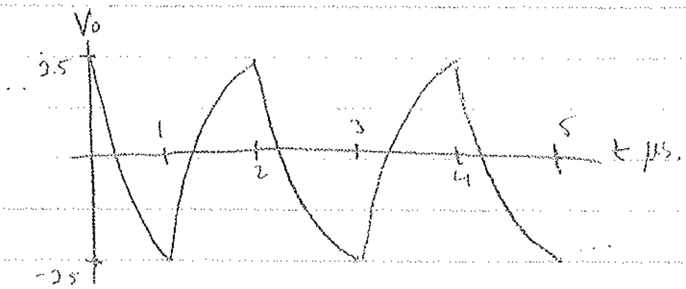
$$= 2mH \ \frac{-0.25mA}{2\mu s}\ e^{-(t-T_i)/\tau}$$

$$V_+ = \begin{cases} +0.25\ e^{-(t-T_i)/2\mu s}\ v & \text{Rising} \\ -0.25\ e^{-(t-T_i)/2\mu s}\ v & \text{Falling} \end{cases}$$

Now $V_- = V_+$ → Non-inverting amplifier with $\mu = 1 + 9k/1k = 10$.

$V_0 = 10\,V_+$

$$\boxed{V_0 = \begin{cases} 2.5\, e^{-(t-T_1)/2\mu s}\ \text{v for Rising transitions of } V_{in} \\ -2.5\, e^{-(t-T_2)/2\mu s}\ \text{v for falling transitions of } V_{in}. \end{cases}}$$



$T_1 = 0, 2, 4,$ etc..
$T_2 = 1, 3, 5,$ etc..