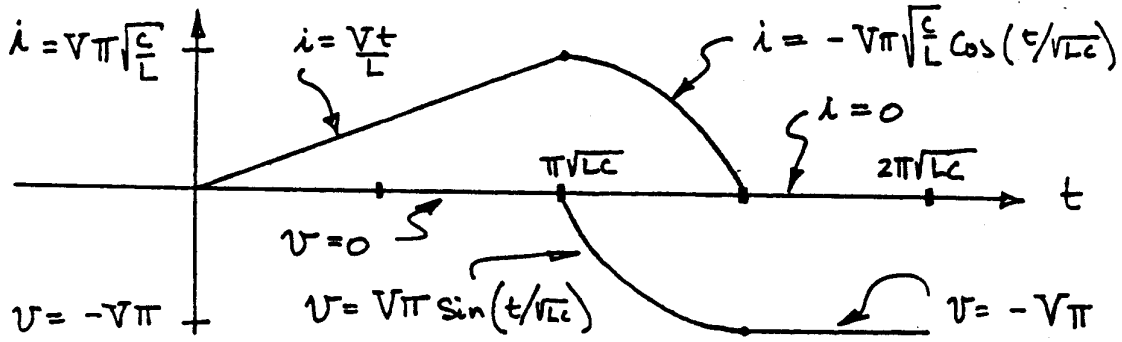
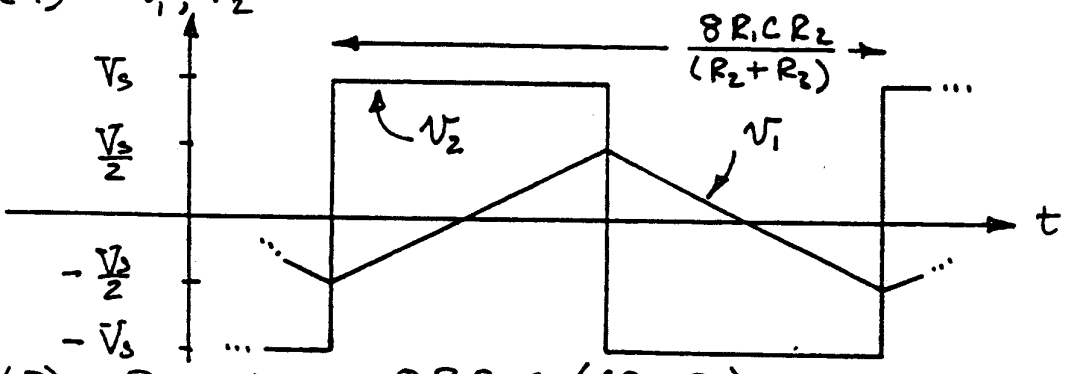
Problem 1 (A) $R = 1\Omega$; $V_1 = 4V$; $V_2 = 2V$.
(B) $i = -1A$; $v = 2V$. (C) $v = 4V(1 - e^{-t/\tau})$ for $t \leq \ln(2)\,s$ where $\tau = 1\,s$; $v = 2V$ for $t \geq \ln(2)\,s$.

Problem 2 (A) $i = \frac{V}{L}t$; $v = 0$.
(B) $i = -V\pi\sqrt{\frac{C}{L}}\cos(t/\sqrt{LC})$ for $\pi\sqrt{LC} \leq t \leq \frac{3\pi}{2}\sqrt{LC}$, and $i = 0$ for $\frac{3\pi}{2}\sqrt{LC} \leq t \leq 2\pi\sqrt{LC}$; $v = V\pi\sin(t/\sqrt{LC})$ for $\pi\sqrt{LC} \leq t \leq \frac{3\pi}{2}\sqrt{LC}$, and $v = -V\pi$ for $\frac{3\pi}{2}\sqrt{LC} \leq t \leq 2\pi\sqrt{LC}$.
(C) v, i



(D) Energy $= \frac{\pi^2}{2}CV^2$ at $t = \pi\sqrt{LC}$; Energy $= 0$ at $2\pi\sqrt{LC}$.
(E) $v = -\sqrt{2}\,\pi\,V$

Problem 3 (A) $v_1 = \frac{1}{2R_1C}\int_{-\infty}^{t} v_2\,dt$ (B) v_2 switched down for $v_1 \geq \frac{R_2}{R_2+R_3}V_s$, and v_2 switched up for $v_1 \leq \frac{-R_2}{R_2+R_3}V_s$.
(C) v_1, v_2



(D) Period $= 8R_1R_2C/(R_2+R_3)$

Solutions

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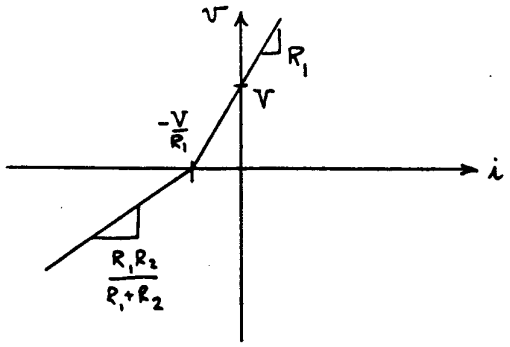
Problem 1

(A)



(B) $i = \frac{-V}{R_1+R_3} + \frac{-R_3 I}{R_1+R_3}$ $\qquad v = \frac{V R_3}{R_1+R_3} + \frac{I R_1 R_3}{R_1+R_3}$

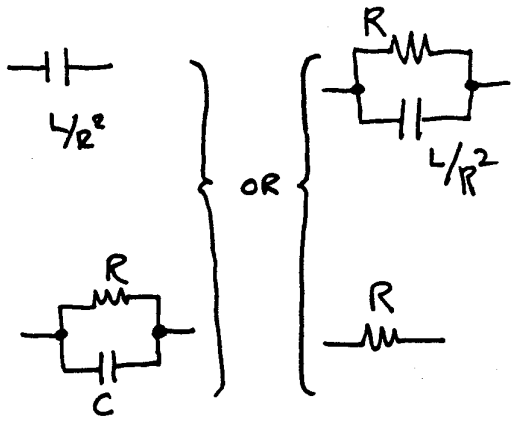
(C) $i(t) = -\frac{V_0}{R_1}\left(1-e^{-\frac{R_1 t}{L}}\right)$ $t \le T$ $\quad$ $-\frac{V_0}{R_1}\left(1-e^{-\frac{R_1 T}{L}}\right)\left(e^{-\frac{(t-T)R_1R_2}{(R_1+R_2)L}}\right)$ $t \ge T$

Problem 2

(A) Equation:
$$\begin{cases} \frac{v_1}{R} + \frac{v_2}{R} + \frac{L}{R^2}\frac{dv_2}{dt} + \frac{1}{R^2C}\int_{-\infty}^{t} v_2\,dt = 0 \\ \frac{d^2v_2}{dt^2} + \frac{R}{L}\frac{dv_2}{dt} + \frac{1}{LC}v_2 = -\frac{R}{L}\frac{dv_1}{dt} \end{cases}$$

(B) Equation: $v_3 = \frac{1}{RC}\int_{-\infty}^{t} v_2\,dt$

(C) Network #1:



Network #2:

Problem 3

(A) $v_1 = |v_0|$

(B) $v_2 \cong -v_T \ln\left(\frac{v_1}{RI_s}\right)$

(C) $v_3 = -v_2$

(D) $v_3 = v_T \ln\left(\frac{|v_0|}{RI_s}\right)$

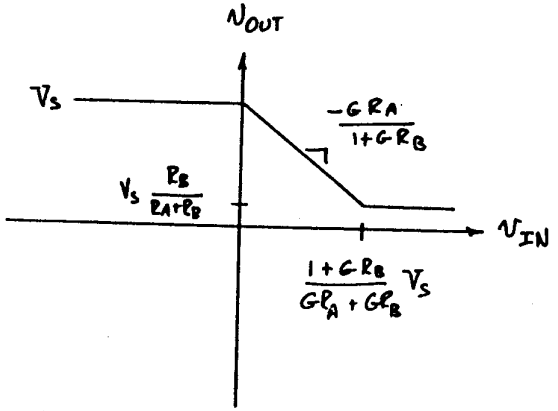
(E) Function: log absolute value

Problem 4

(A) Max v_{OUT} = V_S

Min v_{OUT} = $V_S \dfrac{R_B}{R_A + R_B}$

(B)



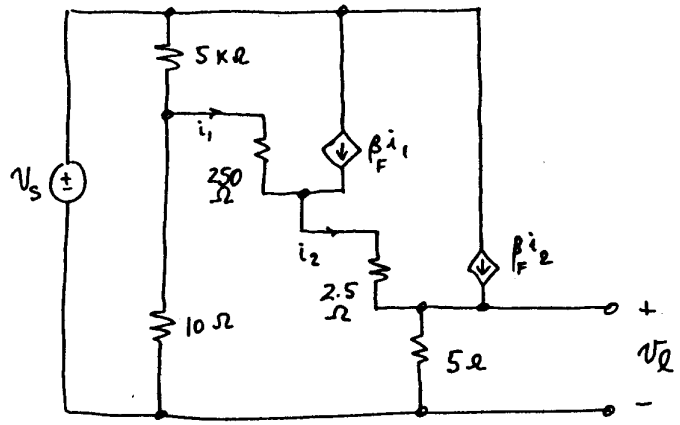
(C) $v_{OUT} = V_s - GR_A\left(\dfrac{V_B}{1+GR_B} + \dfrac{V_s}{\sqrt{(1+GR_B)^2 + (\omega R_B C)^2}} \cos\left(\omega t - \tan^{-1}\left(\dfrac{\omega R_B C}{1+GR_B}\right)\right)\right)$

(D) ω: $\omega \ll \dfrac{1+GR_B}{R_B C}$

Problem 5

(A) V_L = 5 Volts

(B) Small-Signal Model:



(C) $v_l/v_s \cong \dfrac{1}{500}$

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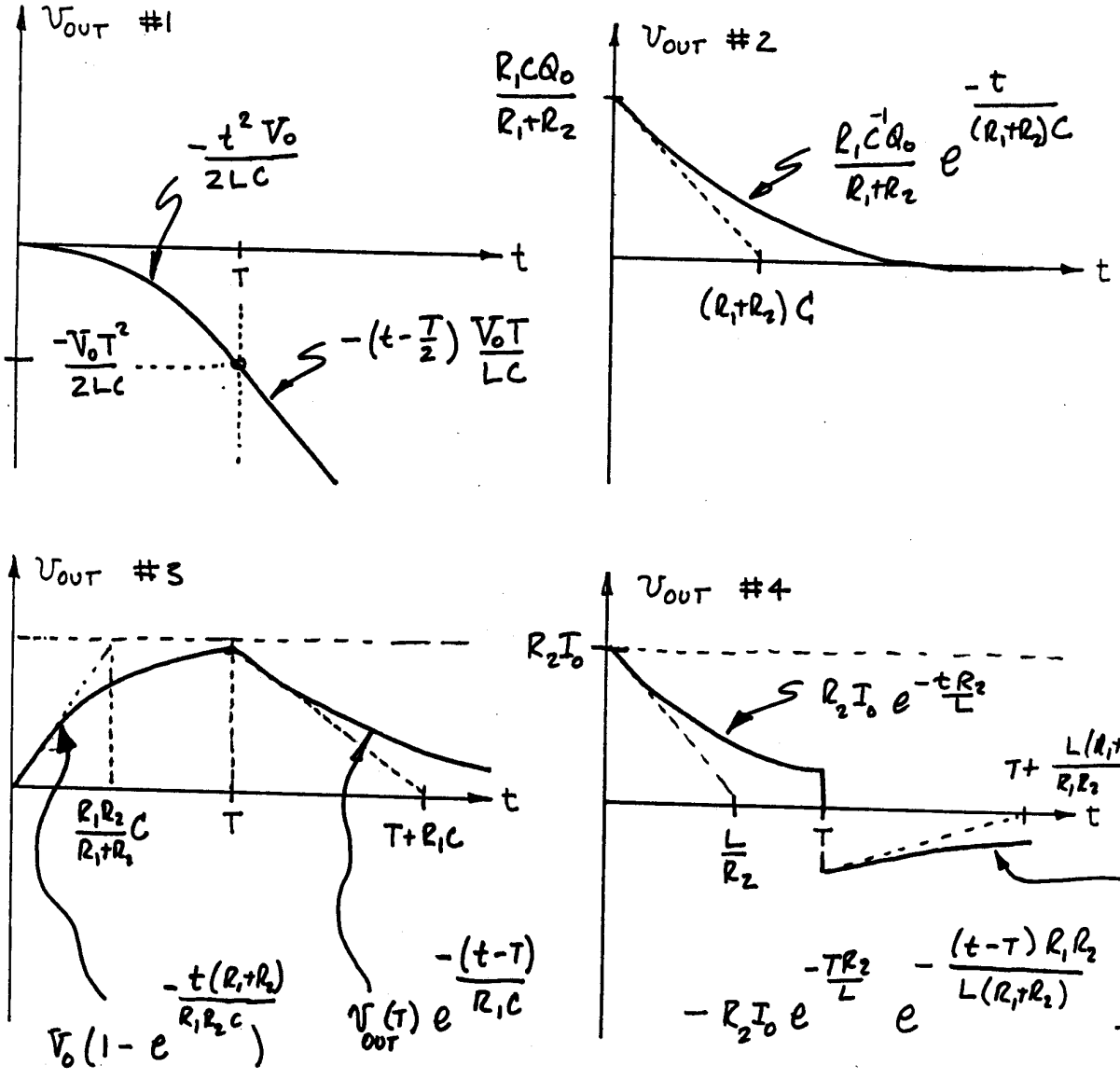
6.002 Final Exam

Name: SOLUTIONS

Instructor:	Wilson	Antoniadis	Pratt	Gould	Kolodziejski	Lee
Time:	9 10	10	10	11 12	11 12	1 2

Problem 1



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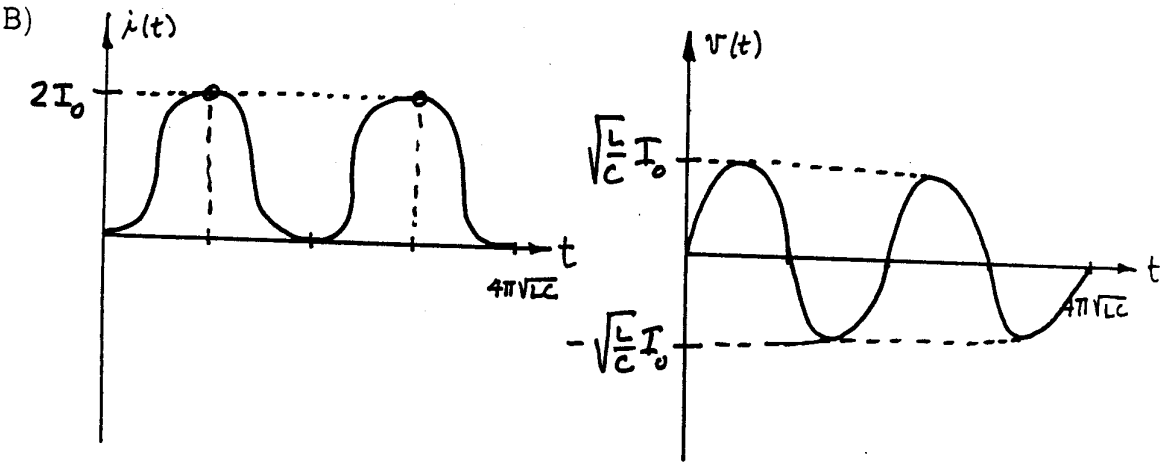
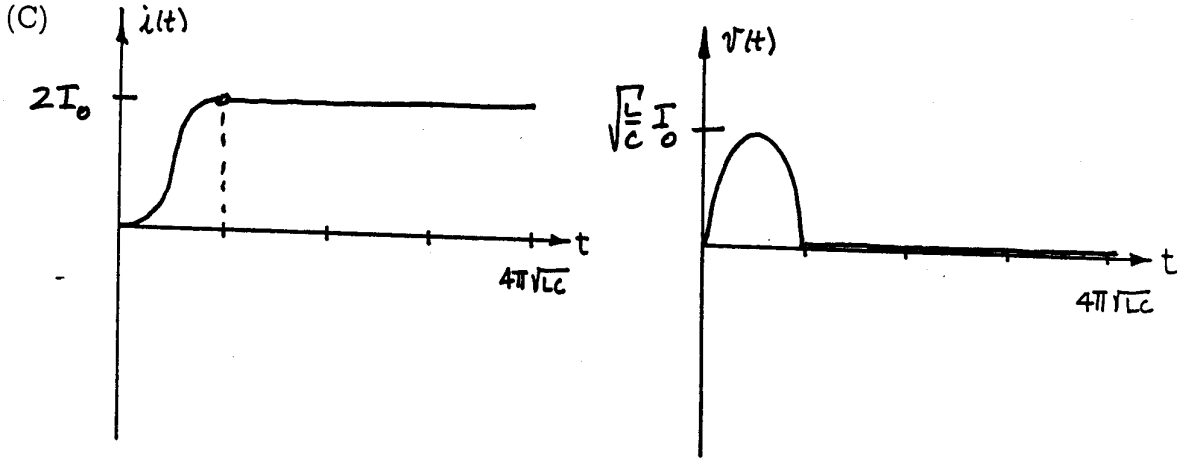
Problem 2

(A) $i(t) = I_0\left(1 - \cos\left(\frac{t}{\sqrt{LC}}\right)\right)$ $\quad v(t) = \sqrt{\frac{L}{C}}\, I_0 \sin\left(\frac{t}{\sqrt{LC}}\right)$

(B)



(C)



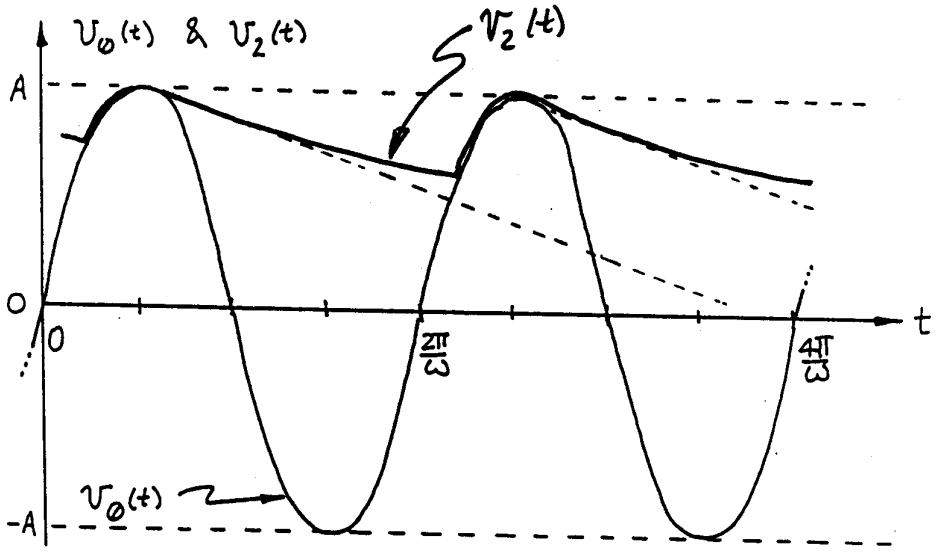
(D) $i = \sqrt{4+\pi^2}\, I_0$ $\quad v = 0$

6.002 Final Exam Name: SOLUTIONS

Problem 3

(A) $\|v_1(t)\| = \dfrac{2\omega^2}{\omega^2 + \omega_1^2} A$

(B)



(A) $v_2(t) = A$

(D) $v_4(t) = V\ \mathrm{sgn}\left(v_2(t) - v_3(t)\right)$

(E) Light Bulb Lights $\Leftrightarrow$ $\omega > \omega_1$

6.002 Final Exam Solutions

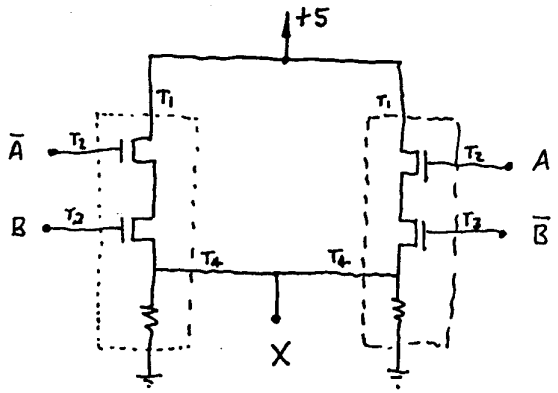
Problem 1

(A) $C = \overline{\overline{A} \cdot B} = A + \overline{B}$

Truth Table

A	B	C
0	0	1
0	1	0
1	0	1
1	1	1

(B) Implementation:



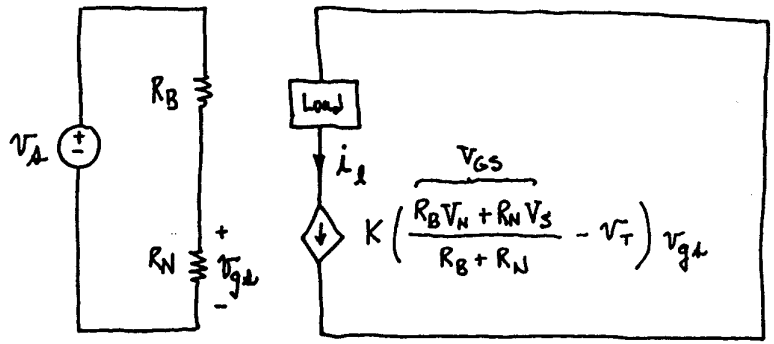
(C) Constraint: $\left(\frac{5\text{ V}}{\tilde{V}_{OH}} - 1\right)\frac{R}{4R_n} > \frac{L}{W}$

Problem 2

(A) $V_{GS} = \dfrac{R_B V_N + R_N V_S}{R_B + R_N}$

(B) $I_L = \dfrac{K}{2}\left(\underbrace{\dfrac{R_B V_N + R_N V_S}{R_B + R_N}}_{V_{GS}} - V_T\right)^2$

(C) Circuit Model:



(D) $i_L/v_s = K\left(\dfrac{R_B V_N + R_N V_S}{R_B + R_N} - V_T\right)\dfrac{R_N}{R_N + R_B}$

Problem 3

(A) Differential Equation: $\frac{R_I C_I}{A}\frac{dv_{OUT}}{dt} + \left[\frac{R_A}{R_A+R_B} + \frac{1}{A}\right] v_{OUT} = v_{IN}$

(B) $G = \frac{R_A+R_B}{R_A}$

(C) $v_{OUT} = G V_I \left(1 - e^{-t/\tau}\right)$ & $\tau \equiv \frac{R_I C_I G}{A}$

(D) $T = \frac{R_I C_I G}{A}$

(E) Circle One: (Increase) Decrease Remains Unchanged

Problem 4

(A) Differential Equation: $LC\frac{d^2 v_{OUT}}{dt^2} + \frac{L}{R}\frac{dv_{OUT}}{dt} + v_{OUT} = v_{IN}$

(B) $N = \frac{1}{\sqrt{(1-\omega^2 LC)^2 + \left(\frac{\omega L}{R}\right)^2}}$

$\phi = -\tan^{-1}\left(\frac{\frac{\omega L}{R}}{1-\omega^2 LC}\right)$

(C) $C = 1/\omega^2 L$

$N = \frac{R}{\omega L}$

(D) $\tau = \frac{\omega}{2N}$

(E) Disadvantage: Large voltage boost, as measured by N, and the ability to rapidly vary the output voltage amplitude, as measured by $1/\tau$, are opposing objectives.

Problem 5

(A) $v_1 = \frac{v_A + v_B}{2}$

(B) $v_2 = -2RK v_1^2$

(C) $v_3 = RK v_A v_B$