Physics 120 Midterm "Cheat Sheet"

Device	$V = f(I)$	$I = f(V)$	Z
R	$V = IR$	$I = V/R$	R
L	$V = L\frac{dI}{dt}$	$I = \frac{1}{L}\int_{0^+}^{t} dx\, V(x) + V_0$	$j\omega L$
C	$V = \frac{1}{C}\int_{0^+}^{t} dx\, I(x) + V_0$	$I = C\frac{dV}{dt}$	$\frac{1}{j\omega C}$

Convolution

$$V(t) = \int_{-\infty}^{t} dx\, \Phi(x)\, F(t-x)$$

$\Phi(x)$: Solution to homogeneous equation

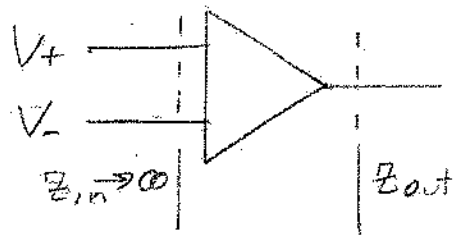
$F(t-x)$: Drive term

Fourier Transform

$$\hat{V}(\omega) = \int_{-\infty}^{+\infty} dt\, V(t)\, e^{-i\omega t}$$

$$V(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} d\omega\, \hat{V}(\omega)\, e^{+i\omega t}$$

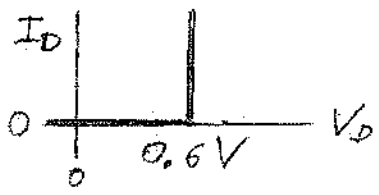
Ideal Operational Amplifier



$V_0 = A(V_+ - V_-)$ with $A \to \infty$

Diode

$$I_D = I_0\left(e^{eV_0/k_BT} - 1\right) \xrightarrow{\text{Approx}}$$



Some Math Relations

Complex numbers

Let $c \equiv a + ib$

$$|c| = \sqrt{(a+ib)(a-ib)} = \sqrt{a^2+b^2}$$

$$\arg\{c\} = \operatorname{atan}(\mathrm{Im}\{c\}/\mathrm{Re}\{c\}) = \operatorname{atan}\{b/a\}$$

Trigonometry

$$\sin x = x - \frac{x^3}{3!} + \cdots$$

$$\cos x = 1 - \frac{x^2}{2} + \cdots$$

$$\sin x = \frac{1}{2i}\left[e^{ix} - e^{-ix}\right]$$

$$\cos x = \frac{1}{2}\left[e^{ix} + e^{-ix}\right]$$

Calculus

$$\frac{d(xy)}{dt} = x\frac{dy}{dt} + y\frac{dx}{dt}$$

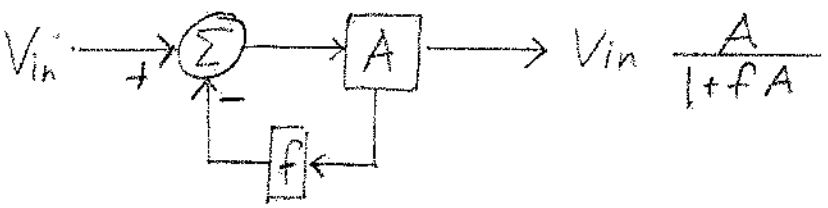
$$\int \frac{dx}{x} = \log x + \text{Constant}$$

When $f(x) \to 0$ and $g(x) \to 0$ as $x \to 0$, then

$$\lim_{x\to 0}\left[f(x)/g(x)\right] = \lim_{x\to 0}\left[\frac{df(x)}{dx} \Big/ \frac{dg(x)}{dx}\right]$$

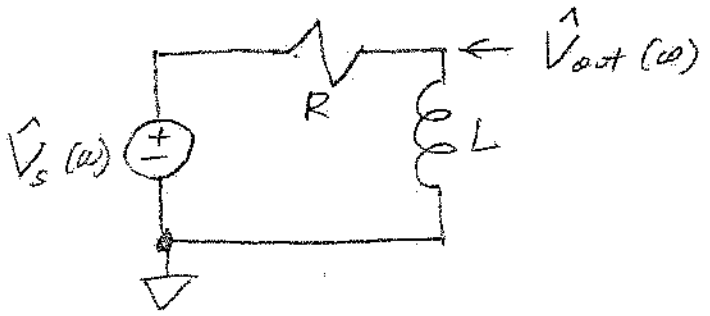
$$\delta(x - x_0) = \frac{1}{2\pi}\int_{-\infty}^{\infty} dy\, e^{-i(x-x_0)y}$$

Systems



Physics 120 Midterm Exam (4 Problems)

(1)



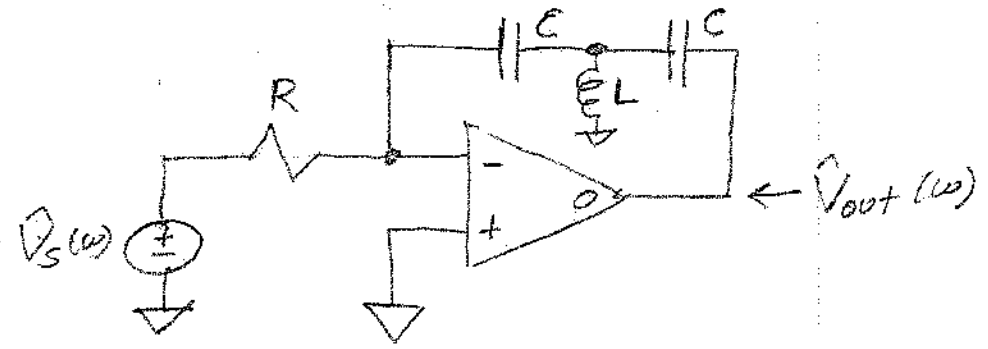
A: Write an expression for $\hat{V}_{out}(\omega)$ in terms of $\hat{V}_s(\omega)$, R, and L.

B: Sketch a Bode plot, with labeled slopes and "break" frequencies (or frequency), i.e.,

B1: $\log |\hat{V}_{out}(\omega)/\hat{V}_s(\omega)|$ vs. $\log \omega$

B2: $\arg\{\hat{V}_{out}(\omega)/\hat{V}_s(\omega)\}$ vs. $\log \omega$

(2)



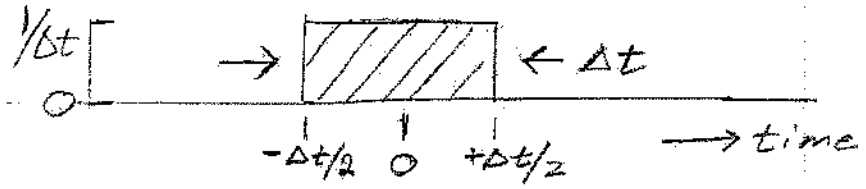
A: Write an expression for $\hat{V}_{out}(\omega)$ in terms of $\hat{V}_s(\omega)$, R, L, and C. Assume an ideal op-amp.

B: Sketch a Bode plot, as in problem 1

C: Is there a frequency for which $\hat{V}_{out}(\omega) = 0$? If so, what is that frequency in terms of R, L, and/or C?

(3)

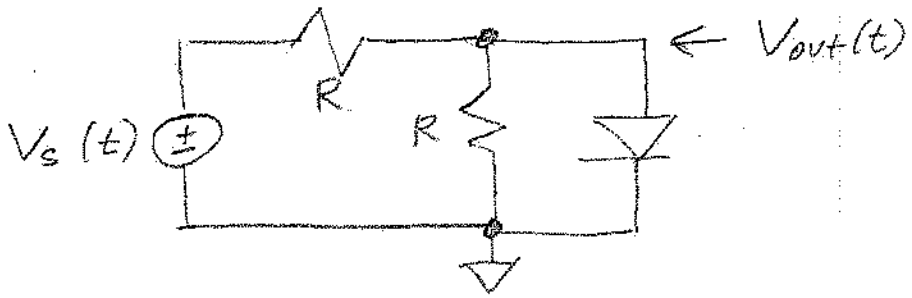
A: What is the Fourier transform, $\hat{V}(\omega)$, of a pulse of width Δt and height $1/\Delta t$?

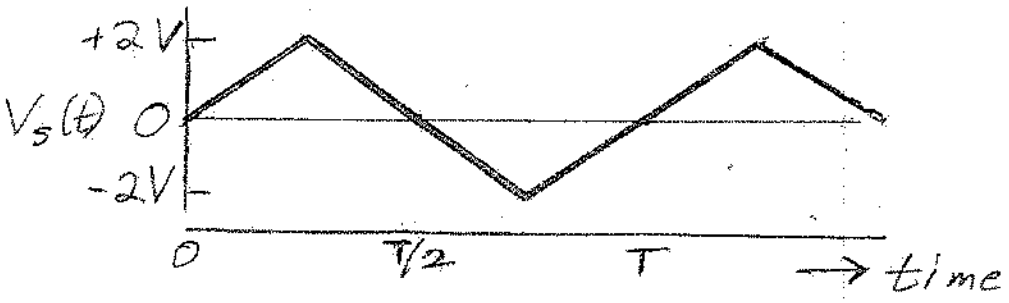


$$V(t) = \begin{cases} 0 & \text{if } t < -\Delta t/2 \\ 1/\Delta t & \text{if } -\Delta t/2 < t < \Delta t/2 \\ 0 & \text{if } t > \Delta t/2 \end{cases}$$

B: What is the form of the Fourier transform in the limit $\Delta t \to 0$?

(4)





A: Plot the form of $V_{out}(t)$. Assume the diode is an ideal diode in series with a 0.6 V source. Lable your axes and label all voltage levels clearly.