University of California at Berkeley
Department of Electrical Engineering and Computer Sciences
Professor J.M. Kahn

EECS 120
Midterm 2

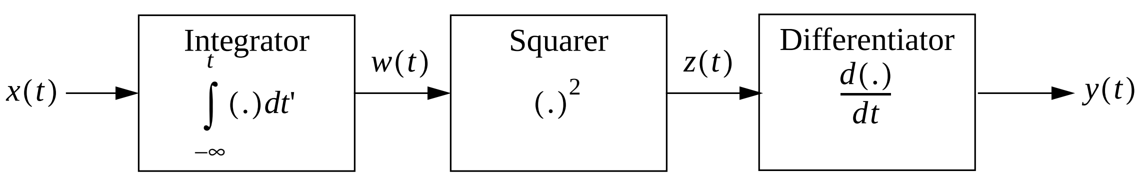
Monday, November 10, 1997, 2:10-3:10 pm

Name: ____

1. Pace yourself. Don't spend too much time on any one problem.
2. Do all work in the space provided. If you need more room, use the back of previous page.
3. Indicate your answer clearly by circling it or drawing a box around it.
4. Think carefully about the problem before you begin to write.

Problem	1	2	3	TOTAL
Points	35	25	40	100
Score				

Problem 1 (35 pts.) Consider the system shown below, which has input $x(t)$ and output $y(t)$.



(a) (5 pts.) Find an expression for $y(t)$ in terms of $x(t)$.

(b) (5 pts.) Can the input-output relationship be described by an expression of the form $y(t) = x(t) \otimes h(t)$ for some $h(t)$? If so, specify $h(t)$. If not, explain why very briefly.

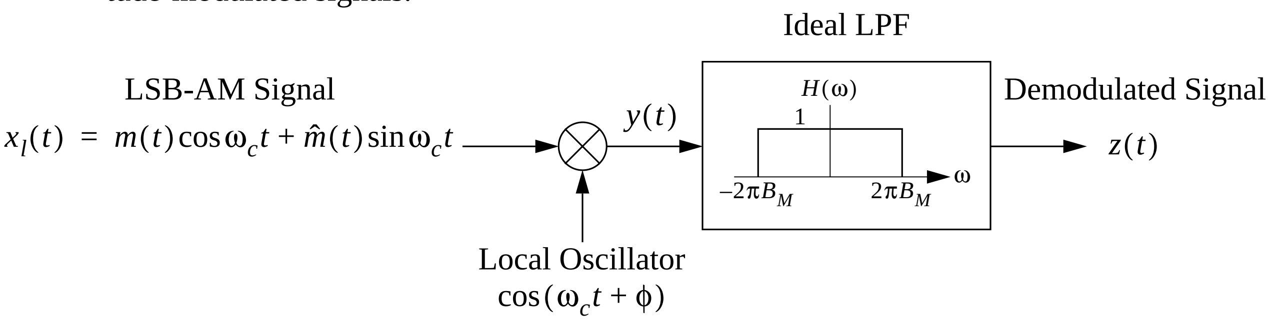
(c) (10 pts.) Let the input be $x(t) = e^{-t}u(t)$. Find expressions for the output $y(t)$ and its Fourier transform $Y(\omega)$.

(d) (15 pts.) Now consider an arbitrary $x(t)$ (not necessarily that in part (c)). Let $X(\omega)$ and $Y(\omega)$ denote the Fourier transforms of $x(t)$ and $y(t)$, respectively. Find an expression for $Y(\omega)$ in terms of $X(\omega)$. Use the properties of Fourier transforms, not the Fourier transform integral. Your answer may contain a symbolic convolution ($\otimes$).

Problem 2 (25 pts.)

(a) (10 pts.) Sketch two different systems that can perform lower-sideband amplitude modulation of a message signal $m(t)$ onto a carrier at frequency ω_c.

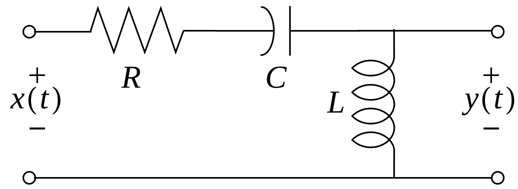
(b) (15 pts.) The system pictured below can perform demodulation of lower-sideband amplitude-modulated signals.



(Note that $\hat{m}(t)$ denotes the Hilbert transform of $m(t)$, and that the lowpass filter has a cutoff frequency equal to the bandwidth of $m(t)$.) The local oscillator has a phase error ϕ. Derive an expression for the demodulated signal $z(t)$, and use it to explain whether the demodulator works well when $\phi \neq 0$. You can assume that $m(t)$ is an audio signal and that $\hat{m}(t)$ sounds very different from $m(t)$. *Hint*: you may use the trigonometric identities:

$$\cos A \cos B = \frac{1}{2}[\cos(A+B) + \cos(A-B)] \qquad \sin A \cos B = \frac{1}{2}[\sin(A+B) + \sin(A-B)].$$

Problem 3 (40 pts.) Consider the circuit shown below, which has input and output voltages $x(t)$ and $y(t)$, respectively.

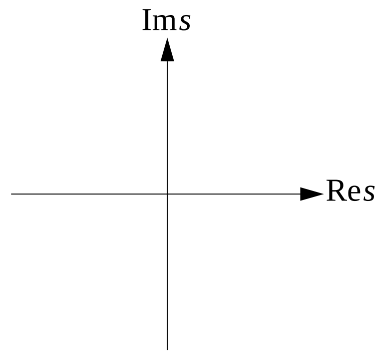


(a) (5 pts.) Write down the differential equation relating $x(t)$ and $y(t)$. If you are unable to do this quickly, skip this part, and you will only lose 5 points.

For the remainder of the problem, assume $R = 2$, $C = 1$ and $L = 1$, so that the differential equation becomes: $\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + y = \frac{d^2x}{dt^2}$.

(b) (5 pts.) Find the transfer function $H(s)$.

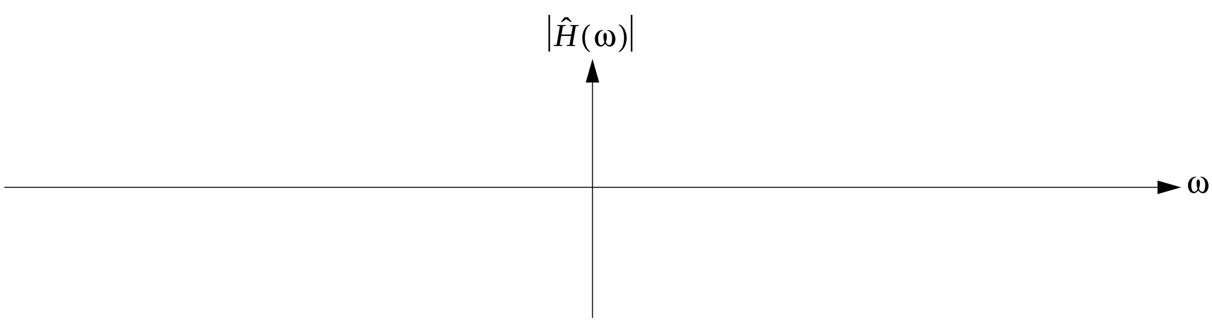
(c) (5 pts.) Plot the poles and zeros of $H(s)$ on the s plane, labeling the locations and multiplicities of all poles and zeros.



(d) (10 pts.) Find the impulse response $h(t)$.

(e) (5 pts.) Find an expression for the frequency response $\hat{H}(\omega) = H(j\omega)$.

(f) (5 pts.) Find an expression for the magnitude of the frequency response $|\hat{H}(\omega)| = |H(j\omega)|$ and sketch it, labeling the vertical and horizontal axes.



(g) (5 pts.) Suppose that the input is $x(t) = \cos\omega_0 t$ for some $0 \le \omega_0 < \infty$. For what value(s) of ω_0 is the output zero, i.e., $y(t) = 0$?