The University of Texas at Austin
Dept. of Electrical and Computer Engineering
Midterm #2

Date: November 18, 2010 Course: EE 313 Evans

Name: ____
Last, First

- The exam is scheduled to last 75 minutes.
- Open books and open notes. You may refer to your homework assignments and homework solution sets.
- **Power off all cell phones**
- You may use any standalone calculator or other computing system, i.e. one that is not connected to a network.
- All work should be performed on the quiz itself. If more space is needed, then use the backs of the pages.
- **Fully justify your answers unless instructed otherwise.**

Problem	Point Value	Your score	Topic
1	24		Differential Equation
2	21		Integrator
3	24		Transfer Functions
4	21		Quadrature Amplitude Modulation
5	10		Fourier Series
Total	100		

Problem 2.1 Differential Equation. *24 points*.

For a continuous-time linear time-invariant (LTI) system with input $x(t)$ and output $y(t)$ is governed by the differential equation

$$\frac{d^2}{dt^2} y(t) + 5\frac{d}{dt} y(t) + 6y(t) = x(t)$$

for $t \geq 0^-$.

(a) Find the transfer function in the Laplace domain. *6 points*.

(b) Draw the pole-zero diagram in the Laplace domain. What are the pole location(s)? What are the zero location(s)? *6 points*.

(c) Find the impulse response. *6 points*.

(d) Give a formula for the step response of the system in the time domain. *6 points*.

$X(s)$ + $E(s)$ $x(t)$ $G(s)$ $y(t)$ $Y(s)$

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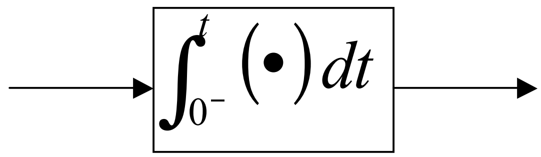
Problem 2.2 Integrator. *21 points.*

K

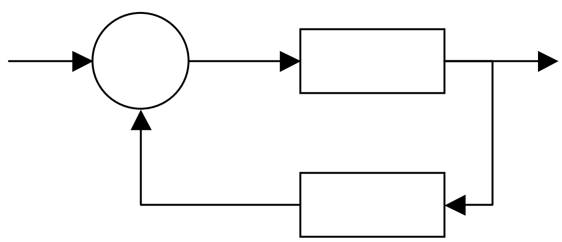
A continuous-time linear time-invariant (LTI) integrator is shown on the right. The initial condition $y(0^-) = 0$ for LTI.



(a) For the integrator above, give formulas for the impulse response $g(t)$, the transfer function in the Laplace domain $G(s)$, and the frequency response $G_{freq}(\omega)$ or $G_{freq}(f)$. *9 points.*

(b) Is the integrator bounded-input bounded-output (BIBO) stable? Why or why not? *3 points.*

(c) Consider the following LTI feedback system using the integrator building block, where $G(s)$ represents the LTI integrator and K represents a scalar gain under computer control.



What is the transfer function $H(s)$? *3 points.*

For what values of K is the system BIBO stable? *3 points.*

When system is BIBO stable, what kind of frequency selectivity does the system have? Lowpass, highpass, bandpass, bandstop, notch or all-pass? *3 points.*

Problem 2.3 Transfer Functions. *24 points*.

A causal linear time-invariant (LTI) continuous-time system has the following transfer function in the Laplace transform domain:

$$H(s) = \frac{s-1}{s+1}$$

(a) Find the corresponding differential equation using $x(t)$ to denote the input signal and $y(t)$ to denote the output signal. Give the minimum number of initial conditions, and their values. *6 points*.

(b) Is the system bounded-input bounded-output (BIBO) stable? Why or why not? *6 points*.

(c) Give a formula for the frequency response. *6 points*.

(d) Plot the magnitude of the frequency response and describe the system's frequency selectivity (lowpass, highpass, bandpass, bandstop, notch or all-pass). *6 points*.

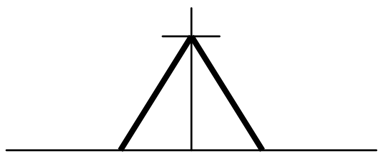
1 1 $M_1(f)$ $M_2(f)$ $m_1(t)$ $m_2(t)$ $s_1(t)$ $s_2(t)$

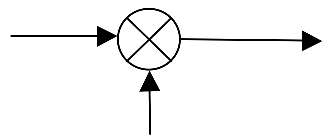
f f f_{max} f_{max} $\cos(2\pi f_c t)$ $\sin(2\pi f_c t)$

Problem 2.4 Quadrature Amplitude Modulation. *21 points*.

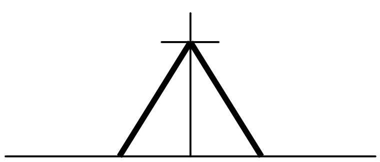
Quadrature amplitude modulation uses cosine modulation and sine modulation together to use bandwidth more efficiently than using cosine modulation alone. Assume $f_c > f_{max}$.

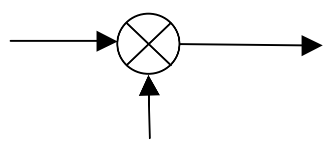
(a) For amplitude modulation using the cosine below, draw the spectrum $S_1(f)$. What is the transmission bandwidth? *6 points*.





(b) For amplitude modulation using the sine below, draw the spectrum $S_2(f)$. *6 points*.

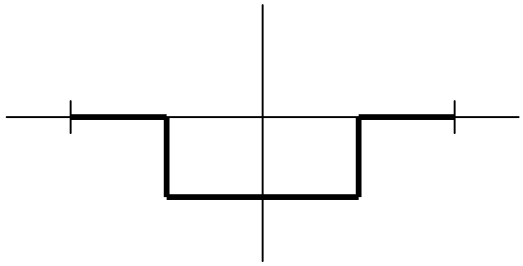




(c) Draw the spectrum of $S_1(f) - S_2(f)$. How would this more efficiently use transmission bandwidth than using amplitude modulation by a cosine? *9 points.*

Problem 2.5 Fourier Series. *10 points*.

Compute the Fourier series according to its definition of the following signal:



The fundamental period T_0 is 2 s.