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ECE-205

Exam 2

Spring 2010

Calculators and computers are not allowed. You must show your work to receive credit.

Problem 1 _________/20

Problem 2 _________/20

Problem 3 _________/28

Problems 5-11 _______/32 (4 points each)

Total ______________

90-100	17
80-89	8
70-79	6
60-69	8
<60	3
	42

average = 80
median = 86

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1) (20 points) Fill in the following table with a Y (yes) or N (no) for each of the system models given. Assume $-\infty < t < \infty$ for all of the systems and all initial conditions are zero.

System	System Model	Linear?	Time-Invariant?	Causal?	Memoryless?
1	$y(t)=\cos(t+1)x(t)$	Y	N	Y	Y
2	$y(t)=\dfrac{1}{1+x(t)}$	N	Y	Y	Y
3	$y(t)=x(1-t)$	Y	N	N	N
4	$\dot{y}(t)+y(t)=e^{-t}x(t+1)$	Y	N	N	N
5	$y(t)=\int_{-\infty}^{t+1} e^{-(t-\lambda)}x(\lambda)d\lambda$	Y	Y	N	N

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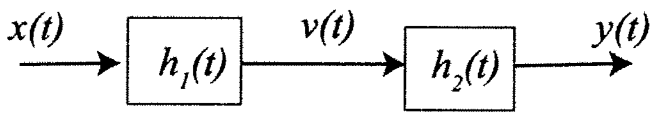
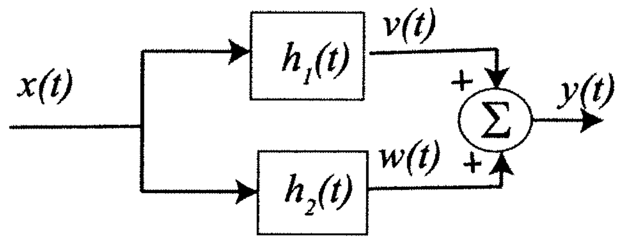
2) (20 points) For the following interconnected systems,

i) determine the overall impulse response (the impulse response between input *x(t)* and output *y(t)*) and

ii) determine if the system is causal.





a) $h_1(t) = u(t-2),\ h_2(t) = u(t+1)$

b) $h_1(t) = e^{-(t-2)}u(t-2),\ h_2(t) = \delta(t+1)$

$t-\lambda-2 \geq 0$
$t-2 \geq \lambda$

$\lambda+1 \geq 0$
$\lambda \geq -1$

(a) series $h(t) = h_1(t) * h_2(t) = \int_{-\infty}^{\infty} h_1(t-\lambda)h_2(\lambda)\,d\lambda = \int_{-\infty}^{\infty} u(t-\lambda-2)u(\lambda+1)\,d\lambda$

$= \int_{-1}^{t-2} d\lambda = [(t-2)-(-1)]u((t-2)-(-1)) = \boxed{(t-1)u(t-1) = h(t) \text{ causal}}$

parallel $h(t) = h_1(t) + h_2(t) = \boxed{u(t-2) + u(t+1) = h(t) \text{ non causal}}$

(b) series $h(t) = h_1(t) * h_2(t) = \int_{-\infty}^{\infty} h_1(t-\lambda)h_2(\lambda)\,d\lambda = \int_{-\infty}^{\infty} e^{-(t-\lambda-2)}u(t-\lambda-2)\,\delta(\lambda+1)\,d\lambda$

$= e^{-(t-(-1)-2)}u(t-(-1)-2) = \boxed{e^{-(t-1)}u(t-1) = h(t) \text{ causal}}$

parallel $h(t) = h_1(t) + h_2(t) = \boxed{e^{-(t-2)}u(t-2) + \delta(t+1) = h(t) \text{ noncausal}}$

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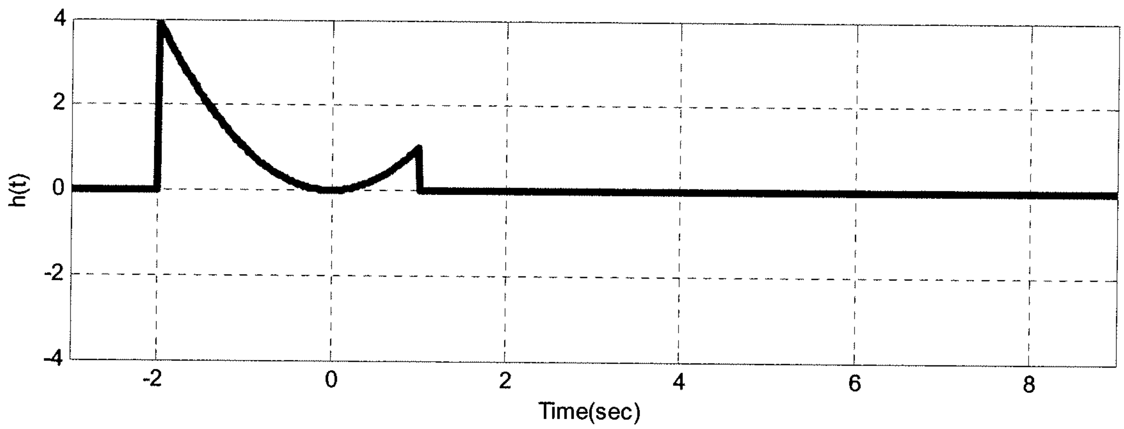
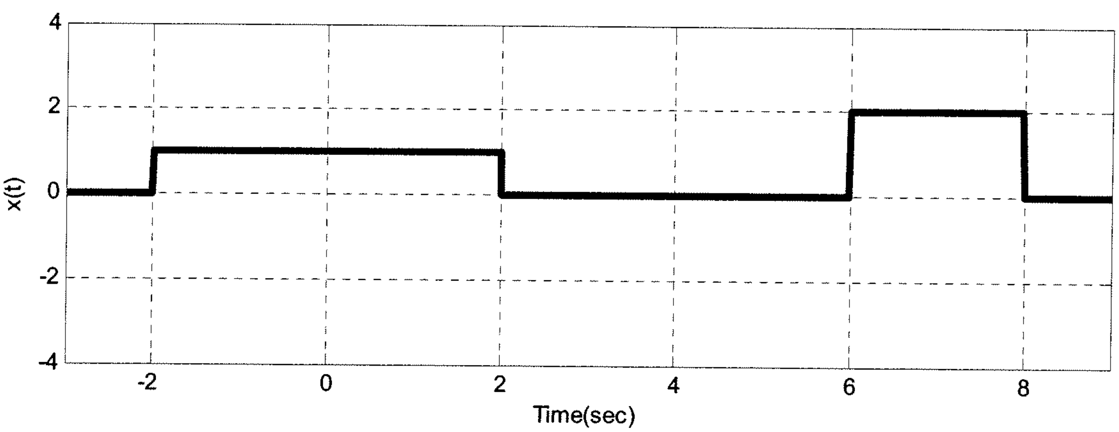
3) (28 points) Consider a linear time invariant system with impulse response given by

$$h(t) = t^2[u(t+2) - u(t-1)]$$

The input to the system is given by

$$x(t) = [u(t+2) - u(t-2)] + 2[u(t-6) - u(t-8)]$$





Using ***graphical convolution***, determine the output $y(t)$ Specifically, you must

- Flip and slide $h(t)$, ***NOT*** $x(t)$
- Show graphs displaying both $h(t-\lambda)$ and $x(\lambda)$ for each region of interest
- Determine the range of t for which each part of your solution is valid
- Set up any necessary integrals to compute $y(t)$. Your integrals must be complete, in that they cannot contain the symbols $x(\lambda)$ or $h(t-\lambda)$ but must contain the actual functions.
- Your integrals cannot contain any unit step functions
- ***DO NOT EVALUATE THE INTEGRALS!!***

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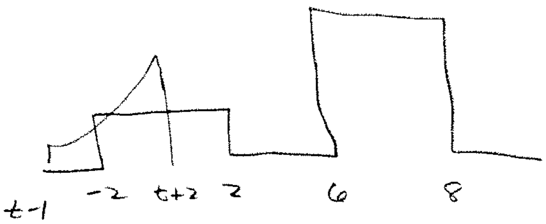
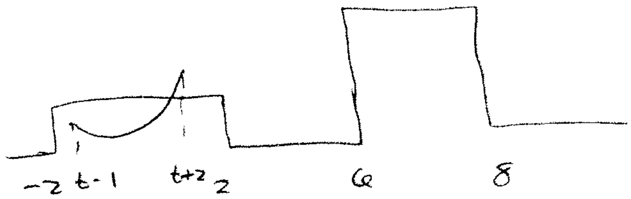
$y(t) = 0 \quad t \le -4$



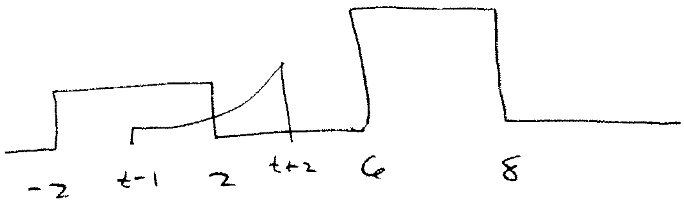
$-4 \le t \le -1$

$$y(t) = \int_{-2}^{t+2} (t-\lambda)^2 (1)\, d\lambda$$



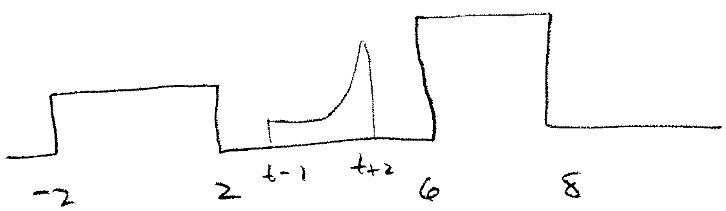
$-1 \le t \le 0$

$$y(t) = \int_{t-1}^{t+2} (t-\lambda)^2 (1)\, d\lambda$$



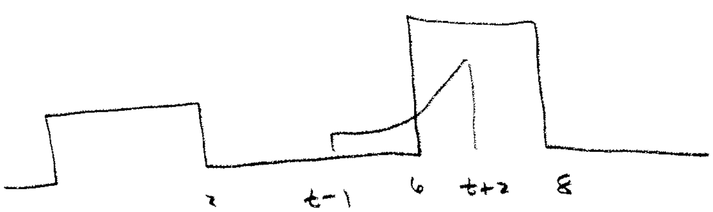
$0 \le t \le 3$

$$y(t) = \int_{t-1}^{2} (t-\lambda)^2 (1)\, d\lambda$$



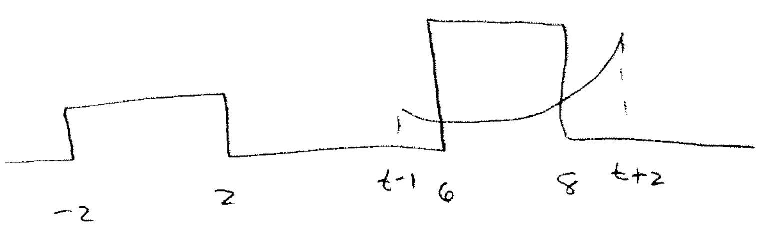
$3 \le t \le 4$

$y(t) = 0$



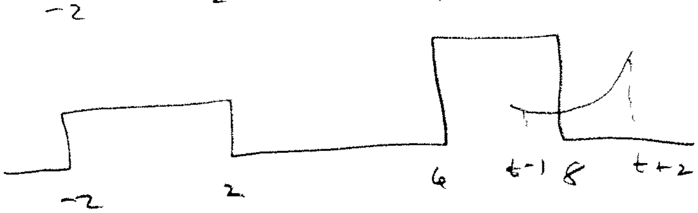
$4 \le t \le 6$

$$y(t) = \int_{6}^{t+2} (t-\lambda)^2 (2)\, d\lambda$$



$6 \le t \le 7$

$$y(t) = \int_{6}^{8} (t-\lambda)^2 (2)\, d\lambda$$



$7 \le t \le 9$

$$y(t) = \int_{t-1}^{8} (t-\lambda)^2 (2)\, d\lambda$$

$y(t) = 0 \quad t \ge 9$

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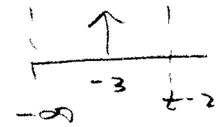
Multiple Choice Problems (4 points each)

4) The **impulse response** for the LTI system $y(t) = 2x(t) + \int_{-\infty}^{t-2} e^{-(t-\lambda)} x(\lambda+3) d\lambda$ is



a) $h(t) = 2u(t) + e^{-(t+3)}u(t+1)$ b) $h(t) = 2\delta(t) + e^{-(t+3)}u(t+1)$

c) $h(t) = 2\delta(t) + e^{-(t+3)}u(t)$ d) $h(t) = 2\delta(t) + e^{-(t+3)}u(t-2)$

e) $h(t) = 2\delta(t) + e^{-(t+3)}u(t+3)$ f) none of these

$t-2 > -3$

$t > -1$

$\frac{d}{dt}(he^t) = e^t\delta(t-1) = e^1\delta(t-1)$

5) The **impulse response** for the LTI system $\dot{y}(t) + y(t) = x(t-1)$ is

$h(t)e^t = \int_{-\infty}^{t} e^1\delta(\lambda-1)d\lambda = e^1 u(t-1)$

a) $h(t) = e^t u(t)$ b) $h(t) = e^{-t}u(t)$ c) $h(t) = e^{-(t-1)}u(t)$

d) $h(t) = e^{-(t-1)}u(t-1)$ e) $h(t) = e^{(t-1)}u(t-1)$ f) none of these

$h(t) = e^{-(t-1)}u(t-1)$

6) Assume we have a first order system in standard form, and the input is a step. The usual form used to compute the response of the system is

a) $y(t) = [y(0) - y(\infty)]e^{-t/\tau} + y(0)$ b) $y(t) = [y(\infty) - y(0)]e^{-t/\tau} + y(0)$ $y(t)\big|_{t=0} = y(0)$

c) $y(t) = [y(\infty) - y(0)]e^{-t/\tau} + y(\infty)$ d) $y(t) = [y(0) - y(\infty)]e^{-t/\tau} + y(\infty)$ $y(t)\big|_{t=\infty} = y(\infty)$

7) Is the system $y(t) = \sin\left(\frac{1}{1-2x(t)}\right)$ bounded input-bounded output (BIBO) stable?

a) yes b) no Sin always bounded

8) Is the LTI system with impulse response $h(t) = e^t u(t)$ BIBO stable?

a) yes b) no $\int_{-\infty}^{\infty} |h(t)|dt$ not finite

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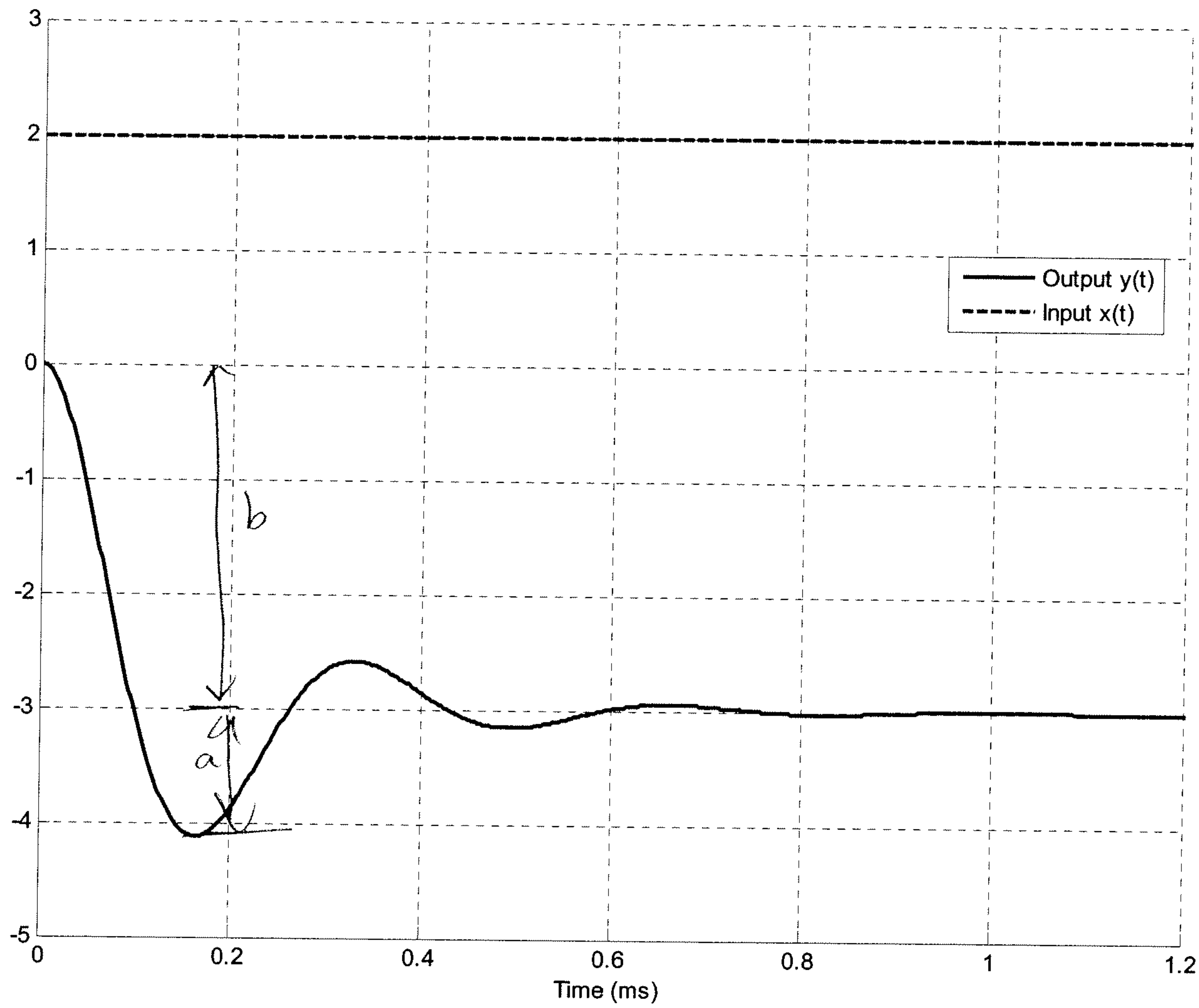
Problems 9-11 refer the following graph showing the response of a second order system to a step input.



9) The percent overshoot for this system is best estimated as

$\frac{a}{b} = \frac{-1}{-3} = \frac{1}{3}$

a) 400% b) -400 % c) 300% d) -300 % e) -33% f) 33%

10) The (2%) settling time for this system is best estimated as

a) 0.3 ms b) 0.6 ms c) 1.0 ms d) 1.2 ms

11) The static gain for this system is best estimated as

$K(2) = -3$

a) 1.5 b) 3 c) -1.5 d) -3

$K = -3/2 = -1.5$