EECS 20. Midterm No. 2 April 9, 2004.

Please use these sheets for your answer and your work. Use the backs if necessary. **Write clearly and put a box around your answer, and show your work.**

Print your name and lab day and time below

Name: _____

Lab time: _____

Problem 1:

Problem 2:

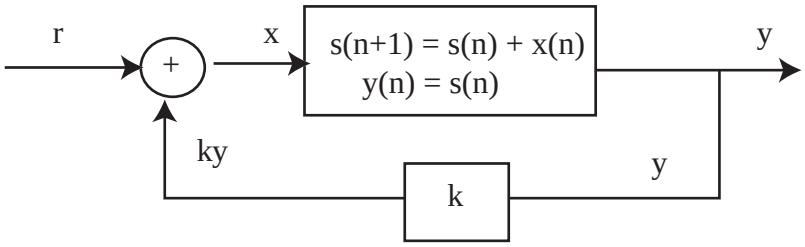
Problem 3:

Problem 4:

Problem 5:

Total:

1. **20 points** The block diagram of a feedback composition of a discrete-time system is given below:



The state s, input signal x, and output signal y are related by the update equation:

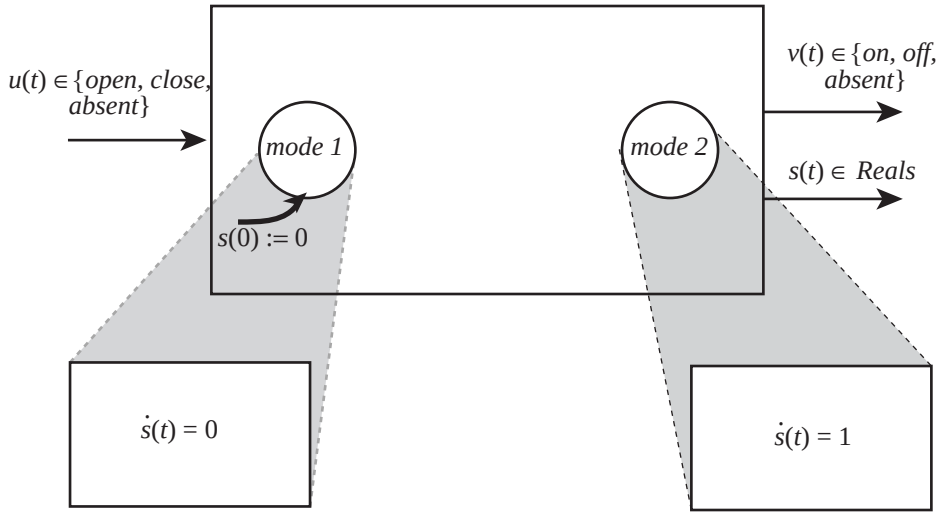
$$\begin{aligned} s(n+1) &= s(n) + x(n) \\ y(n) &= s(n) \end{aligned}$$

(a) **6 points** Find the zero-state impulse response of this system.

(b) **6 points** Find the update equation for the feedback system with input signal r, output signal y and state s.

(c) **8 points** Find the zero-state impulse response for the feedback composition, when the 'gain' $k = -0.5$

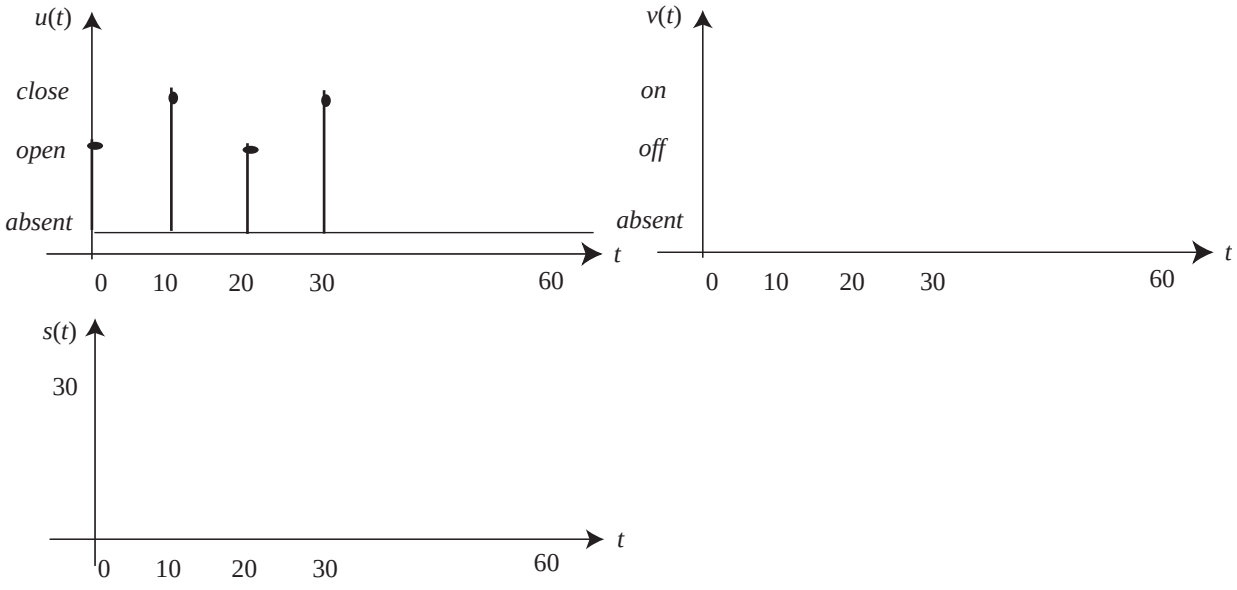
2. **20 points** The figure below is a partial hybrid system description of the dome light controller of an automobile.



When someone opens the door ($u(t) = \textit{open}$), the light is turned on ($v(t) = \textit{on}$). After the door is closed ($u(t) = \textit{close}$) for 30 seconds, the light is turned off ($v(t) = \textit{off}$). Note that the door must be closed for the entire 30 seconds, before the light is turned off.

(a) **10 points** Design the transitions (including guard, action, and output) so that the system meets this specification.

(b) **10 points** Plot the output signal $v(t)$ and the trajectory of the refinement state $s(t)$, $0 \leq t \leq 60$, when the input signal u is as shown below.



3. **15 points** The continuous-time signal x is given by (t is in seconds)

$$\forall t \in R, \quad x(t) = \cos(2\pi \times 60 + \pi/4) + 2\cos(2\pi \times 120 + \pi/8) + 3\cos(2\pi \times 180 + \pi/12).$$

(a) **5 points** Is x periodic? If it is, what is its period?

(b) **10 points** The signal x is input to a LTI system whose frequency response is

$$\forall \omega \in R, \quad H(\omega) = \begin{cases} 1, & |\omega| < 2\pi \times 150, \\ 0.5, & \text{otherwise} \end{cases}$$

What is the output signal y? Is y periodic? If it is, what is its period?

4. **25 points** A LTI system with input signal x and output signal y is described by the differential equation

$$\frac{dy}{dt} + 0.5y(t) = x(t), \quad t \in R.$$

(a) **10 points** Suppose the input signal is $\forall t, x(t) = e^{i\omega t}$, where ω is fixed. What is the output signal y?

(b) **5 points** What is the frequency response,

$$\forall \omega \in R, \quad H(\omega) =$$

(c) **10 points** What is the magnitude and phase of the frequency response for $\omega = 0.5$ rad/sec?

$$|H(0.5)| =$$

$$\angle H(0.5) =$$

5. **20 points**

(a) **10 points** Consider a continuous-time system $S : [R \to R] \to [R \to R]$

i. Suppose

$$\forall x, \forall t, \quad S(x)(t) = x(t-2).$$

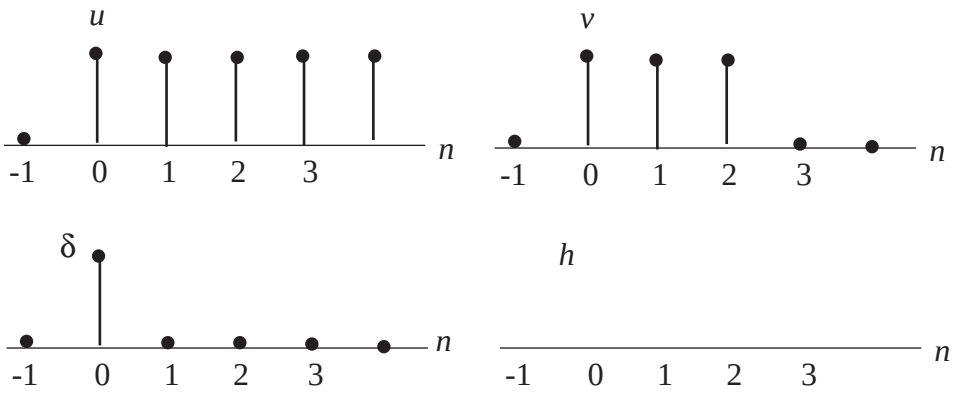
Is S time-invariant? Why?

ii. Suppose

$$\forall x, \forall t, \quad S(x)(t) = x(2t).$$

Is S time-invariant? Why?

(b) A discrete-time linear system produces output v when the input is the step u. What is the output h when the input is the impulse δ?



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