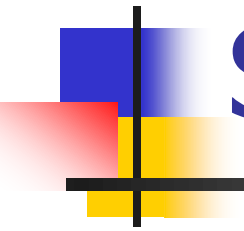


Signal Operation

Dhidik Prastiyanto

Operations of CT Signals

1. Time Reversal $y(t) = x(-t)$
2. Time Shifting $y(t) = x(t-t_d)$
3. Amplitude Scaling $y(t) = Bx(t)$
4. Addition $y(t) = x_1(t) + x_2(t)$
5. Multiplication $y(t) = x_1(t)x_2(t)$
6. Time Scaling $y(t) = x(at)$

1. Time Reversal

- Flips the signal about the y axis
- y(t) = x(-t)

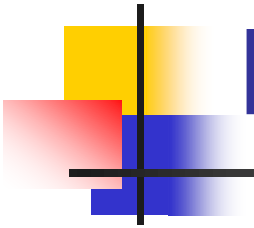
ex. Let x(t) = u(t), and perform time reversal

Solution: Find y(t) = u(-t)
Let "a" be the argument of the step function → u(a)

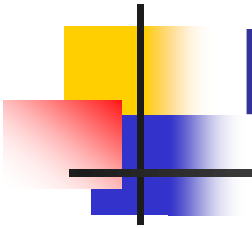
$$u(a)=\begin{cases}1 & a\geq 0\\ 0 & a<0\end{cases}$$

Let a = -t, and plug in this value of "a"

$$u(-t)=\begin{cases}1 & t\leq 0\\ 0 & t>0\end{cases}$$



Exercise 1



Exercise 1

2. Time Shifting / Delay

- $y(t) = x(t - t_d)$
- Shifts the signal left or right
- Shifts the origin of the signal to t_d

- Rule → Set $(t - t_d) = 0$ (set the argument equal to zero)
  → Then move the origin of $x(t)$ to t_d

- Effectively, $y(t)$ equals what $x(t)$ was t_d seconds ago

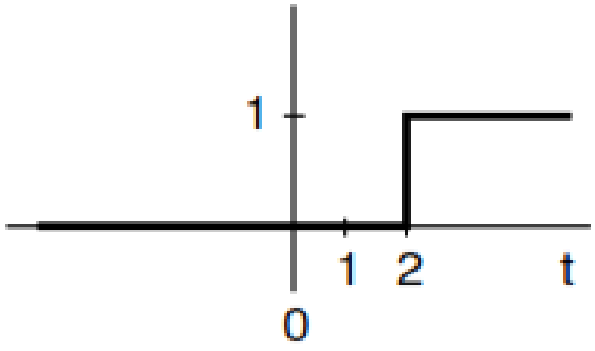
2. Time Shifting / Delay

ex. Sketch $y(t) = u(t-2)$

Method 1

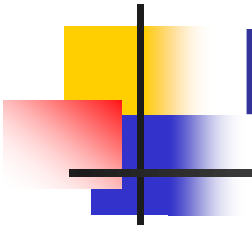
Let "a" be the argument of "u"

$$y(a)=\begin{cases}1 & a\geq 0\\ 0 & a<0\end{cases}=\begin{cases}1 & t-2\geq 0\\ 0 & t-2<0\end{cases}=\begin{cases}1 & t\geq 2\\ 0 & t<2\end{cases}$$

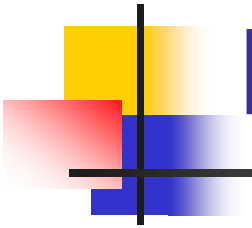


Method 2 (by inspection)

Simply shift the origin to $t_d = 2$



Exercise 2

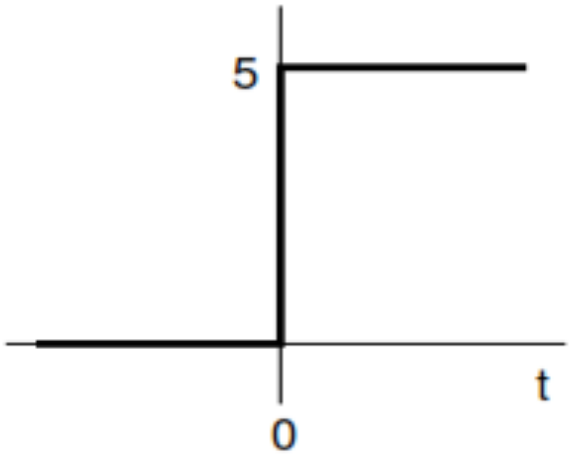


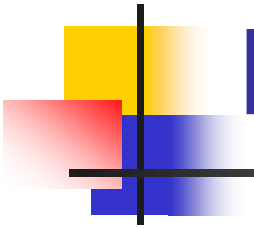
Exercise 2

3. Amplitude Scaling

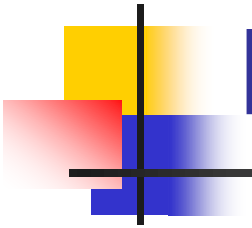
- Multiply the entire signal by a constant value
- $y(t) = Bx(t)$

ex. Sketch $y(t) = 5u(t)$





Exercise 3



Exercise 3

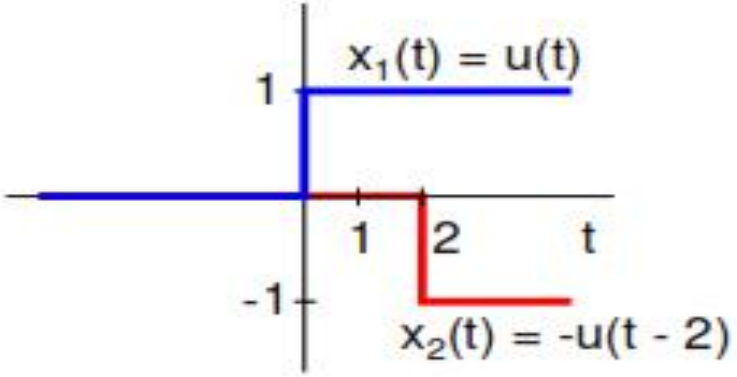
4. Addition of Signals

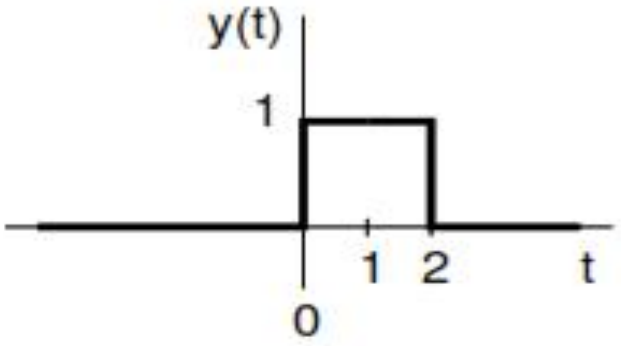
ex. Sketch $y(t) = u(t) - u(t-2)$

First, plot each of the portions of this signal separately

- $x_1(t) = u(t)$ → Simply a step signal
- $x_2(t) = -u(t-2)$ → Delayed step signal, multiplied by -1

Then, move from one side to the other, and add their instantaneous values





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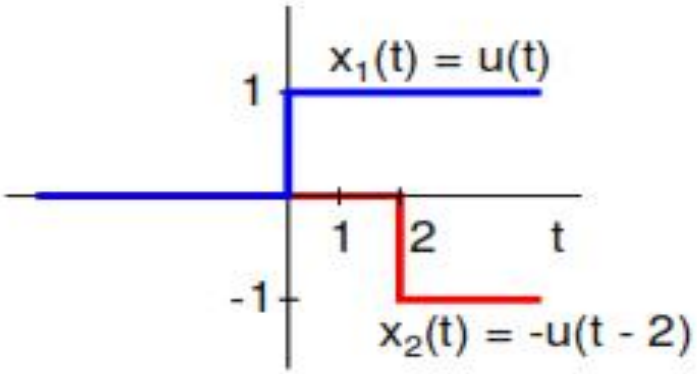
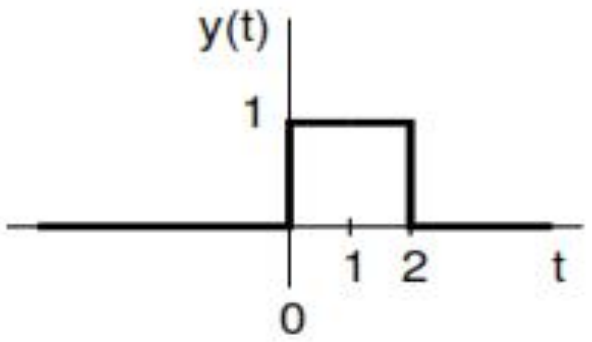
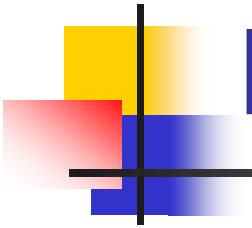
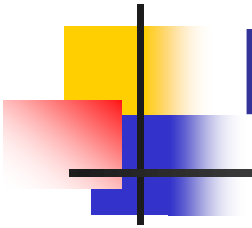






Exercise 4



Exercise 4

5. Multiplication of Signals

- Point-by-point multiplication of the values of each signal
- $y(t) = x_1(t)x_2(t)$

- Graphical solution
  - Plot each individual portion of the signal (break into parts)
  - Multiply the signals point by point

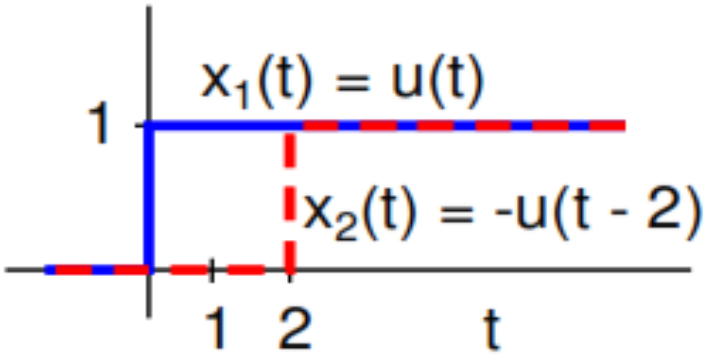
5. Multiplication of Signals

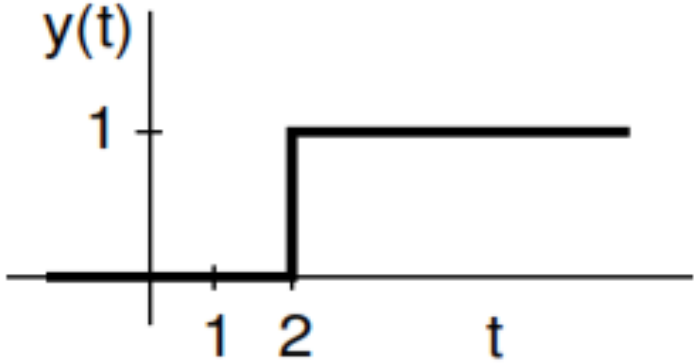
ex. Sketch $y(t) = u(t) \cdot u(t-2)$

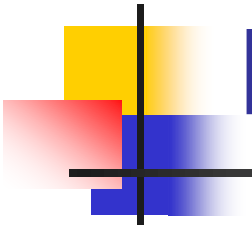
First, plot each of the portions of this signal separately

- $x_1(t) = u(t)$ → Simply a step signal
- $x_2(t) = u(t\text{-}2)$ → Delayed step signal

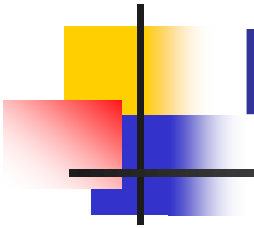
Then, move from one side to the other, and multiply instantaneous values







Exercise 4



Exercise 4

6. Time Scaling

- Speed up or slow down a signal
- Multiply the time in the argument by a constant
- $y(t) = x(at)$

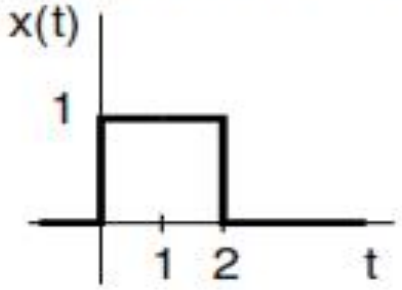
  $|a| > 1$ → Speed up x(t) by a factor of "a"

  $|a| < 1$ → Slow down x(t) by a factor of "a"
- Key → Replace all instances of "t" with "at"

6. Time Scaling

ex. Let $x(t) = u(t) - u(t-2)$
Sketch $y(t) = x(t/2)$

First, plot x(t)



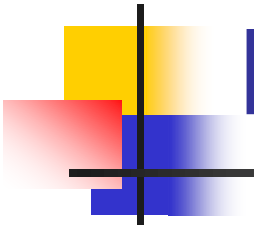
Replace all t's with t/2

$$y(t) = x(t/2) = u(t/2) - u((t/2) - 2)$$

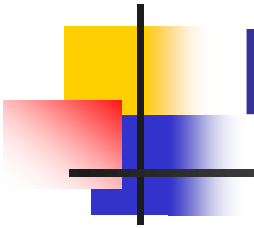
Turns on at
$t/2 \geq 0$
$t \geq 0$
No change

Turns on at
$t/2 - 2 \geq 0$
$t \geq 4$

This has effectively "slowed down" x(t) by a factor of 2
(What occurred at t=1 now occurs at t=2)



Exercise 6



Exercise 6

Wassalamu'alaikum

Wassalamu'alaikum

Many Thanks