BME 350: Signals & Systems for Bioengineers

Homework #2 (50 Points)

Deadline: 9AM on Tuesday, September 20.
Late Assignments: 5 points deducted per hour (delay rounded up to the next hour).
Note: For questions 3-7, show all your work to receive full credit.

1) **(7 points).** Select if the following statements are true or false.
   a. $x(t)$ is even if $x(t) = -x(-t)$. T F
   b. Continuous time signals are always periodic. T F
   c. A signal can have infinite energy or power. T F
   d. Amplitude scaling is a type of signal transformation. T F
   e. In a discrete signal $x[n]$, both $x[n]$ and n are integers. T F
   f. Aperiodic signals can be decomposed into even and odd components. T F
   g. Time scaling for a signal $x(t)$ and scaling factor α is represented as $\alpha x(t)$. T F

2) **(8 points)**. Complete the following statements.
   a. A discrete time signal can be expressed as a sum of scaled and shifted impulses.
   b. The interval over which a signal repeats is called the period.
   c. The period T_0 must be a real number in the continuous case.
   d. $\delta(t-1)$ is zero everywhere except at $t =$ 1.
   e. The output of a discrete time system is u[n] when the input is δ[n].
   f. The BIOB criterion is used to test stability of systems.
   g. A system is simultaneous if it satisfies the properties of additivity and intensity scaling.

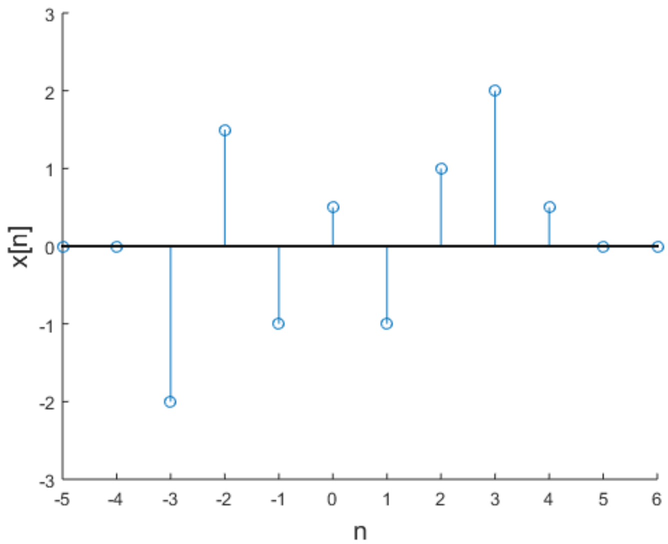
3) **Continuous and discrete Step Functions (6 points).** Given the signals below, sketch the following. Show all the procedure down for each transformation. *(Note: remember to properly label all your axes)*

   a. Given $x[n] = \begin{cases} 1, n = -2, 0, 1, 3, 5 \\ 2, n = -1, 2, 4 \\ 0, elsewhere \end{cases}$

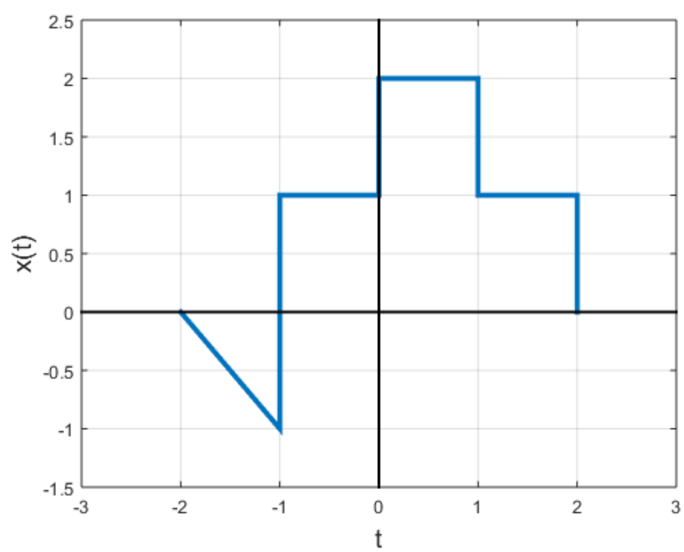
   sketch the signal, $y[n] = x[2-n]u[n-1]$

   b. Sketch the signal, $x(t) = 3u(t-2) - 3u(t-7)$

4) **Delta Decomposition (2 points).** Given the signal $x[n]$ below, decompose $x[n]$ into a weighted sum of delta impulses. Sketch each impulse individually and be sure to label all axes. Also specify the final equation for $x[n]$.



5) **A) Even and Odd Functions (5 points).** Given the continuous signal $x(t)$ below, decompose $x(t)$ into its even and odd components. Sketch and clearly label each component.



B) Signal Power and Energy (5 points). Determine the Power and Energy of the following signal. (Clearly show all your steps in your calculations)

$$x(t) = 5e^{-\frac{3}{2}t}u(t)$$

6) **LTI Systems (5 points).** Determine whether the following system is linear, time-invariant, or both. Be sure to show your work.

$$y(t) = \frac{7}{2}x(3t/5)$$

7) **Convolution Integral (7 points).** Given the following signals $x(t)$ and $h(t)$, compute and plot the convolution $y(t) = x(t) * h(t)$.

$$x(t) = 2u(t+3) - 2u(t-3)$$

$$h(t) = 4u(-t)e^{2t}$$

8) **MATLAB (5 points).**

a. Plot the discrete time signals, $x_1[n] = \begin{cases} 1, n = -2, 0, 1, 3, 5 \\ 2, n = -1, 2, 4, 6 \\ 0, elsewhere \end{cases}$ and

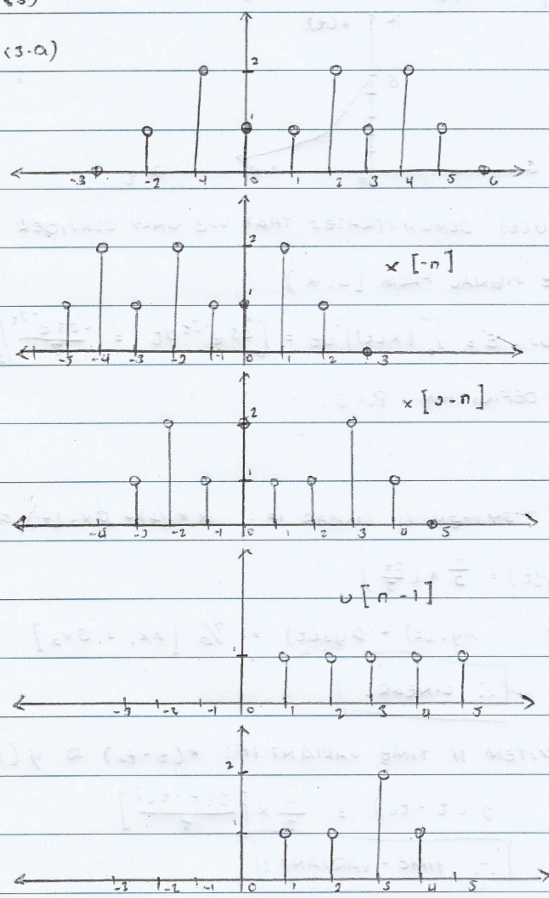
$x_2[n] = u[n+3] - u[n-2]$ in MATLAB with proper axes labels.

b. Plot the discrete time signal, $h_1[n] = x_2[n-\beta]$ in MATLAB with proper axes labels, where 'β' is given as the last digit of your ASU ID.

c. Determine $y_1[n] = x_1[n] * h_1[n]$ using the 'conv' function in MATLAB. Plot $y_1[n]$ with proper axes labels.

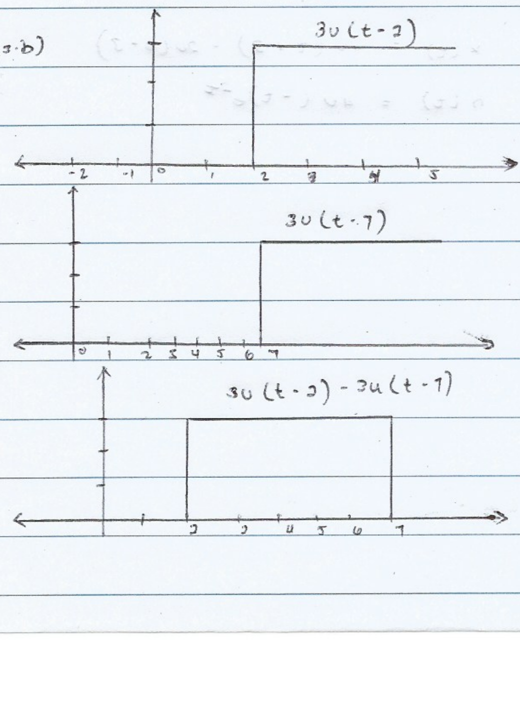
(3.) CONTINUOUS & DISCRETE STEP FUNCTION

(3.a)



$$y[n] = x[2-n]\,u[n-1]$$

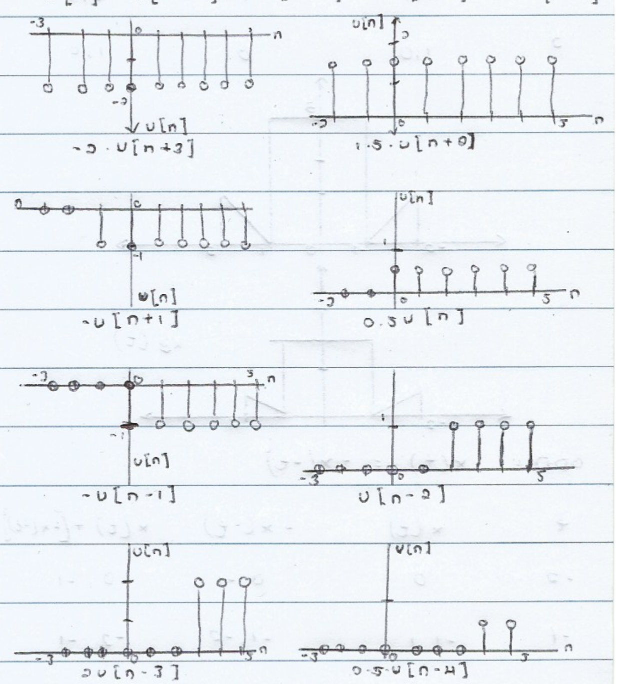
(3.b)

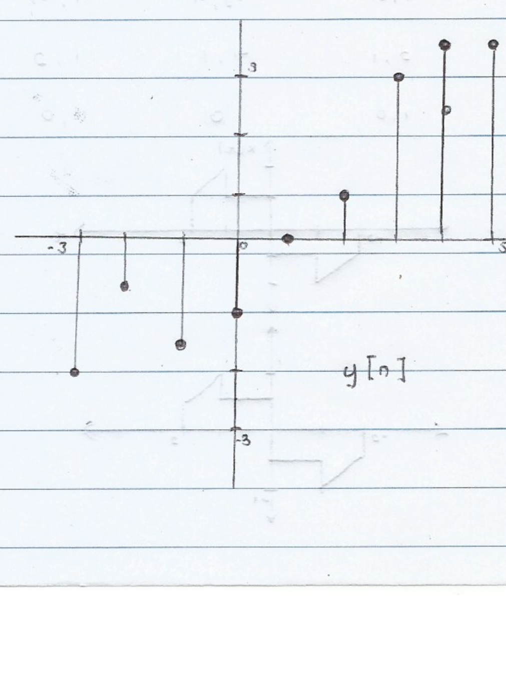


(4) DELTA DECOMPOSITION

$$x[n] = -2\cdot\delta[n+3] + 1.5\cdot\delta[n+2] - 1\cdot\delta[n+1] + 0.5\,\delta[n] - 1\cdot\delta[n-1] + 1\cdot\delta[n-2] + 2\cdot\delta[n-3] + 0.5\cdot\delta[n-4]$$

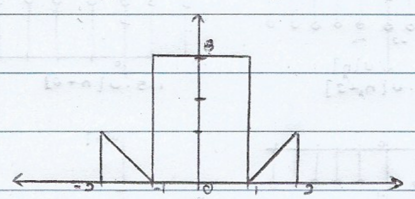
$$y[n] = -2u[n+3] + 1.5u[n+2] - u[n+1] + 0.5\,u[n] - u[n-1] + u[n-2] + 2u[n-3] + 0.5u[n-4]$$

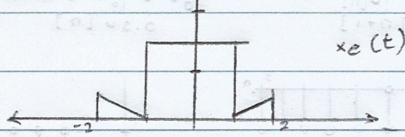




(5A) EVEN $x(t) = x(-t)$

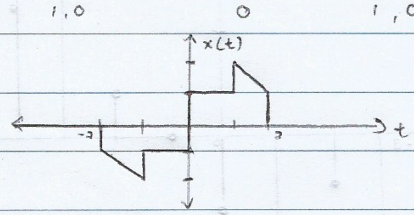
t	$x(t)$	$x(-t)$	$x(t)+x(-t)$
-2	0	0, 1	0, 1
-1	-1, 1	1, 2	0, 3
0	1, 2	2, 1	3, 3
1	2, 1	1, -1	3, 0
2	1, 0	0	1, 0

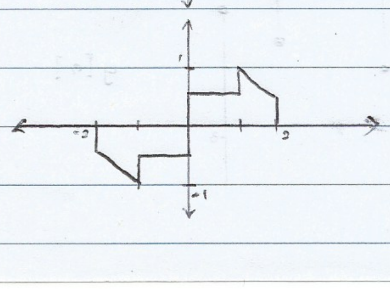




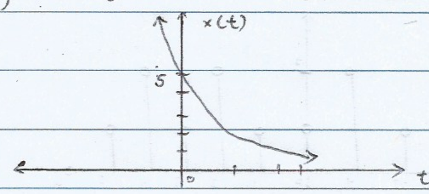
ODD: $x(t) = -x(-t)$

t	$x(t)$	$-x(-t)$	$x(t)+[-x(-t)]$
-2	0	0, -1	0, -1
-1	-1, 1	-1, -2	-2, -1
0	1, 2	-2, -1	-1, -1
1	2, 1	-1, 1	1, 2
2	1, 0	0	1, 0





(5.B) $x(t) = 5e^{-3/2t}\,u(t)$



★ $u(t)$ DEMONSTRATES THAT WE ONLY CONSIDER THE SIGNAL FROM $[0, \alpha)$

THUS, $E = \int_0^\alpha |x(t)|^2 dt = \int_0^\alpha 25 e^{-3t} dt = \frac{-25e^{-3t}}{3}\Big|_0^\alpha = 25/3$

BY DEFINITION, $P = 0$.

(6) SYSTEM IS LINEAR IF: $\alpha x_1(t) + \beta x_2(t) \rightarrow \alpha y_1(t) + \beta y_2(t)$

$y(t) = \frac{7}{2} x\left(\frac{3t}{5}\right)$

$\approx \quad Ay_1(t) + By_2(t) = 7/2\,[Ax_1 + Bx_2]$

$\boxed{\therefore \text{ LINEAR!}}$

SYSTEM IS TIME VARIANT IF: $x(t-t_0) \approx y(t-t_0)$

$y(t-t_0) = \frac{7}{2} x\left[\frac{3(t-t_0)}{5}\right]$

$\boxed{\therefore \text{ TIME-VARIANT!}}$

(7) $x(t) = 2u(t+3) - 2u(t-3)$

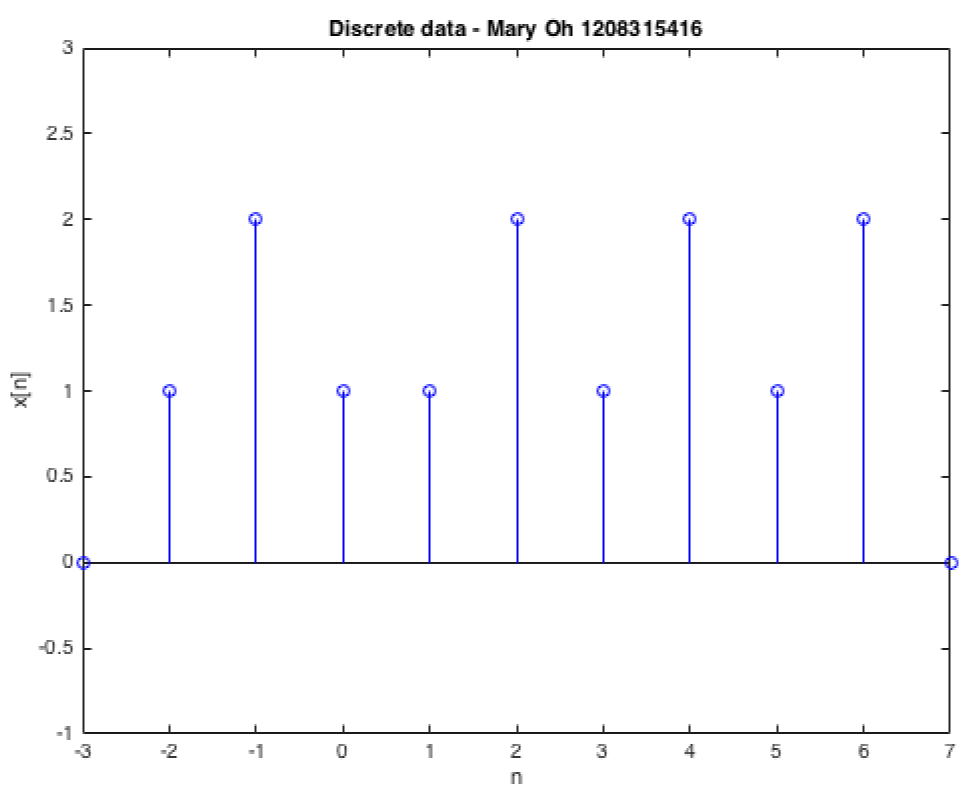
$h(t) = 4u(-t)e^{2t}$

Table of Contents

Discrete Impulse function

```
clear;
clc;

% x[n]
n = -3:7;
x = [0 1 2 1 1 2 1 2 1 2 0];
figure;
stem(n,x,'b'); %plot of discrete data
xlabel('n')
ylabel('x[n]')
ylim([-1 3])
title('Discrete data - Mary Oh 1208315416')
```



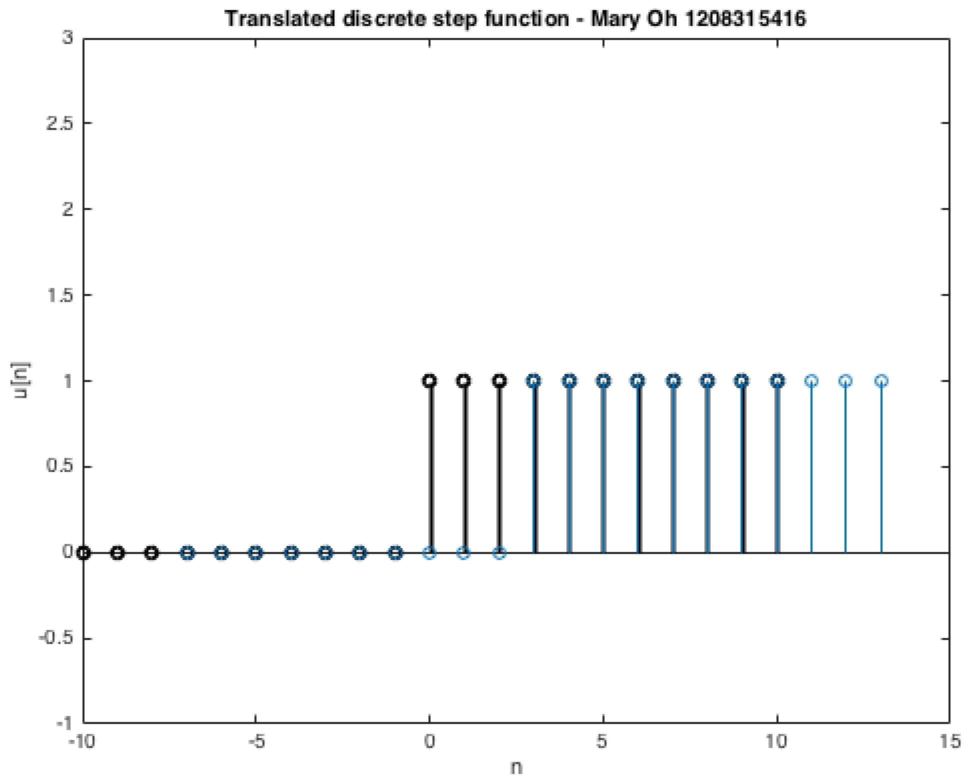
Create discrete step function

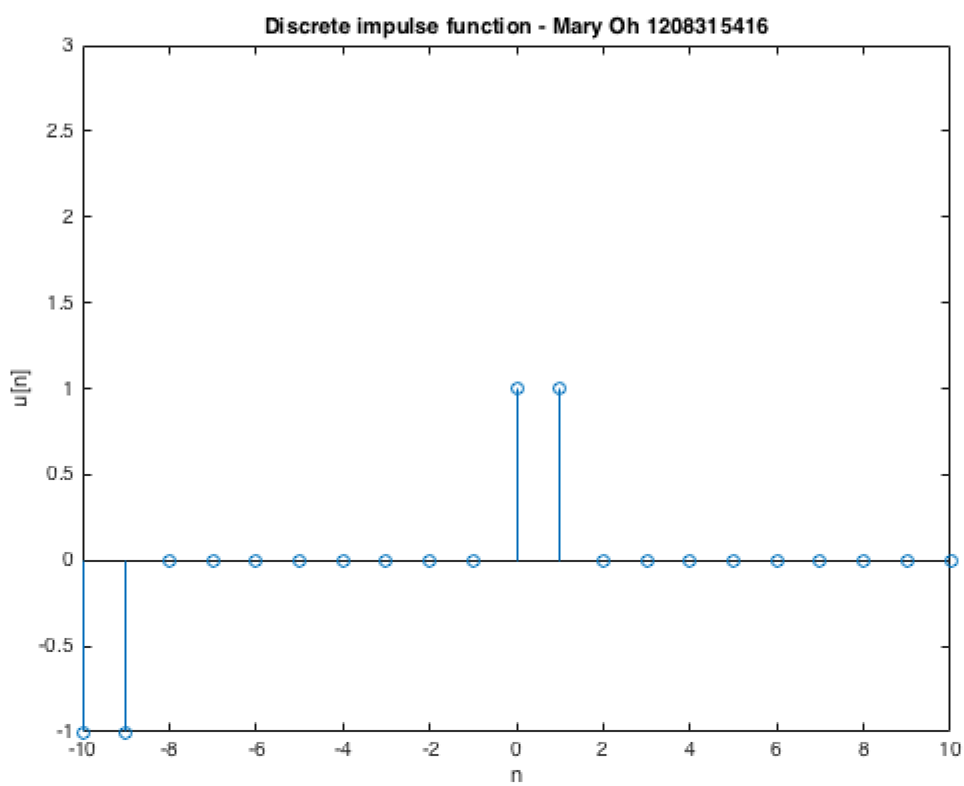
```
n = -10:10;
u = zeros(1,length(n));
u(find(n==0):end) = 1;

figure;
stem(n,u,'k','LineWidth',2);
hold on;

% create translated discrete step function
n0 = -3;
stem(n - n0,u);
xlabel('n')
ylabel('u[n]')
ylim([-1 3])
title('Translated discrete step function - Mary Oh 1208315416')

% substract step functions to create impulse function
n0 = 2;
d = u - circshift(u,[0 n0]);
figure;
stem(n,d);
xlabel('n')
ylabel('u[n]')
ylim([-1 3])
title('Discrete impulse function - Mary Oh 1208315416')
```


Translated discrete step function - Mary Oh 1208315416
u[n]
n
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-10
-5
0
5
10
15


Discrete impulse function - Mary Oh 1208315416
u[n]
n
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-10
-8
-6
-4
-2
0
2
4
6
8
10

Create discrete time signal

```
clc
clear all

n = -10:10;
x = zeros(1,length(n));
x(n==0) = 1;

figure;
stem(n,x);
xlabel('n')
ylabel('h[n]')
ylim([-1 3])
title('Discrete time signal - Mary Oh 1208315416')

sum(x(find(n==-10):find(n==-1)))
sum(x(find(n==1):find(n==10)))
sum(x)

% moving impulse in time
n0 = 6;
n_trans = n - n0;

figure;
stem(n,x,':b','LineWidth',2);
hold on;

stem(n_trans,x,':r','LineWidth',2);
xlabel('n')
ylabel('h[n]')
ylim([-1 3])
title('Discrete time signal - Mary Oh 1208315416')
```

```
ans =

     0


ans =

     0


ans =

     1
```

Conv function

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