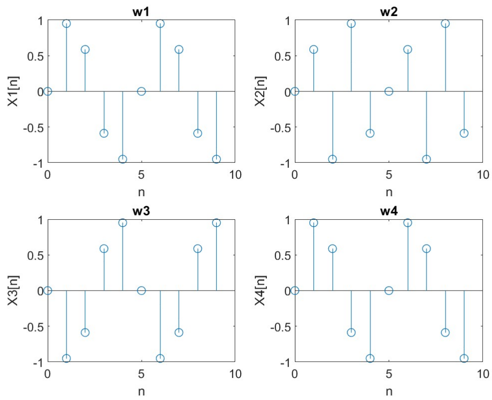
Lab1 Report

Problem1

In problem1, we use **stem** to plot given discrete-time sequences. The source code of plotting the signal at $k = 1$ is demonstrated below, and other cases can be deduced by analogy.

```
k=[1,2,4,6]; wk=2*k*pi/5;
n=0:9;       x=sin(wk'*n);

%k=1
subplot(2,2,1);
stem(n,x(1,:));
title('w1');
xlabel('n');
ylabel('X1[n]');
```

Figures of four signals



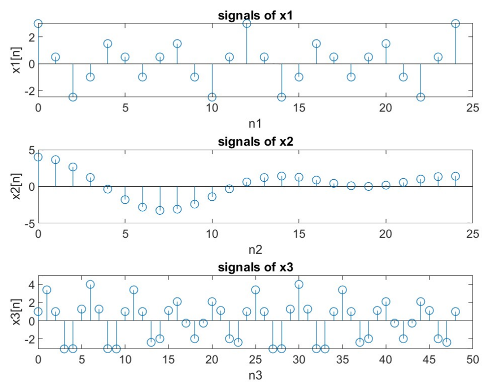
It's easy to see that we have plotted **three** unique signals, since $w1$ and $w4$ are identical. We can demonstrate that w_k and w_{k+5} can yield the same signal

$$sin(w_{k+5}n) = sin(2\pi(k+5)n/5) = sin(2\pi kn/5 + 2\pi n) = sin(w_k n) \tag{1}$$

Problem2

- $x_1[n]$ is periodic with fundamental period of $T = 2N = 12$
- $x_2[n]$ is not periodic, because the fundamental period of the corresponding expression is not an integer
- $x_3[n]$ is periodic with fundamental of $T = 4N = 24$

Figures of three signals

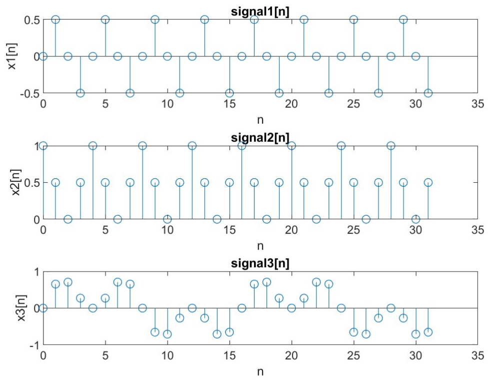


Figures above can testify to our conclusion.

Problem3

- The fundamental period of $x_1[n]$ is 4, since $x_1[n] = 0.5sin(\frac{\pi n}{2})$
- The fundamental period of $x_2[n]$ is 4, since $x_2[n] = 0.5(1 + cos(\frac{\pi n}{2}))$
- The fundamental period of $x_3[n]$ is 16, since $x_3[n] = 0.5(sin(\frac{\pi n}{8}) + sin(\frac{3\pi n}{8}))$

Figures of three signals



Figures above can testify to our conclusion.

Problem4

(1) For **discrete-time signals**, the addition or multiplication of two periodic signals is necessarily periodic.

Consider signal $x_1[n]$ with fundamental period T_1, signal $x_2[n]$ with fundamental period T_2, signal $x_3[n] = x_1[n] + x_2[n]$, signal $x_4[n] = x_3[n] * x_4[n]$

$$\begin{aligned} x_3[n + T_1 \times T_2] = x_1[n + T_1 \times T_2] + x_2[n + T_1 \times T_2] = x_1[n] + x_2[n] = x_3[n] \\ x_4[n + T_1 \times T_2] = x_1[n + T_1 \times T_2] * x_2[n + T_1 \times T_2] = x_1[n] * x_2[n] = x_4[n] \end{aligned} \quad (2)$$

(2) For continuous-time signals, the addition or multiplication of two periodic signals isn't necessarily periodic.

For example, $x_1(t) = sin(t)$ and $x_2(t) = sin(2\pi t)$ are two periodic signals, but neither their addition or multiplication is periodic signal.

Problem5

(a)

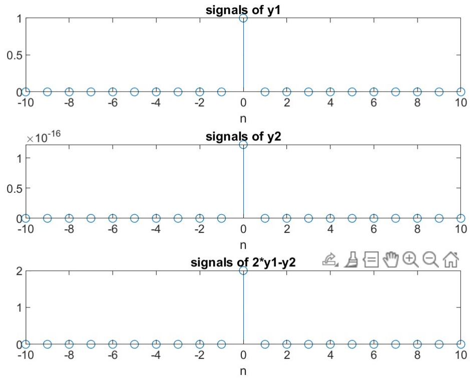
The following source code can plot the system output $y[n] = sin((\pi/2)x[n])$ corresponding to $x_1[n] = \delta[n]$ and $x_2[n] = 2\delta[n]$

```
n=-10:1:10;
x1=[zeros(1,10),1,zeros(1,10)];
x2=[zeros(1,10),2,zeros(1,10)];

y1=sin(x1*pi/2);
subplot(3,1,1)
stem(n,y1)
title('signals of y1')
xlabel('n')

y2=sin(x2*pi/2);
subplot(3,1,2)
stem(n,y2)
title('signals of y2')
xlabel('n')
```

If the system is linear, $2y_1$ will be equal to y_2, so let's add a piece of code

```
subplot(3,1,3)
stem(n,2*y1-y2)
title('signals of 2*y1-y2')
xlabel('n')
```

Figures we get

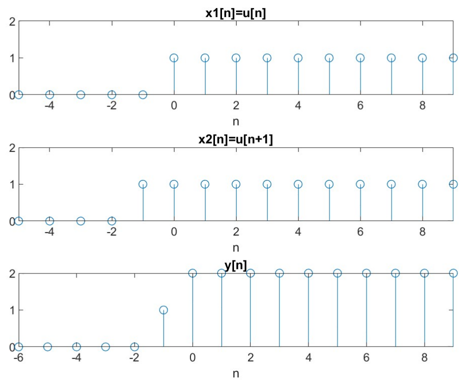


It is easy to see that $2y_1$ is not equal to y_2, so the system is nonlinear.

I notice that $y_2[0]$ is a very small number rather than strictly zero. Through research, it has been found that the occurrence of not strictly equal to zero is due to machine precision and internal calculation truncation errors. If the error in the result is within the range of eps (machine epsilon), it is considered equal. Furthermore, different arithmetic operation orders can also lead to varying results in MATLAB.

(b)

Figures of three signals



We can see that signal $y[n]$ has generated at $n = -1$, when $x[n]$ has not generated yet, so the system is noncausal.

Problem6

(a)

The following is the source code of the function `diffeqn`

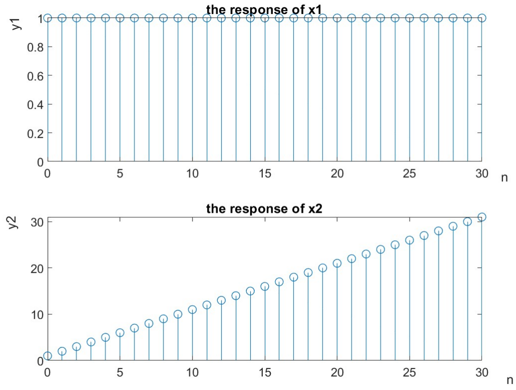
```
function y = diffeqn(a, x, yn1)
    N = length(x); % Length of input vector x
    y = zeros(1, N); % Initialize output vector y

    % Compute y[0] using y[-1]
    y(1) = a * yn1 + x(1);

    % Compute y[n] for n > 0
    for n = 2:N
        y(n) = a * y(n-1) + x(n);
    end
end
```

(b)

We can use `stem` and `diffeqn` to plot the response of unit impluse and unit step seperately

```
n=0:30;
a=1;
yn1=0;
x1=[1,zeros(1,30)];
x2=[ones(1,31)];

subplot(2,1,1)
stem(n,diffeqn(a,x1,yn1))
title('the response of x1')
xlabel('n')
ylabel('y1')

subplot(2,1,2)
stem(n,diffeqn(a,x2,yn1))
title('the response of x2')
xlabel('n')
ylabel('y2')
```

Figures of two signals



Problem7

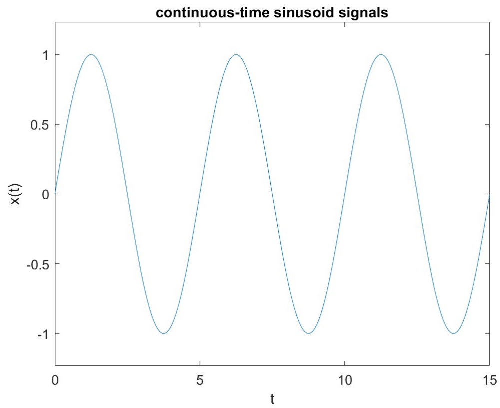
We represent $x(t) = sin(2\pi t/T)$ by symbolic expression

```
%declare t and T as symbolic variables
syms t T;
x = sin(2*pi*t/T);
x5=subs(x,T,5);  %T=5
```

Then use `ezplot` to plot $x5$

```
ezplot(x5, [0, 15]);
title('continuous-time sinusoid signals');
xlabel('t');
ylabel('x(t)');
```

The figure below is what we get



We can see that the curve indeed coincide with theoretical expressions.

Problem8

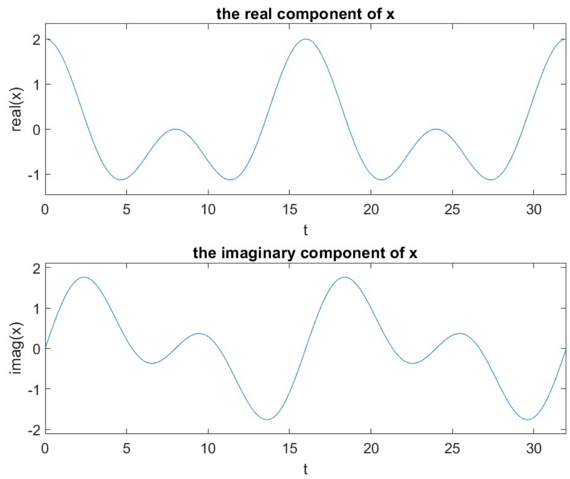
First, write two functions `sreal(x)` and `simag(x)` to extract the real and imaginary components of signal x

```
function xr = sreal(x)
    xr = real(x);
end

function xi = simag(x)
    xi = imag(x);
end
```

Then use `ezplot` to draw the pciture

```
x=sym(exp(1i*2*pi*t/16)+exp(1i*2*pi*t/8));
xr=sreal(x);
xi=simag(x);

subplot(2,1,1)
ezplot(xr,[0,32]);
title('the real component of x')
xlabel('t')
ylabel('real(x)')

subplot(2,1,2)
ezplot(xi,[0,32]);
title('the imaginary component of x')
xlabel('t')
ylabel('imag(x)')
```

Figures below is what we get



So we can see that the fundamental period of $x(t)$ is 16.