Aim ↬ To study and generate various elementary discrete time signals such as Unit Impulse, Unit Step, Ramp, Square, Triangular, Sinusoidal, Exponential, etc., using MATLAB.

Software Required ↬ MATLAB

Theory ↬

A signal is a set of information or data that can be modeled as a function of one or more independent variables. Ex - Speech, image, voltage, video, music, etc.

A signal is said to be a discrete-time signal if it is defined only at specific, discrete points in time, often referred to as sample points. Such signals are often called digital signals. A discrete-time signal can take on any value within a range of possible values at these discrete points. For instance, an audio recording stored on a digital device is a discrete-time signal, as the continuous sound wave has been sampled at regular intervals, converting the continuous signal into a sequence of discrete values.

Signal Types and Equations ↴

- **Unit Impulse (Kronecker Delta) Signal ↪** A theoretical signal that is zero everywhere except at n=0, where it is one.

$$\delta[n] = \begin{cases} 1, & \text{if } n = 0 \\ 0, & \text{if } n \neq 0 \end{cases}$$

- **Unit Step Signal ↪** A signal that is zero for all negative time and one for zero and positive time.

$$u[n] = \begin{cases} 0, & \text{if } n < 0 \\ 1, & \text{if } n \geq 0 \end{cases}$$

- **Ramp Signal ↪** A signal that increases linearly over time, starting from zero at n=0.

$$r[n] = \begin{cases} 0, & \text{if } n < 0 \\ n, & \text{if } n \geq 0 \end{cases}$$

- **Increasing Exponential Signal ↪** A signal that grows exponentially over time.

$$e[n] = Ae^{\propto n}$$

where A and α are constants, with $\alpha > 0$.

- **Decreasing Exponential Signal ↪** A signal that decays exponentially over time.

$$e[n] = Ae^{-\alpha n}$$

where A and α are constants, with $\alpha > 0$.

- **Sinusoidal Signal ↪** A smooth, periodic oscillation that can represent many natural phenomena such as sound waves and digital modulation.

$$x[n] = Asin(\omega n + \varphi)$$

- **Square Signal ↪** A periodic waveform that alternates between a maximum and a minimum value at a fixed frequency.

$$\text{sq}[n] = \text{N} \qquad \text{for } -\frac{N}{2} \leq n \leq \frac{N}{2}$$

- **Sawtooth Signal ↪** A periodic waveform that linearly rises over time and then drops sharply.

$$\text{saw[n]} = 2\left(\frac{n}{N}\right) - 1 \qquad \text{for } -\frac{N}{2} \leq n \leq \frac{N}{2}$$

- **Triangular Signal ↪** A periodic waveform that rises and falls linearly, forming a triangular shape.

$$\text{tri}[n] = 1 - \frac{|n|}{N} \qquad \text{for } -N \leq n \leq N$$

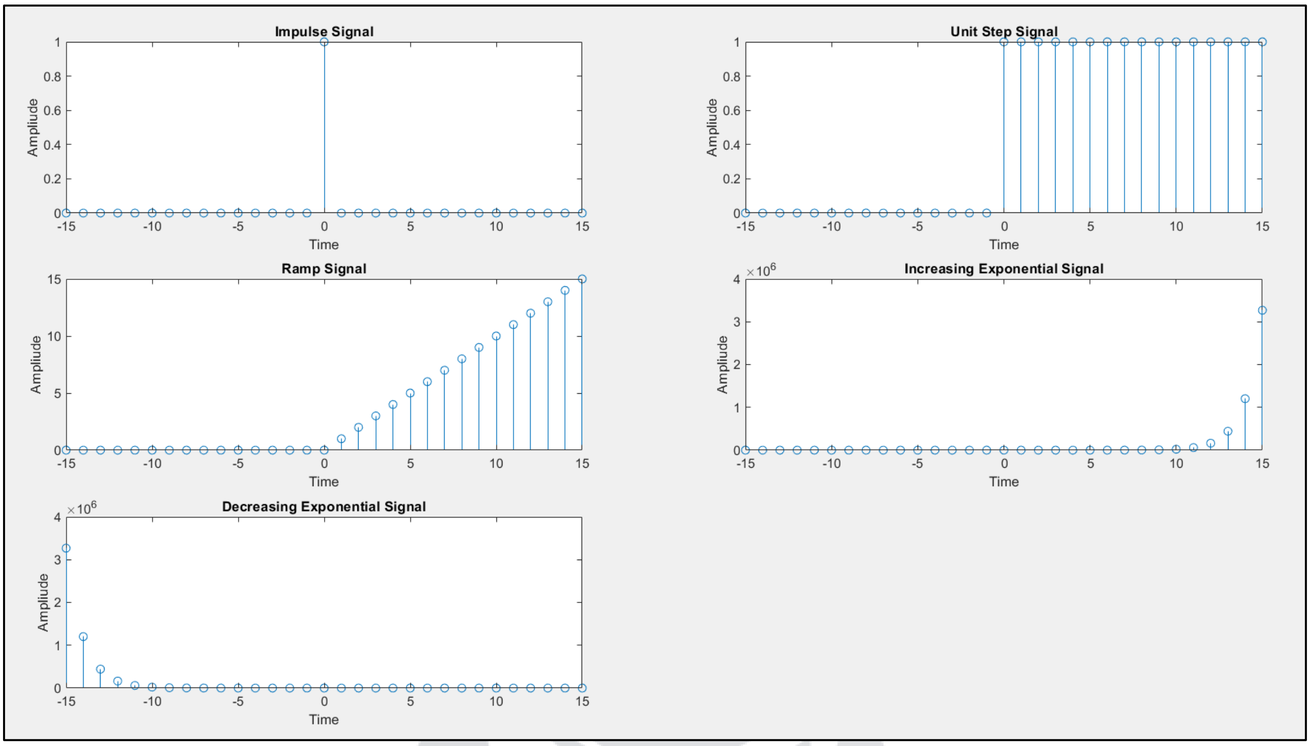
Code ↬

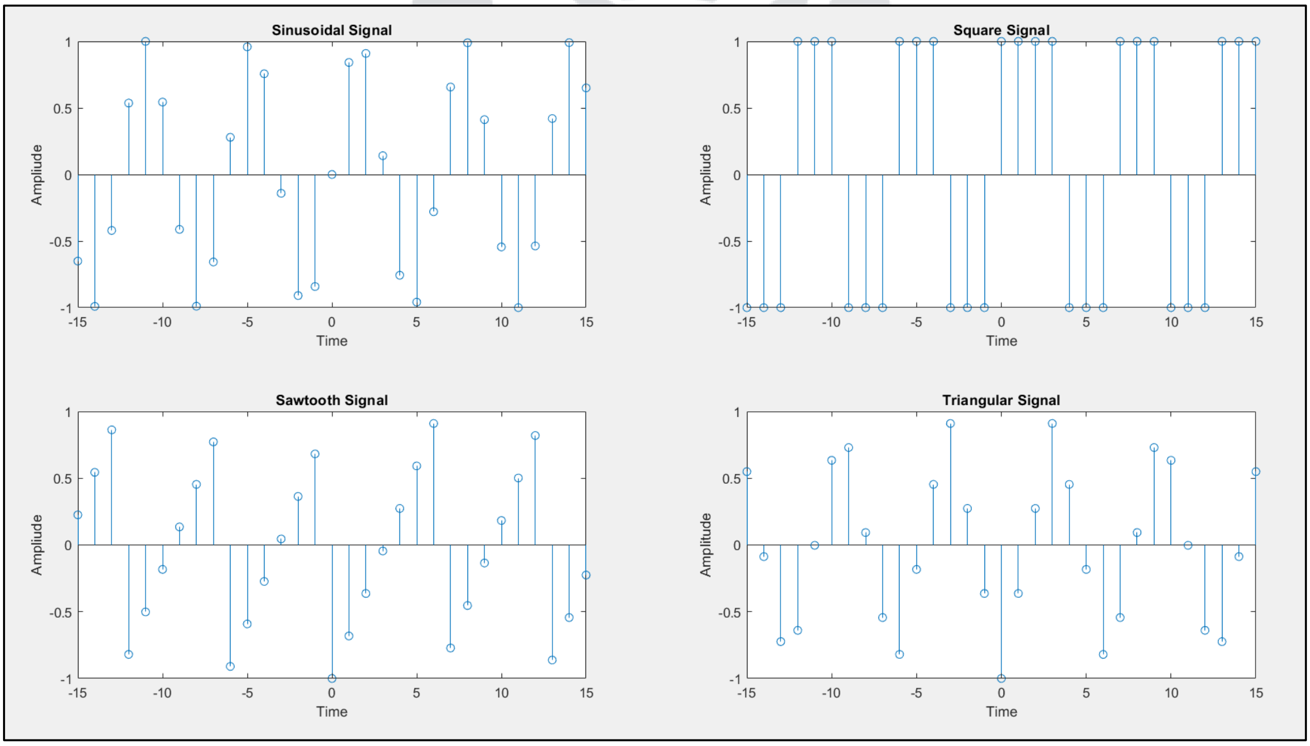
```
%Discrete Time Signals
clc;
clear;
n = -15:1:15;

figure;

%Impulse Signal
d=(n==0);
subplot(3,2,1);
stem(n,d);
xlabel('Time');
ylabel('Ampliude');
```

```
title('Impulse Signal');

%Unit Step Signal
u=(n>=0);
subplot(3,2,2);
stem(n,u);
xlabel('Time');
ylabel('Ampliude');
title('Unit Step Signal');

%Ramp Signal
r=n.*(n>=0);
subplot(3,2,3);
stem(n,r);
xlabel('Time');
ylabel('Ampliude');
title('Ramp Signal');

%Increasing Exponential Signal
e=exp(n);
subplot(3,2,4);
stem(n,e);
xlabel('Time');
ylabel('Ampliude');
title('Increasing Exponential Signal');

%Decreasing Exponential Signal
subplot(3,2,5);
stem(-n,e);
xlabel('Time');
ylabel('Ampliude');
title('Decreasing Exponential Signal');

figure;

%Sinusoidal Signal
s=sin(n);
subplot(2,2,1);
stem(n,s);
xlabel('Time');
```

```
ylabel('Ampliude');
title('Sinusoidal Signal');

%Square Signal
sq=square(n);
subplot(2,2,2);
stem(n,sq);
xlabel('Time');
ylabel('Ampliude');
title('Square Signal');

%Sawtooth Signal
saw=sawtooth(n);
subplot(2,2,3);
stem(n,saw);
xlabel('Time');
ylabel('Ampliude');
title('Sawtooth Signal');

%Triangular Signal
tri=sawtooth(n, 0.5);
subplot(2,2,4);
stem(n,tri);
xlabel('Time');
ylabel('Amplitude');
title('Triangular Signal');
```

Output ↬





Result ↬

In this experiment, various discrete-time elementary signals were generated using MATLAB. The signals include Unit Impulse, Unit Step, Ramp, Increasing and Decreasing Exponential, Sinusoidal, Square, Sawtooth, and Triangular signals.

Each signal was plotted against discrete time indices to visualize its characteristics and behavior.

Conclusion ↬

The experiment successfully demonstrated the generation and visualization of different elementary discrete-time signals using MATLAB. Understanding these signals and their properties is crucial in digital signal processing and related fields. The practical application of MATLAB for signal generation provides a strong foundation for further studies in signal analysis and processing.

Precautions ↬

- Ensure the correct range and step size for the discrete-time variable.
- Verify the mathematical expressions used for each signal.
- Use proper labels and titles for the plots.