Aim ↬ To study and generate various elementary continuous 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 continuous-time signal if it is defined for all time t, a real number. Such signals are often called analog signals. A CT signal is one that can take on any value within a range of possible values. An analog speech transmitted over a twisted-pair telephone line can be categorized as a continuous-time signal, as the signal level over time can continuously range from a quiet whisper to a deafening scream.

Signal Types and Equations ↴

- **Unit Impulse (Dirac Delta) Signal ↪** A theoretical signal that is zero everywhere except at t=0, where it is infinitely high such that its integral over the entire time axis is one.

$$\delta(t) = \begin{cases} \infty, & \text{if } t = 0 \\ 0, & \text{if } t \neq 0 \end{cases}$$

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

$$u(t) = \begin{cases} 0, & \text{if } t < 0 \\ 1, & \text{if } t \geq 0 \end{cases}$$

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

$$r(t) = \begin{cases} 0, & \text{if } t \geq 0 \\ t, & \text{if } t < 0 \end{cases}$$

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

$$e(t) = Ae^{\propto t}$$

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

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

$$e(t) = Ae^{-\propto t}$$

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 AC power.

$$x(t) = Asin(\omega t + \varphi)$$

- **Sinc Signal** ↪ A Signal commonly used in signal processing, particularly in interpolation and Fourier analysis.

$$sinc(t) = \frac{\sin(\pi t)}{\pi t}$$

- **Sampling Signal** ↪ This Signal is particularly important in the context of the Nyquist-Shannon sampling theorem, where it is used to reconstruct a continuous signal from its samples.

$$sa(t) = \frac{\sin(t)}{t}$$

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

$$\mathrm{sq(t)} = \mathrm{T} \qquad \text{for } -\frac{T}{2} \leq t \leq \frac{T}{2}$$

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

$$\mathrm{saw(t)} = 2\left(\frac{t}{T}\right) - 1 \qquad \text{for } -\frac{T}{2} \leq t \leq \frac{T}{2}$$

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

$$\mathrm{tri(t)} = 1 - \frac{|t|}{T} \qquad \text{for } -T \leq t \leq T$$

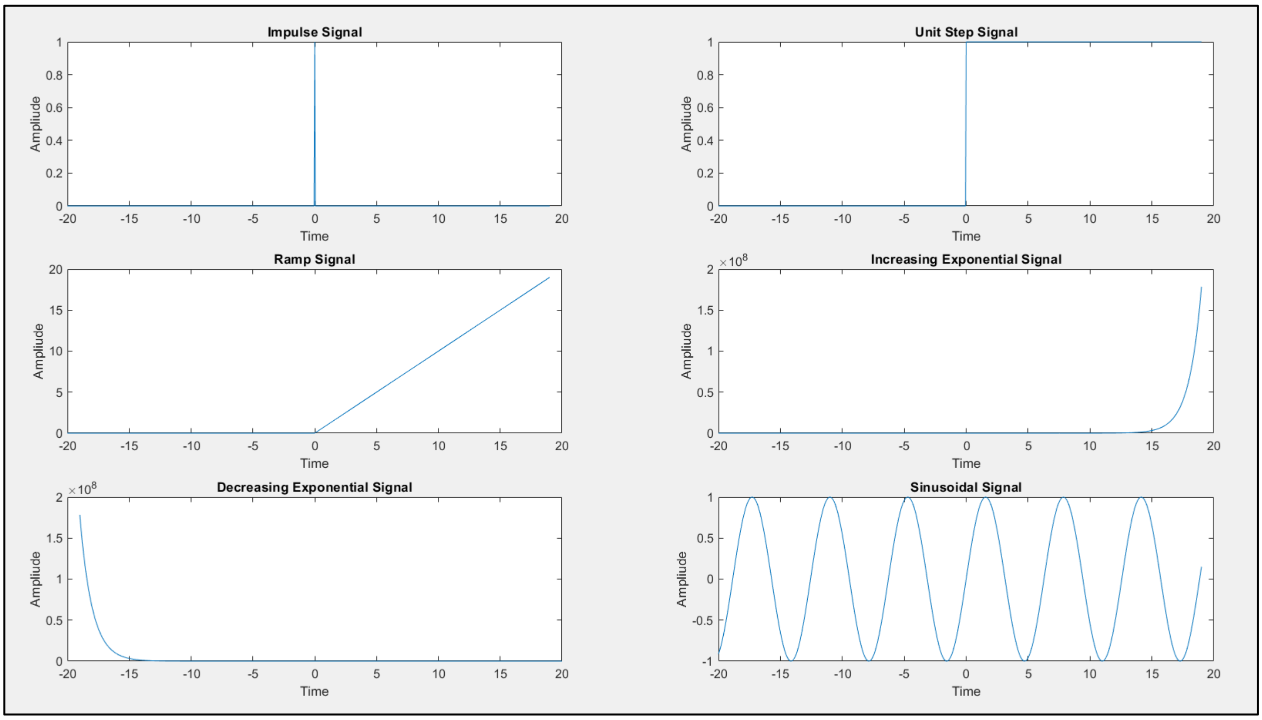
Code ↬

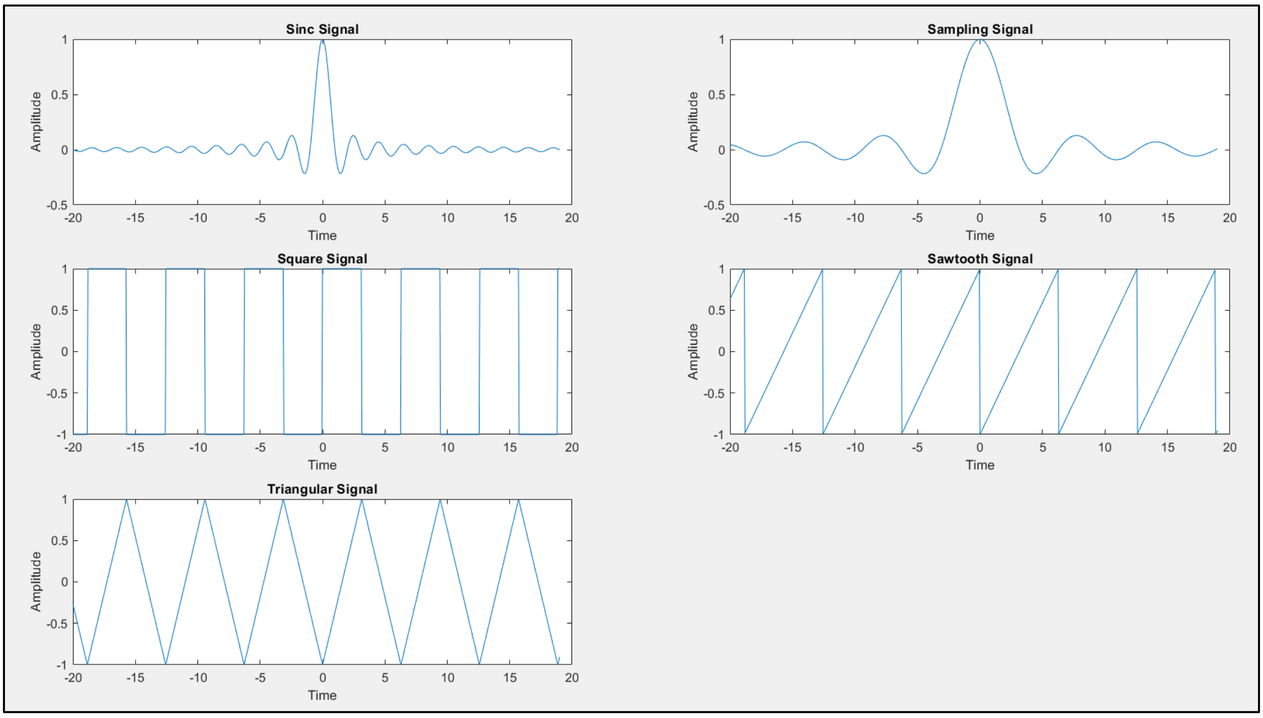
```
%Continuous Time Signals
clc;
clear;
n = -20:0.05:19;

figure;

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

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

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

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

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

%Sinusoidal Signal
s=sin(n);
subplot(3,2,6);
plot(n,s);
xlabel('Time');
ylabel('Ampliude');
title('Sinusoidal Signal');

figure;

%Sinc Signal
sinc = sinc(n);
subplot(3,2,1);
plot(n,sinc);
xlabel('Time');
ylabel('Amplitude');
title('Sinc Signal');

%Sampling Signal
sa = sin(n)./n;
subplot(3,2,2);
plot(n,sa);
xlabel('Time');
ylabel('Amplitude');
title('Sampling Signal');

%Square Signal
sq=square(n);
subplot(3,2,3);
plot(n,sq);
xlabel('Time');
ylabel('Ampliude');
title('Square Signal');
```

```
%Sawtooth Signal
saw=sawtooth(n);
subplot(3,2,4);
plot(n,saw);
xlabel('Time');
ylabel('Ampliude');
title('Sawtooth Signal');

%Triangular Signal
tri=sawtooth(n, 0.5);
subplot(3,2,5);
plot(n,tri);
xlabel('Time');
ylabel('Amplitude');
title('Triangular Signal');
```

Output ↬





Result ↬

In this experiment, various continuous-time elementary signals were generated using MATLAB. The signals include Unit Impulse, Unit Step, Ramp, Increasing and Decreasing Exponential, Sinusoidal, Sinc, Sampling, Square, Sawtooth, and Triangular signals. Each signal was plotted against time to visualize its characteristics and behavior.

Conclusion ↬

The experiment successfully demonstrated the generation and visualization of different elementary continuous-time signals using MATLAB. Understanding these signals and their properties is crucial in 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 time variable to accurately visualize the signals.
- Verify the mathematical expressions used for each signal to avoid errors in signal generation.
- Handle division by zero carefully, especially for functions like the sinc function.