EXPERIMENT 1: Basic Functions/Signals in MATLAB

Date: 20/01/2020

Aim: To plot basic functions sine, cosine, tangent and exponential in MATLAB. Plot basic signals such as unit impulse, unit step and unit ramp. Plot the periodic signals impulse train, square wave, saw tooth wave and triangular wave.

Theory/Equations:

Sine Wave:

A **sine wave** or **sinusoid** is a mathematical curve that describes a smooth periodic oscillation. A sine wave is a continuous wave. It is named after the function sine, of which it is the graph. It occurs often in pure and applied mathematics, as well as physics, engineering, signal processing and many other fields. Its most basic form as a function of time (*t*) is:

$$y(t) = A\sin(2\pi ft + \varphi) = A\sin(\omega t + \varphi)$$

where:

- ***A***, *amplitude*, the peak deviation of the function from zero.
- ***f***, *ordinary frequency*, the *number* of oscillations (cycles) that occur each second of time.
- $\boldsymbol{\omega} = \mathbf{2\pi}\boldsymbol{f}$, *angular frequency*, the rate of change of the function argument in units of radians per second
- **φ**, *phase*, specifies (in radians) where in its cycle the oscillation is at $t = 0$.

  When **φ** is non-zero, the entire waveform appears to be shifted in time by the amount $\boldsymbol{\varphi}/\boldsymbol{\omega}$ seconds. A negative value represents a delay, and a positive value represents an advance.

Cosine Wave:

A cosine wave is a signal waveform with a shape identical to that of a sine wave , except each point on the cosine wave occurs exactly 1/4 cycle earlier than the corresponding point on the sine wave. A cosine wave and its corresponding sine wave have the same frequency, but the cosine wave leads the sine wave by 90 degrees of phase .

$$f(t) = A\cos(2\pi ft + \varphi) = Asin(\omega t + \varphi)$$

Tangent Wave:

$$f(t) = \tan(t)$$

The tan function operates element-wise on arrays. The function accepts both real and complex inputs.
For real values of X, tan(X) returns real values in the interval [-∞, ∞].
For complex values of X, tan(X) returns complex values.

Exponential Function:

An exponential function can be defined as:

$$f(t) = e^t$$

It is expected to rise at a very fast rate within a short span of time. Usually, in electronics, a degrading exponential function is found common with the coefficient of 't' usually negative.

Unit Step Function:

$$f(t) = \begin{cases} 0, & x < 0 \\ 1, & x > 0 \end{cases}$$

Unit **Impulse Function:**

$$f(t) = \begin{cases} 0, & x = 0 \\ 1, & x \neq 0 \end{cases}$$

Ramp Function:

$$f(t) = \begin{cases} 0, & x < 0 \\ t, & x \geq 0 \end{cases}$$

Impulse Train function with a period T:

$$f(t) = \begin{cases} 0, & x \neq nT \\ 1, & x = nT \end{cases} \; n \epsilon Z$$

Square Wave function with a period T:

$$f(t) = 1(-1)^{\lfloor 2t/T \rfloor}$$

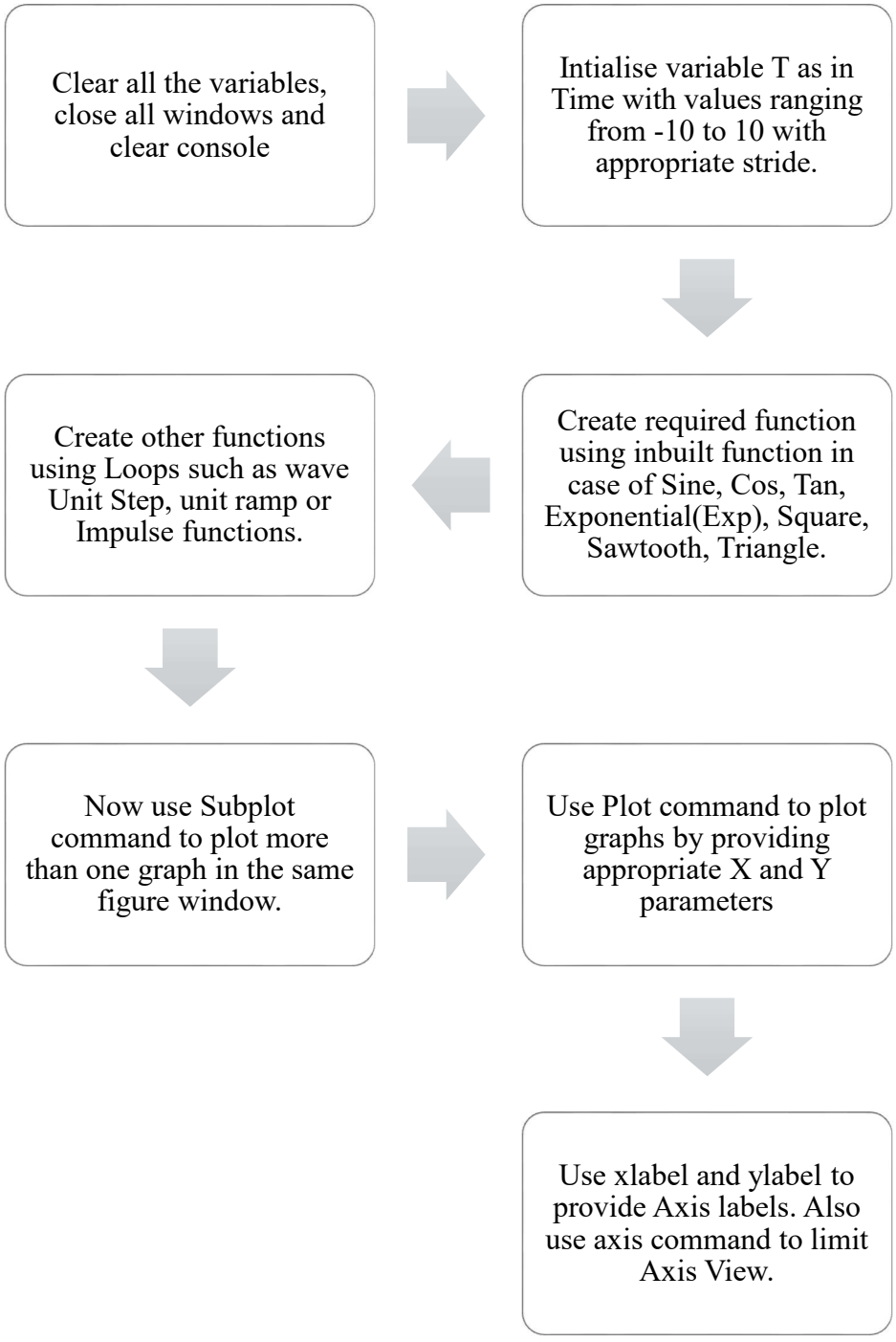
Saw-tooth Wave function with a period T:

$$f(t) = t - \lfloor t \rfloor$$

Triangle Wave function with a period T:

$$f(t) = \int_0^t sgn(\sin(t))dt$$

Flowchart/Algorithm:



1. Clear console, screen and close windows using the commands clc, clear all, close all.
2. Initialise t with values from -10 to 10 with step as necessary.
3. Use in-built sin(), cos(), tan(), exp() while using plot function to plot respective graphs.
4. For Unit step function, create unit_step array with value 1 when t>0 and 0 otherwise, and plot it against t.
5. For Unit Impulse function, create unit_impulse array with value 1 when t=0 and 0 otherwise, and plot it against t.
6. For Ramp function, create ramp array with value t when t>0 and 0 otherwise and plot it against t.
7. For Impulse train function, create impulse_train array with value 1 when t = nT and 0 otherwise using for loop.
8. For square function, use in-built function square().
9. For sawtooth function, use in-built function sawtooth().
10. For triangle function, use in built function sawtooth() with width=0.5.
11. Use subplot command to create more than one graphs in one figure window. Use subplot command before plotting any graph such as subplot(<graph count x>,<graph count y>,<graph pos>) where graph count x = No. of graphs to be displayed horizontally, graph count y = No. of graphs to be displayed vertically, graph pos = Position of graph on the window which is usually row majored (1 – top left , 2 –top right , 3 – bottom left, 4 – bottom right in case of 2 by 2 subplot).
12. To plot graph, use plot() command with 1st parameter as the quantity for X axis, that is 't' and 2nd parameter as the quantity for Y axis, that is, any one of the above derived quantities.
13. To provide X axis label, use xlabel(<string>) and to provide Y axis label, use ylabel(<string>).
14. Use title(<string>) to provide title to the graph.
15. Use axis([]) to provide axis limits to the graph.
16. Do the above process for all required graphs.
17. It is recommended to use Sections as shown in the Code section so as to plot the graphs in a legible form. Sections can be used in the following fashion:- %% <title of section>
18. Run the written code using F5 or section using CTRL + F5.
19. Save the graphs from File > Save As.
20. The required experiment has been completed successfully.

Code:

```
%% Part A


clc; %Clear console

clear all; %Clear variables

close all; %Close all windows except Editor window


t = -10:0.001:10; %Initialise t

subplot(2,2,1); %Using subplot to plot next graphs

plot(t,sin(t)); %Plotted Sine graphs

xlabel('Time(in s)'); %X Label for Sine graph

ylabel('Voltage(in V)'); %Y Label for Sine graph

title('Sine');%Title for Sine graph

axis([-10 10 -2 2]); %Axis limitations for Sine graph


subplot(2,2,2);

plot(t,cos(t)); %Plotted Cosine graph

axis([-10 10 -2 2]);

xlabel('Time(in s)');

ylabel('Voltage(in V)');
```

```
title('Cosine');


subplot(2,2,3);
plot(t,tan(t)); %Plotted Tangent graph
axis([-10 10 -2 2]);
xlabel('Time(in s)');
ylabel('Voltage(in V)');
title('Tangent');


subplot(2,2,4);
plot(t,exp(t)); %Plotted Exponential graph
axis([-10 10 -2 20000]);
xlabel('Time(in s)');
ylabel('Voltage(in V)');
title('Exponential');
%% Part B
clc;
clear all;
close all;
```

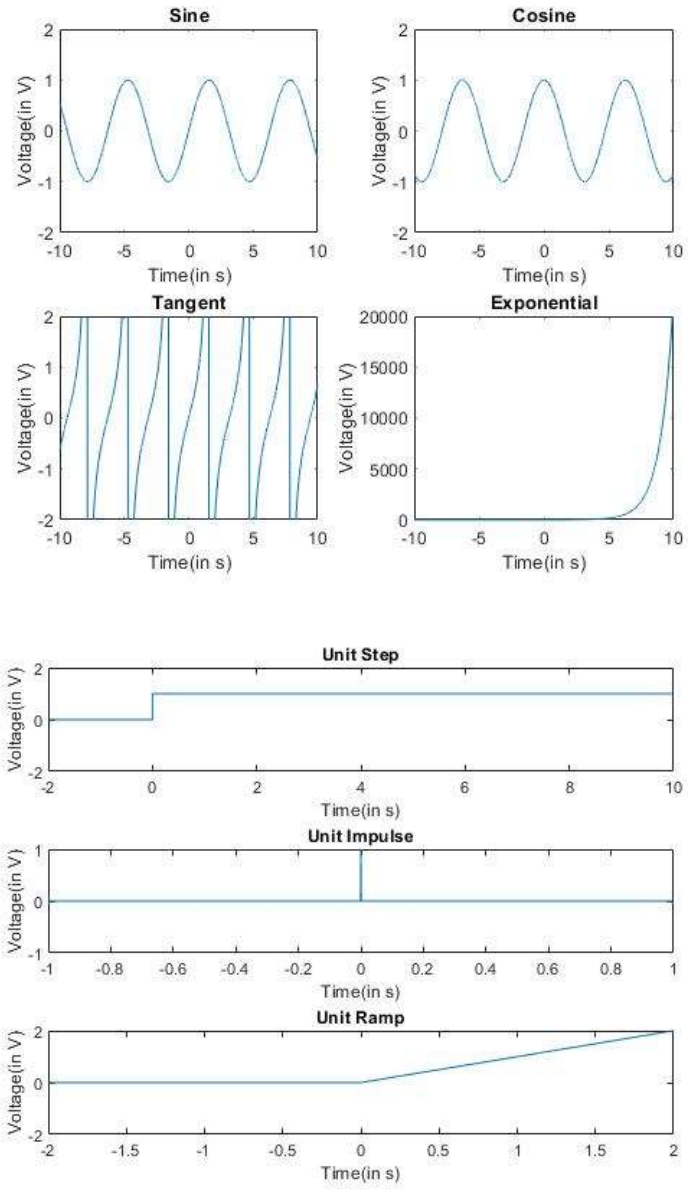
```
t = -10:0.001:10;

unit_step = double(t>0); %Set values for unit_step for different values
of t

unit_impulse = double(t==0); %Set value for unit_impulse for different
values of t (1 when t=0 else 0)

unit_ramp = zeros(size(t)); %Initialise unit_ramp with 0

[m n] =  size(t); %Retrieve size of t for the below loop

for i=1:n

   if (t(1,i)>0)

       unit_ramp(1,i)=t(1,i); %Set unit_ramp = t when t>0

   end

end


subplot(3,1,1);

plot(t,unit_step) %Plotted Unit Step graph

axis([-2 10 -2 2]);

xlabel('Time(in s)');

ylabel('Voltage(in V)');

title('Unit Step');


subplot(3,1,2);
```

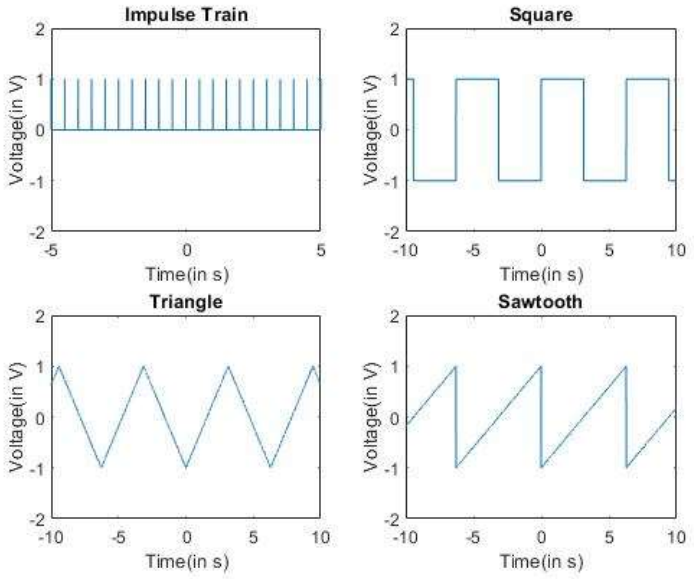
```
plot(t,unit_impulse) %Plotted Unit Impulse graph

axis([-1 1 -1 1]);

xlabel('Time(in s)');

ylabel('Voltage(in V)');

title('Unit Impulse');



subplot(3,1,3);

plot(t,unit_ramp) %Plotted Unit Ramp graph

axis([-2 2 -2 2]);

xlabel('Time(in s)');

ylabel('Voltage(in V)');

title('Unit Ramp');



%% Part C



clc;

clear all;

close all;



t = -10:0.001:10;
```

```
time_period =0.5; %Set period for Impulse strain and triangle function
[m n] = size(t);


impulse_train=double(mod(t,time_period)==0);   %Iterating Impulse over
certain period
sqr = square(t); %Generating Square Wave
saw = sawtooth(t); %Generating Sawtooth Wave
trng1 = sawtooth(t,time_period); %Generating triangle wave by setting
width = time_period


subplot(2,2,1);
plot(t,impulse_train); %Plotted Impulse Train graph
axis([-5,5 -2 2]);
xlabel('Time(in s)');
ylabel('Voltage(in V)');
title('Impulse Train');


subplot(2,2,2);
plot(t,sqr); %Plotted Square Wave graph
axis([-10 10 -2 2]);
```

```
xlabel('Time(in s)');

ylabel('Voltage(in V)');

title('Square');



subplot(2,2,3);

plot(t,trngl); %Plotted Triangle Wave graph

axis([-10 10 -2 2]);

xlabel('Time(in s)');

ylabel('Voltage(in V)');

title('Triangle');



subplot(2,2,4);

plot(t,saw); %Plotted Sawtooth Wave graph

axis([-10 10 -2 2]);

xlabel('Time(in s)');

ylabel('Voltage(in V)');

title('Sawtooth');
```

Result/Output Waveforms:





Conclusion:

The basic functions such as sine, cosine, tangent and exponential as well as various signals such as unit impulse, unit step and unit ramp and periodic signals such as impulse train, square wave, saw tooth and triangular wave have been plotted using MATLAB successfully and appropriate code along with diagram have been observed and mentioned.

Remarks: **Signature**