**Linearity and Non Linearity using Matlab**

clc;clear all;

close all;

% Define the input signals

t = -2:0.01:2; % time vector

% Define two input signals x1(t) and x2(t)

x1\_t = sin(t);

x2\_t = cos(t);

% Define scalars a and b

a = 2;

b = 3;

% Define the system output for each input

y1\_t = x1\_t.^2;

y2\_t = x2\_t.^2;

% Check superposition

y\_superposition\_left = (a \* x1\_t + b \* x2\_t).^2;

y\_superposition\_right = a^2 \* y1\_t + b^2 \* y2\_t + 2 \* a \* b \* x1\_t .\* x2\_t;

% Plot the results for superposition

figure;

subplot(2, 1, 1);

plot(t, y\_superposition\_left);

title('System output for (a\*x1(t) + b\*x2(t))^2');

xlabel('t');

ylabel('y\_{superposition\\_left}(t)');

grid on;

subplot(2, 1, 2);

plot(t, y\_superposition\_right);

title('a^2\*y1(t) + b^2\*y2(t) + 2ab\*x1(t)x2(t)');

xlabel('t');

ylabel('y\_{superposition\\_right}(t)');

grid on;

% Check if the system is linear by comparing the two results

is\_linear\_superposition = isequal(y\_superposition\_left, y\_superposition\_right);

% Check homogeneity

y\_homogeneity\_left = (a \* x1\_t).^2;

y\_homogeneity\_right = a^2 \* y1\_t;

% Plot the results for homogeneity

figure;

subplot(2, 1, 1);

plot(t, y\_homogeneity\_left);

title('System output for (a\*x1(t))^2');

xlabel('t');

ylabel('y\_{homogeneity\\_left}(t)');

grid on;

subplot(2, 1, 2);

plot(t, y\_homogeneity\_right);

title('a^2\*y1(t)');

xlabel('t');

ylabel('y\_{homogeneity\\_right}(t)');

grid on;

% Check if the system is linear by comparing the two results

is\_linear\_homogeneity = isequal(y\_homogeneity\_left, y\_homogeneity\_right);

% Display the results

if is\_linear\_superposition && is\_linear\_homogeneity

disp('The system is linear.');

else

disp('The system is non-linear.');

end

**Time Variance and Invariance**

% Define the time vector

t = -2:0.01:2;

% Define the input signal x(t)

x\_t = sin(t);

% Define the time shift t0

t0 = 1;

% Calculate the output without shift y(t) = x(2t)

y\_t = x\_t(2\*t);

% Calculate the shifted input x(t-t0)

x\_t\_shifted = sin(t - t0);

% Calculate the output for shifted input y(t-t0) = x(2(t-t0))

y\_t\_shifted = x\_t(2\*(t - t0));

% Calculate the shifted output x(2t - t0)

y\_t\_shifted\_direct = sin(2\*t - t0);

% Plot the original and shifted signals

figure;

subplot(3, 1, 1);

plot(t, y\_t, 'LineWidth', 1.5);

title('y(t) = x(2t)');

xlabel('t');

ylabel('y(t)');

grid on;

subplot(3, 1, 2);

plot(t, y\_t\_shifted, 'LineWidth', 1.5);

title('y(t-t0) = x(2(t-t0))');

xlabel('t');

ylabel('y(t-t0)');

grid on;

subplot(3, 1, 3);

plot(t, y\_t\_shifted\_direct, 'LineWidth', 1.5);

title('y(t) = x(2t - t0)');

xlabel('t');

ylabel('y(t)');

grid on;

% Compare the results

is\_time\_invariant = isequal(y\_t\_shifted, y\_t\_shifted\_direct);

% Display the result

if is\_time\_invariant

disp('The system is time-invariant.');

else

disp('The system is time-variant.');

end