Lab 5

Objective:

The objective of this lab is to create an understanding of convolution by writing a code to perform convolution of two signals.

Theoretical Background:

Convolution is the representation of an LTI system in terms of its unit impulse response. Impulse response of a system h[n] is the output when a unit impulse δ[n] is given at its input. For a system with input x[n] and the system impulse response h[n], the output y[n] of the system is calculated by convolution of the system response and input, given as:

$$[] = [] * h[]$$

Tasks:

Write your own code for convolution of the following sets of discrete sequences, such that the convolved signal y[n] is given as described above. Explain each and every step in your code. Compare your results with the results of built in conv function

Task 1:

When x[n] is a unit impulse and h[n] is a unit step function.

```
% Define the unit impulse function δ[n]
n = -10:10;
x = @(n) (n == 0);

% Define the unit step function u[n]
h = @(n) (n >= 0);

% Initialize y_manual and y_conv as arrays of zeros
y_manual = zeros(1, length(n));
y_conv = zeros(1, length(n));

% Perform convolution manually using nested loops
for i = 1:length(n)
    for j = 1:length(n)
        if i - j + 1 > 0
            y_manual(i) = y_manual(i) + x(n(j)) * h(n(i - j + 1));
        end
    end
end

% Perform convolution using the built-in 'conv' function
y_conv = conv(x(n), h(n), 'same');

% Compare the results
isequal(y_manual, y_conv) % Check if the results are equal
```

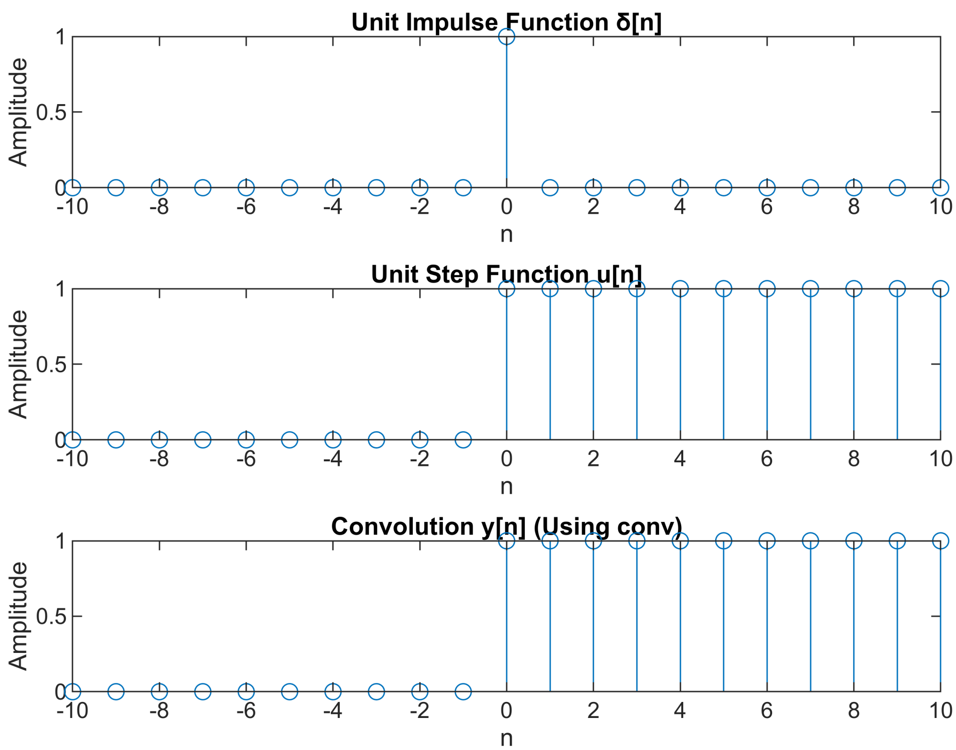
```
ans = logical
```

```
0
```

```
% Plot the signals and their convolution result
subplot(3,1,1);
stem(n, arrayfun(x, n));
title('Unit Impulse Function δ[n]');
xlabel('n');
ylabel('Amplitude');

subplot(3,1,2);
stem(n, arrayfun(h, n));
title('Unit Step Function u[n]');
xlabel('n');
ylabel('Amplitude');

subplot(3,1,3);
stem(n, y_conv);
title('Convolution y[n] (Using conv)');
xlabel('n');
ylabel('Amplitude');
```



Task 2:

When both x[n] and h[n] are unit step functions.

```
% Define the unit step function u[n] one
n = -10:10;
x = @(n) (n >= 0);

% Define the unit step function u[n] two
h = @(n) (n >= 0);

% Initialize y_manual and y_conv as arrays of zeros
y_manual = zeros(1, length(n));
y_conv = zeros(1, length(n));

% Perform convolution manually using nested loops
for i = 1:length(n)
    for j = 1:length(n)
        if i - j + 1 > 0
            y_manual(i) = y_manual(i) + x(n(j)) * h(n(i - j + 1));
        end
    end
end

% Perform convolution using the built-in 'conv' function
y_conv = conv(x(n), h(n), 'same');

% Compare the results
isequal(y_manual, y_conv) % Check if the results are equal
```

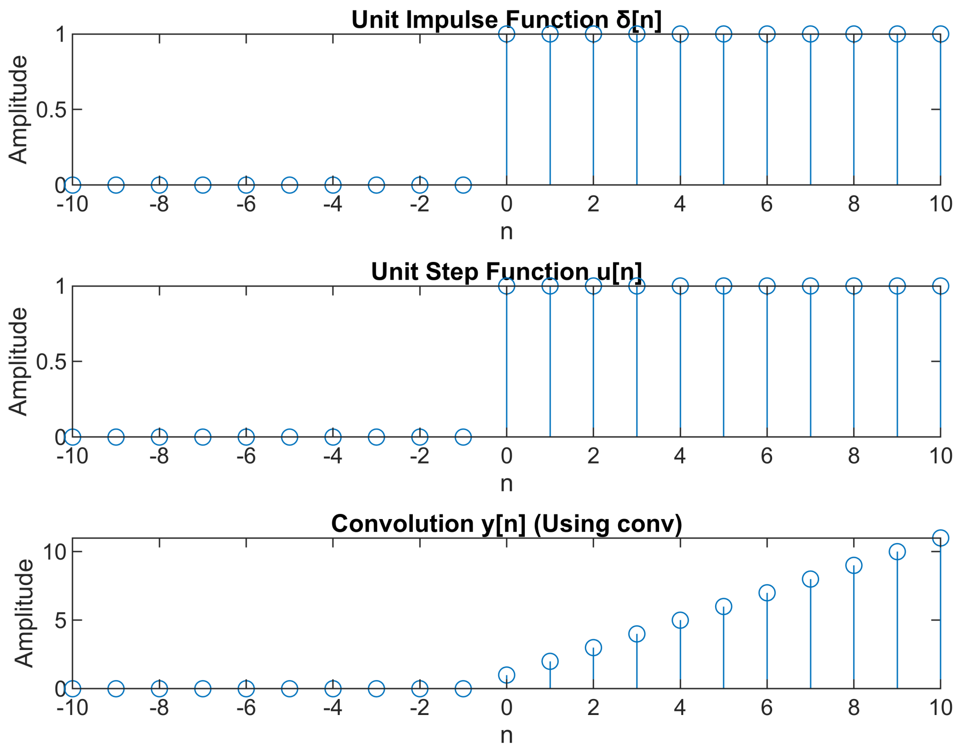
```
ans = logical
   0
```

```

% Plot the signals and their convolution result
subplot(3,1,1);
stem(n, arrayfun(x, n));
title('Unit Impulse Function δ[n]');
xlabel('n');
ylabel('Amplitude');

subplot(3,1,2);
stem(n, arrayfun(h, n));
title('Unit Step Function u[n]');
xlabel('n');
ylabel('Amplitude');

subplot(3,1,3);
stem(n, y_conv);
title('Convolution y[n] (Using conv)');
xlabel('n');
ylabel('Amplitude');
```



Task 3:

When [] = (0.5) [] and h[n] is a unit step function.

```
% Define the unit step function u[n]
n = -10:10;
h = @(n) (n >= 0);

% Define x[n]
x = @(n) (0.5).^n .* (n >= 0);

% Initialize y_manual and y_conv as arrays of zeros
y_manual = zeros(1, length(n));
y_conv = zeros(1, length(n));

% Perform convolution manually using nested loops
for i = 1:length(n)
    for j = 1:length(n)
        if i - j + 1 > 0
            y_manual(i) = y_manual(i) + x(n(j)) * h(n(i - j + 1));
        end
    end
end

% Perform convolution using the built-in 'conv' function
y_conv = conv(arrayfun(x, n), arrayfun(h, n), 'same');
```

```
% Compare the results
isequal(y_manual, y_conv) % Check if the results are equal
```

```
ans = logical
   0
```

```
% Plot the signals and their convolution result
subplot(3,1,1);
stem(n, arrayfun(x, n));
title('Signal x[n]');
xlabel('n');
ylabel('Amplitude');

subplot(3,1,2);
stem(n, arrayfun(h, n));
title('Unit Step Function h[n]');
xlabel('n');
ylabel('Amplitude');

subplot(3,1,3);
stem(n, y_conv);
title('Convolution y[n] (Using conv)');
xlabel('n');
ylabel('Amplitude');
```