LAB 7

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Lab Report:	7
Subject:	Signals & Systems
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LAB 7

Analysis of Continuous Time LTI Systems using Convolution Integral

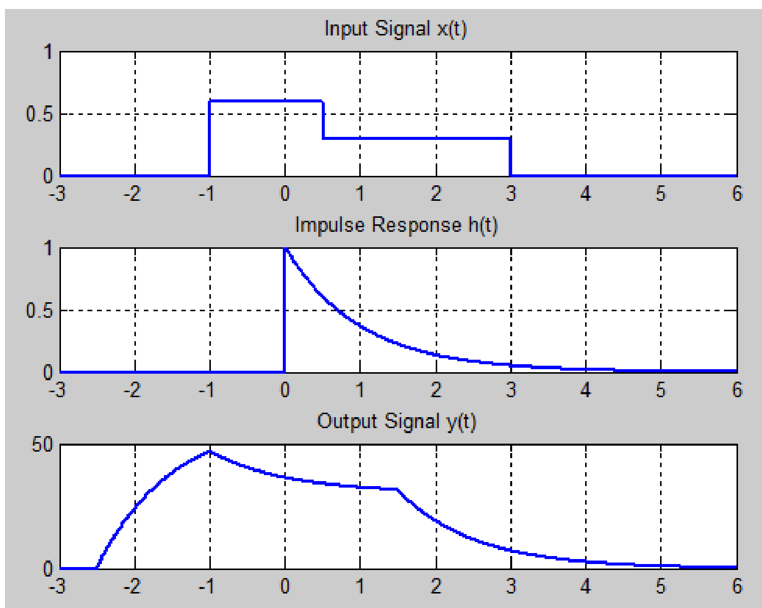
In-Lab Tasks

Task 01: Suppose that a LTI system is described by impulse response $h(t) = e^{-t}u(t)$. Compute the response of the system (by both methods) to the input signal

$$x(t) = \begin{cases} 0.6 & -1 \le t \le 0.5 \\ 0.3 & 0.5 \le t \le 3 \\ 0 & t < -1 \, and \, t > 3 \end{cases}$$

(Method 1)

```
t = -3:0.01:6;
h = exp(-t).*(t >= 0);
x = zeros(size(t));
x(t >= -1 & t <= 0.5) = 0.6;
x(t > 0.5 & t <= 3) = 0.3;
y_conv = conv(x, h, 'same');

subplot(3,1,1);
plot(t, x, 'LineWidth', 1.5);
title('Input Signal x(t)');
grid on;
subplot(3,1,2);
plot(t, h, 'LineWidth', 1.5);
title('Impulse Response h(t)');
grid on;

subplot(3,1,3);
plot(t, y_conv, 'LineWidth', 1.5);
title('Output Signal y(t)');
grid on;
```



(Method 2)

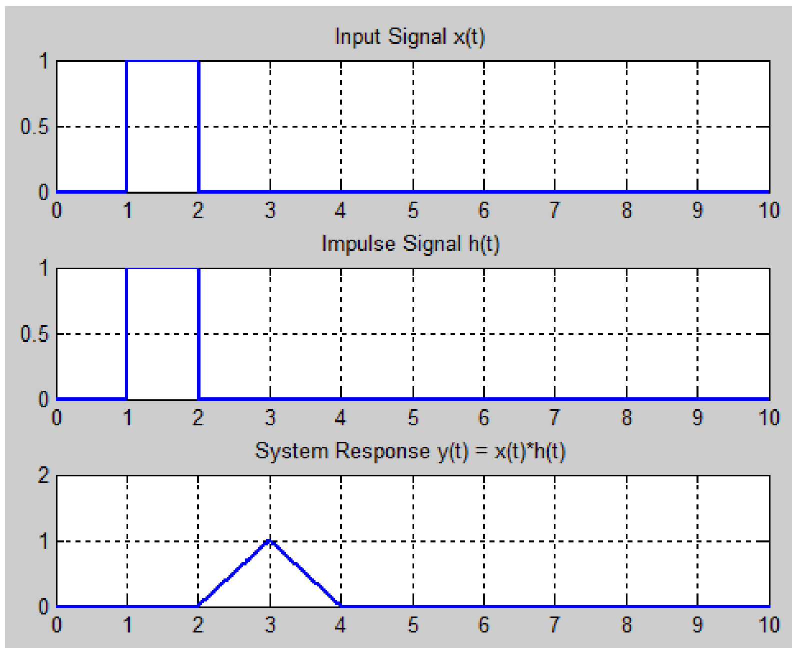
```
time_points = -3:0.01:6;
step_size = 0.01;
total_points = length(time_points);

impulse_response = exp(-time_points) .* (time_points >= 0);

input_signal = zeros(size(time_points));
input_signal(time_points >= -1 & time_points <= 0.5) = 0.6;
input_signal(time_points > 0.5 & time_points <= 3) = 0.3;

output_signal = zeros(1, 2*total_points - 1);

for n = 1:2*total_points-1
  for k = 1:total_points
    if (n - k + 1 > 0) && (n - k + 1 <= total_points)
      output_signal(n) = output_signal(n) + input_signal(k) * impulse_response(n - k + 1);
    end
  end
end

output_signal = output_signal * step_size;
start_index = floor((length(output_signal) - total_points) / 2) + 1;
final_output = output_signal(start_index:start_index + total_points - 1);

subplot(3,1,1);
plot(time_points, input_signal, 'LineWidth', 1.5);
title('Input Signal');
grid on;

subplot(3,1,2);
plot(time_points, impulse_response, 'LineWidth', 1.5);
title('Impulse Response');
grid on;

subplot(3,1,3);
plot(time_points, final_output, 'LineWidth', 1.5);
title('Output Signal');
grid on;
```

Task 02: Compute (by both methods) and plot the response of the system

$$x(t) = h(t) = \begin{cases} 0 & 0 < t < 1 \\ 1 & 1 \le t \le 2 \\ 0 & 2 \le t \le 10 \end{cases}$$

(Method 1)

```
t = 0:0.01:10;
x = zeros(size(t));
x(t >= 1 & t <= 2) = 1;
h = x;
y = conv(x, h) * 0.01;
ty = 0:0.01:20;
figure;
subplot(3,1,1);
plot(t, x, 'LineWidth', 1.5);
title('Input Signal x(t)');
grid on;
subplot(3,1,2);
plot(t, h, 'LineWidth', 1.5);
ylabel('Amplitude');
grid on;
subplot(3,1,3);
plot(ty, y, 'LineWidth', 1.5);
title('System Response y(t) = x(t)*h(t)');
xlim([0 10]);
grid on;
```



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(Method 2)

```
time_points = 0:0.01:10;
step_size = 0.01;
total_points = length(time_points);

impulse_response = zeros(size(time_points));
impulse_response(time_points >= 1 & time_points <= 2) = 1;

input_signal = zeros(size(time_points));
input_signal(time_points >= 1 & time_points <= 2) = 1;

output_signal = zeros(1, 2*total_points - 1);

for n = 1:2*total_points-1
   for k = 1:total_points
      if (n - k + 1 > 0) && (n - k + 1 <= total_points)
         output_signal(n) = output_signal(n) + input_signal(k) * impulse_response(n - k + 1);
      end
   end
end

output_signal = output_signal * step_size;
output_time = (0:length(output_signal)-1)*step_size;

subplot(3,1,1);
plot(time_points, input_signal, 'LineWidth', 1.5);
title('Input Signal');
grid on;

subplot(3,1,2);
plot(time_points, impulse_response, 'LineWidth', 1.5);
title('Impulse Response');
grid on;

subplot(3,1,3);
plot(output_time, output_signal, 'LineWidth', 1.5);
title('Convolution Result ');
xlim([0 10]);
grid on;
```

Task 03: Suppose that a system is described by the impulse response $h(t) = \cos(2\pi t)(u(t) - u(t-4))$.

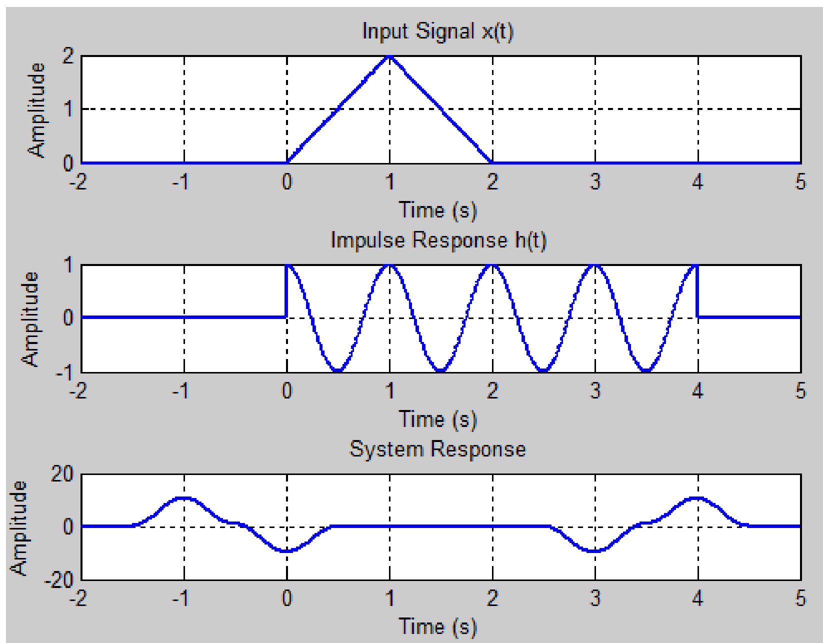
(Method 1)

```
t = -2:0.01:5;
x = zeros(size(t));
x(t>=0 & t <= 1) = 2*t(t>=0 & t <= 1);
x(t > 1 & t <= 2) = 2*(2 - t(t > 1 & t <= 2));
h = cos(2*pi*t) .* (t >= 0 & t <= 4);
y_conv = conv(x, h, 'same');

subplot(3,1,1);
plot(t, x, 'LineWidth', 1.5);
title('Input Signal x(t)');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;

subplot(3,1,2);
plot(t, h, 'LineWidth', 1.5);
title('Impulse Response h(t)');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;

subplot(3,1,3);
plot(t, y_conv, 'LineWidth', 1.5);
title('System Response');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;
```



(Method 2)

```
time_points = -2:0.01:5;
step_size = 0.01;
total_points = length(time_points);

input_signal = zeros(size(time_points));
input_signal(time_points >= 0 & time_points <= 1) = 2*time_points(time_points >= 0 & time_points <= 1);
input_signal(time_points > 1 & time_points <= 2) = 2*(2 - time_points(time_points > 1 & time_points <= 2));

impulse_response = cos(2*pi*time_points) .* (time_points >= 0 & time_points <= 4);

output_signal = zeros(1, 2*total_points - 1);

for n = 1:2*total_points-1
   for k = 1:total_points
      if (n - k + 1 > 0) && (n - k + 1 <= total_points)
         output_signal(n) = output_signal(n) + input_signal(k) * impulse_response(n - k + 1);
      end
   end
end
output_signal = output_signal * step_size;

start_index = floor((length(output_signal) - total_points) / 2) + 1;
final_output = output_signal(start_index:start_index + total_points - 1);

subplot(3,1,1);
plot(time_points, input_signal, 'LineWidth', 1.5);
title('Input Signal x(t)');
grid on;

subplot(3,1,2);
plot(time_points, impulse_response, 'LineWidth', 1.5);
title('Impulse Response h(t)');
grid on;

subplot(3,1,3);
plot(time_points, final_output, 'LineWidth', 1.5);
title('System Response y(t)');
grid on;
```

Post-Lab Task

Critical Analysis / Conclusion

This lab helped us understand how LTI systems work and how signals are changed using convolution. We learned how to calculate convolution manually and with MATLAB to see the differences in ease and accuracy. It also showed how important step size and time points are when working with signals. Using 'same' in the conv function ensures that the output signal has the same length as the original input signal.

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