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Reg. No:	FA23 – BCE – 060
Lab Report:	8
Subject:	Signals & Systems
Course Instructor:	Dr. Bilal Qasim

LAB 8

Properties of Convolution

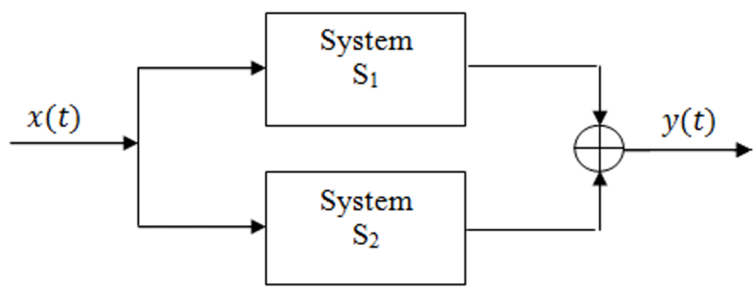
In-Lab Tasks

Task 01: A system is described by the impulse response $h(t) = t^2$. Tell if this is a BIBO stable system.

```
syms t;
h = t.^(2);
int_h = int(h, t, -inf, inf);
if isinf(int_h)
   disp('System is not BIBO stable');
else
   disp('System is BIBO stable');
end
```

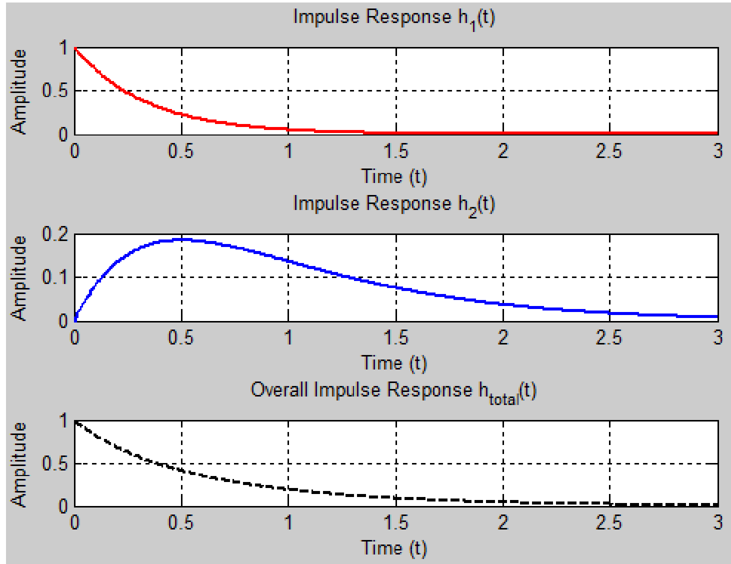
```
>> TASK_1
System is not BIBO stable
```

Task 02: Suppose that the impulse response of the subsystems S_1 and S_2 that are connected as shown in figure below are $h_1(t) = e^{-3t}u(t)$ and $h_2(t) = te^{-2t}u(t)$. Determine if the overall system is BIBO stable.



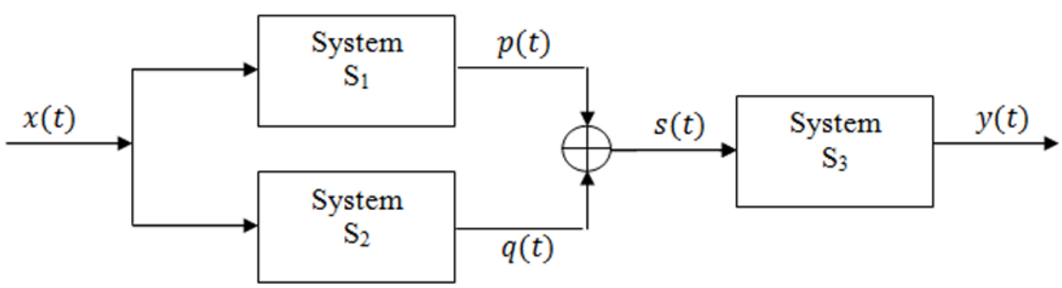

```
dt = 0.01;
t = 0:dt:3;
h1 = exp(-3*t) .* (t >= 0);
h2 = t .* exp(-2*t) .* (t >= 0);
h_total = h1 + h2;
area = trapz(t, abs(h_total));
if area < Inf
   disp('System is BIBO Stable');
else
   disp('System is NOT BIBO Stable');
end
figure;
```

```
subplot(3,1,1);
plot(t, h1, 'r', 'LineWidth', 1.5);
title('Impulse Response h_1(t)');
xlabel('Time (t)');
ylabel('Amplitude');
grid on;
subplot(3,1,2);
plot(t, h2, 'b', 'LineWidth', 1.5);
title('Impulse Response h_2(t)');
xlabel('Time (t)');
ylabel('Amplitude');
grid on;
subplot(3,1,3);
plot(t, h_total, 'k--', 'LineWidth', 1.5);
title('Overall Impulse Response h_{total}(t)');
xlabel('Time (t)');
ylabel('Amplitude');
grid on;
```




```
>> TASK_2
System is BIBO Stable
```

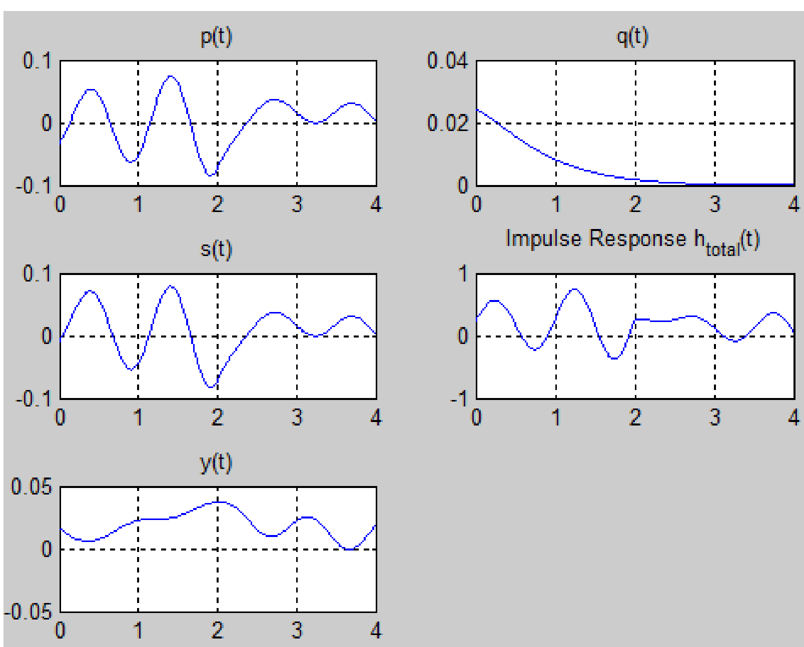
Task 03: Suppose that the impulse responses of the sub-systems S_1, S_2 and S_3 that are connected as shown in the figure below are $h_1(t) = t\cos(2\pi t), 0 \le t \le 4$; $h_2(t) = t\,e^{-2t}, 0 \le t \le 4$; and $h_3(t) = u(t) - u(t-5)$. Compute and plot in the appropriate time interval the impulse response of the overall system and the response of the overall system to the input signal $x(t) = te^{-2t}\,[u(t) - u(t-2)]$.



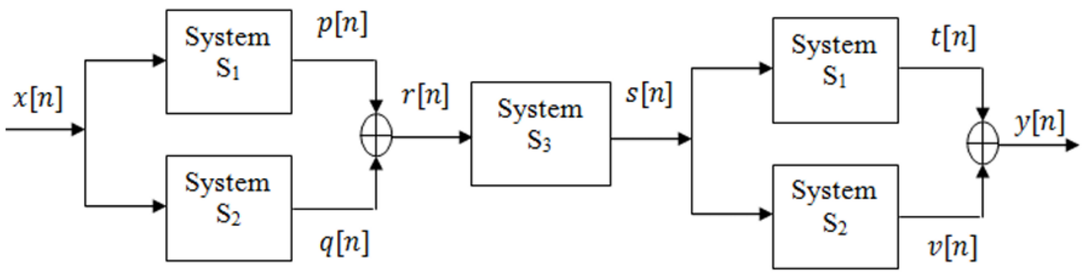
i. Make only one file for this task.
ii. Call functions within this m-file which is needed.
iii. Compute impulse response of the overall system.
iv. Compute the response of the overall system to the given input signal $x(t)$.
v. Plot all graphs $p(t), q(t), s(t)$ and $y(t)$.
vi. Determine if the overall system is BIBO stable or not.

```
dt = 0.01;
t = 0:dt:4;
h1 = (t >= 0 & t <= 4) .* t .* cos(2*pi*t);
h2 = (t >= 0 & t <= 4) .* t .* exp(-2*t);
h3 = (t >= 0) - (t >= 5);
x = (t >= 0 & t <= 2) .* t .* exp(-2*t);
p = conv(x, h1, 'same') * dt;
q = conv(x, h2, 'same') * dt;
s = p + q;
y = conv(s, h3, 'same') * dt;
s_impulse = h1 + h2;
h_total = conv(s_impulse, h3, 'same') * dt;
figure;
subplot(3,2,1); plot(t, p);
title('p(t)'); grid on;
subplot(3,2,2);
plot(t, q); title('q(t)'); grid on;
subplot(3,2,3); plot(t, s); title('s(t)'); grid on;
subplot(3,2,4); plot(t, h_total); title('Impulse Response h_{total}(t)'); grid on;
subplot(3,2,5); plot(t, y); title('y(t)'); grid on;
if trapz(t, abs(h_total)) < Inf
   disp('System is BIBO Stable');
else
   disp('System is NOT BIBO Stable');
end
```

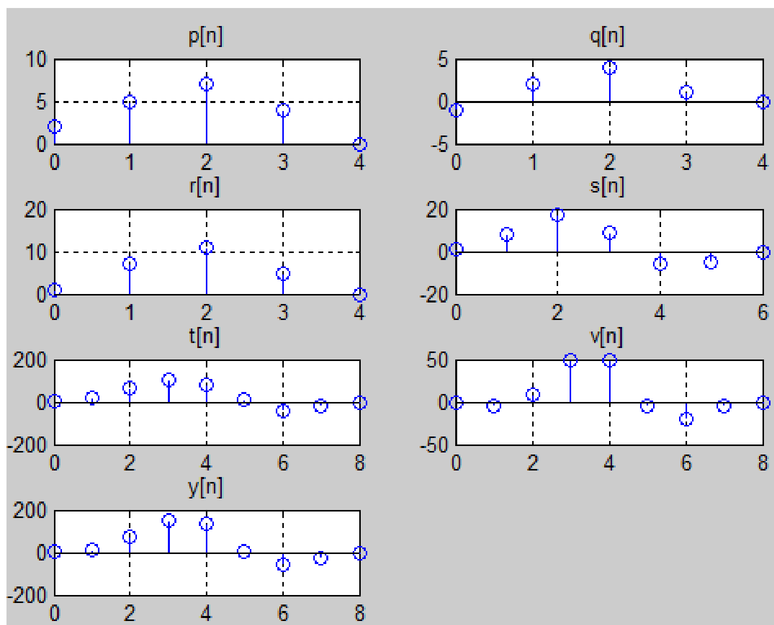
```
>> TASK_3
System is BIBO Stable
```



Task 04: Suppose that the impulse responses of the sub-systems S_1, S_2 and S_3 that are connected as shown in the figure below are $h_1[n] = [2,3,4], 0 \leq n \leq 2$; $h_2[n] = [-1,3,1], 0 \leq n \leq 2$; and $h_3[n] = [1,1,-1], 0 \leq n \leq 2$, respectively. Compute



i. Make only one file for this task.
ii. Call functions within this m-file which is needed.
iii. Compute impulse response of the overall system.
iv. Compute the response of the overall system to the given input signal $x[n] = u[n] - u[n-2]$.
v. Plot all graphs $p[n], q[n], r[n], s[n], t[n], v[n]$and $y[n]$.
vi. Determine if the overall system is BIBO stable or not.




```
h1 = [2 3 4];
h2 = [-1 3 1];
h3 = [1 1 -1];
x  = [1 1 0];
p = conv(x, h1);
q = conv(x, h2);
r = p + q;
s = conv(r, h3);
t = conv(s, h1);
v = conv(s, h2);
y = t + v;
n_p = 0:length(p)-1;
n_q = 0:length(q)-1;
n_r = 0:length(r)-1;
n_s = 0:length(s)-1;
n_t = 0:length(t)-1;
n_v = 0:length(v)-1;
n_y = 0:length(y)-1;
subplot(4,2,1); stem(n_p, p); title('p[n]'); grid on;
subplot(4,2,2); stem(n_q, q); title('q[n]'); grid on;
subplot(4,2,3); stem(n_r, r); title('r[n]'); grid on;
subplot(4,2,4); stem(n_s, s); title('s[n]'); grid on;
subplot(4,2,5); stem(n_t, t); title('t[n]'); grid on;
subplot(4,2,6); stem(n_v, v); title('v[n]'); grid on;
subplot(4,2,7); stem(n_y, y); title('y[n]'); grid on;
```

```
h_eq = conv(conv(h1 + h2, h3), h1) + conv(conv(h1 + h2, h3), h2);
disp('Impulse response of overall system (h_{eq}):');
disp(h_eq);
if sum(abs(h_eq)) < Inf
   disp('System is BIBO stable.');
else
   disp('System is NOT BIBO stable.');
end
```

```
>> TASK_4
Impulse response of overall system (h_{eq}):
     1    13    57    94    39   -35   -25

System is BIBO stable.
```

Post-Lab Tasks

Critical Analysis / Conclusion

In this lab focuses on convolution and system stability, key concepts in signal processing. Convolution helps in understanding how a system responds to different inputs, making it useful for analyzing real-world signals in communication and engineering. By checking Bounded-Input, Bounded-Output (BIBO) stability, we determine whether a system will produce stable outputs when given a limited input.

Lab Assessment		
Lab Task Evaluation	**/6**	**/10**
Lab Report	**/4**	
Instructor Signature and Comments		