Ryerson University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Title:	Signals and Systems 1
Course Number:	ELE 532
Semester/Year (e.g.F2016)	F2021

Instructor:	Soosan Beheshti

Assignment/Lab Number:	02
Assignment/Lab Title:	02

Submission Date:	2021-10-31
Due Date:	2021-10-31

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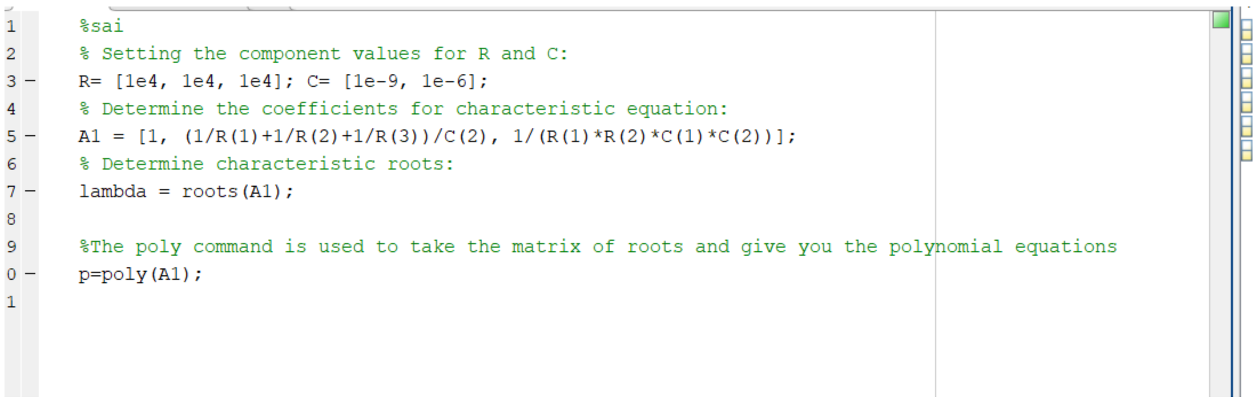
A1.

```
%sai
% Setting the component values for R and C:
R= [1e4, 1e4, 1e4]; C= [1e-9, 1e-6];
% Determine the coefficients for characteristic equation:
A1 = [1, (1/R(1)+1/R(2)+1/R(3))/C(2), 1/(R(1)*R(2)*C(1)*C(2))];
% Determine characteristic roots:
lambda = roots(A1);

%The poly command is used to take the matrix of roots and give you the polynomial equations
p=poly(A1);
```




```
%sai
% Setting the component values for R and C:
R= [1e4, 1e4, 1e4]; C= [1e-9, 1e-6];
% Determine the coefficients for characteristic equation:
A1 = [1, (1/R(1)+1/R(2)+1/R(3))/C(2), 1/(R(1)*R(2)*C(1)*C(2))];
% Determine characteristic roots:
lambda = roots(A1);

%The poly command is used to take the matrix of roots and give you the polynomial equations
p=poly(A1);
```

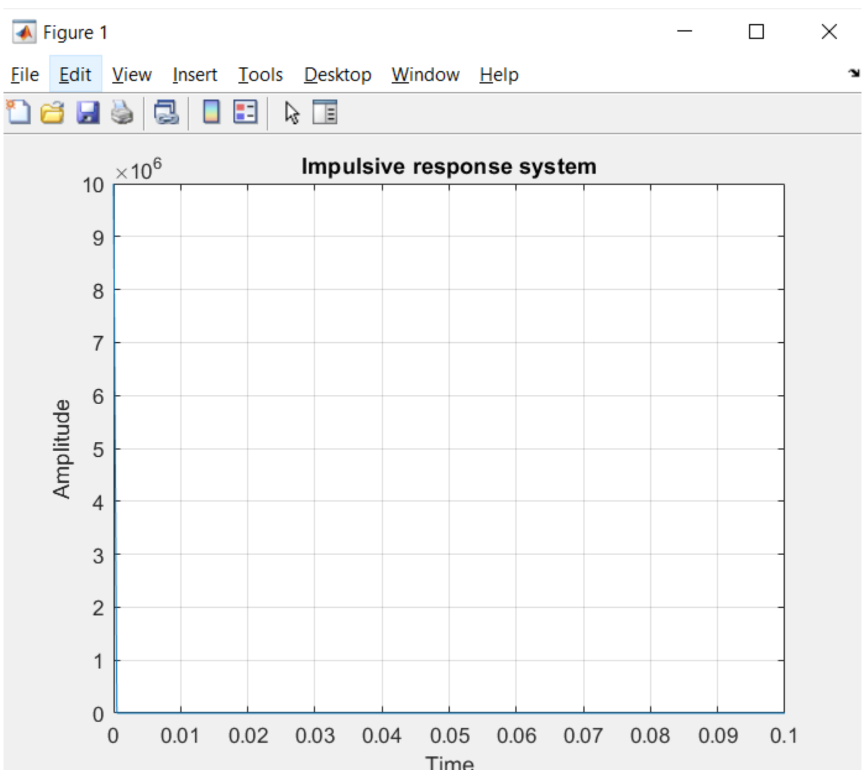

A2.

```
%sai
% Setting the component values for R and C:
R= [1e4, 1e4, 1e4]; C= [1e-9, 1e-6];
% Determine the coefficients for characteristic equation:
A1 = [1 (1/R(1)+1/R(2)+1/R(3))/C(2) 1/(R(1)*R(2)*C(1)*C(2))];
% Determine characteristic roots:
lambda = roots(A1);
%creating the transfer function
k= tf(1/(R(1)*R(2)*C(1)*C(2)),1);
%creating the time limit
t=0:0.0005:0.1;
%creating the function u as a initial function
u = t==0;
%creating a function for impulsive response system
z= lsim(k,u,t);
%creating a graph
plot(t,z);grid;ylabel('Amplitude');xlabel('Time');
title('Impulsive response system');
```

Editor - C:\Users\saire\Downloads\A.m

A.m | CH2MP2.m

```
%sai
% Setting the component values for R and C:
R= [1e4, 1e4, 1e4]; C= [1e-9, 1e-6];
% Determine the coefficients for characteristic equation:
A1 = [1 (1/R(1)+1/R(2)+1/R(3))/C(2) 1/(R(1)*R(2)*C(1)*C(2))];
% Determine characteristic roots:
lambda = roots(A1);
poly(A1);
%creating the transfer function
k= tf(1/(R(1)*R(2)*C(1)*C(2)),1);
%creating the time limit
t=0:0.0005:0.1;
%creating the function u as a initial function
u = t==0;
%creating a function for impulsive response system
z= lsim(k,u,t);
%creating a graph
plot(t,z);grid;ylabel('Amplitude');xlabel('Time');
title('Impulsive response system');
```



A3.

function [lambda] = CH2MP2()

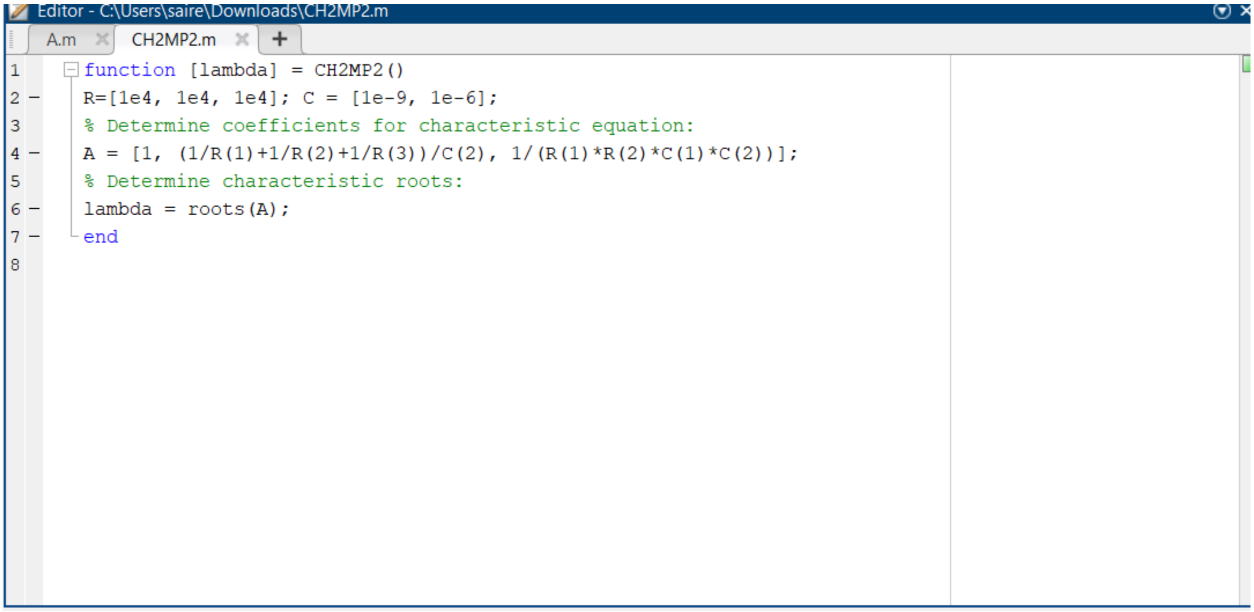
R=[1e4, 1e4, 1e4]; C = [1e-9, 1e-6];

% Determine coefficients for characteristic equation:

A = [1, (1/R(1)+1/R(2)+1/R(3))/C(2), 1/(R(1)*R(2)*C(1)*C(2))];

% Determine characteristic roots:

lambda = roots(A);
end

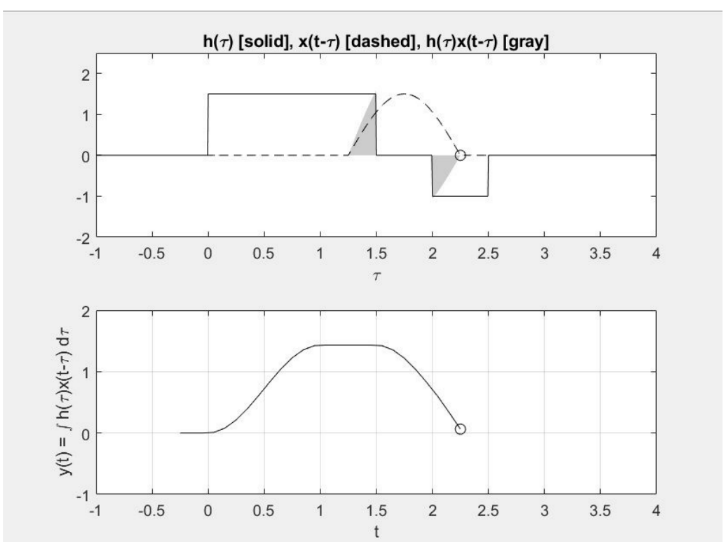



```
function [lambda] = CH2MP2()
R=[1e4, 1e4, 1e4]; C = [1e-9, 1e-6];
% Determine coefficients for characteristic equation:
A = [1, (1/R(1)+1/R(2)+1/R(3))/C(2), 1/(R(1)*R(2)*C(1)*C(2))];
% Determine characteristic roots:
lambda = roots(A);
end
```

B1

In B1 drawnow was replaced with pause as you can see in the code below. While the original code is from the textbook

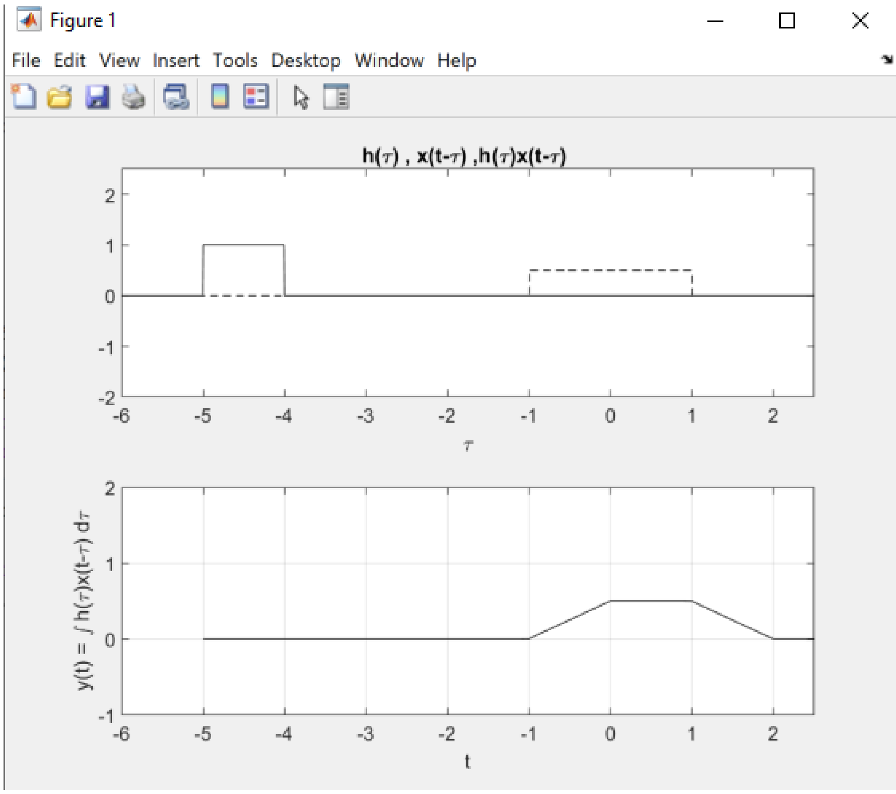
```
% B1

u = @(t) 1.0*(t>=0);
x = @(t) 1.5*sin(pi*t).*(u(t)-u(t-1));
h = @(t) 1.5*(u(t)-u(t-1.5))-u(t-2)+u(t-2.5);
dtau = 0.005; tau = -1:dtau:4;
ti = 0; tvec = -.25:.1:3.75;
y = NaN*zeros(1,length(tvec)); % Pre-allocate memory
for t = tvec,
    ti = ti+1; % Time index
    xh = x(t-tau).*h(tau);
    lxh = length(xh);
    y(ti) = sum(xh.*dtau); % Trapezoidal approximation of convolution integral
    subplot(2,1,1),plot(tau,h(tau),"k-",tau,x(t-tau),"k--",t,0,"ok");
    axis([tau(1) tau(end) -2.0 2.5]);
    patch([tau(1:end-1);tau(1:end-1);tau(2:end);tau(2:end)],...
        [zeros(1,lxh-1);xh(1:end-1);xh(2:end);zeros(1,lxh-1)],...
        [.8 .8 .8],"edgecolor","none");
    xlabel("\tau"); title("h(\tau) [solid], x(t-\tau) [dashed], h(\tau)x(t-\tau) [gray]");
    c = get(gca,"children"); set(gca,"children",[c(2);c(3);c(4);c(1)]);
    subplot(2,1,2),plot(tvec,y,"k",tvec(ti),y(ti),"ok");
    xlabel("t"); ylabel("y(t) = \int h(\tau)x(t-\tau) d\tau");
    axis([tau(1) tau(end) -1.0 2.0]);
    grid;
    pause;%pause instead drawnow
end
```



B3

B3 the code below performs the convolution of the signal x1(t) and x2(t)

```
u = @(t) 1.0*(t>=0);
A = 0.5; B = 1; % Say A = 0.5 and B = 1
x = @(t) A*(u(t-4) - u(t-6));
h = @(t) B*(u(t+5) - u(t+4));
dtau = 0.005;
tau = -6:dtau:2.5;ti = 0;
tvec = -5:.1:5; y = NaN*zeros(1,length(tvec));
for t = tvec,
    ti = ti+1; % Time index
    xh1 = x(t-tau).*h(tau);
    len = length(xh1);
    y(ti) = sum(xh1.*dtau);
    subplot(2,1,1),plot(tau,h(tau),"k-",tau,x(t-tau),"k--",t,0,"ok");
    axis([tau(1) tau(end) -2.0 2.5]);
    patch([tau(1:end-1);tau(1:end-1);tau(2:end);tau(2:end)],...
    [zeros(1,len-1);xh1(1:end-1);xh1(2:end);zeros(1,len-1)],...
    [0.8 0.8 0.8],"edgecolor","none");
    xlabel("\tau"); title("h(\tau) , x(t-\tau) ,h(\tau)x(t-\tau) ");
    c = get(gca,'children'); set(gca,'children',[c(2);c(3);c(4);c(1)]);
    subplot(2,1,2),plot(tvec,y,"k",tvec(ti),y(ti),"ok");
    xlabel("t");
    ylabel("y(t) = \int h(\tau)x(t-\tau) d\tau");
    axis([tau(1) tau(end) -1.0 2.0]);
    grid;
    drawnow;
end
```



h)

```
u = @(t) 1.0*(t>=0);
x = @(t) exp(t).*(u(t+2) - u(t));
h = @(t) exp(-2*t).*(u(t) - u(t-1));
dtau = 0.005;
tau = -6:dtau:2.5;ti = 0;
tvec = -5:.1:5; y = NaN*zeros(1,length(tvec));
for t = tvec,
    ti = ti+1; % Time index
    xh = x(t-tau).*h(tau);
    lxh = length(xh);
    y(ti) = sum(xh.*dtau);
    subplot(2,1,1),plot(tau,h(tau),"k-",tau,x(t-tau),"k--",t,0,"ok");
    axis([tau(1) tau(end) -2.0 2.5]);
    patch([tau(1:end-1);tau(1:end-1);tau(2:end);tau(2:end)],...
    [zeros(1,lxh-1);xh(1:end-1);xh(2:end);zeros(1,lxh-1)],...
    [.8 .8 .8],"edgecolor","none");
    xlabel("\tau"); title("h(\tau) [solid], x(t-\tau) [dashed] h(\tau)x(t-\tau) [gray]");
    c = get(gca,'children'); set(gca,'children',[c(2);c(3);c(4);c(1)]);
    subplot(2,1,2),plot(tvec,y,"k",tvec(ti),y(ti),"ok");
    xlabel("t"); ylabel("y(t) = \int h(\tau)x(t-\tau) d\tau");
    axis([tau(1) tau(end) -1.0 2.0]); grid;
    drawnow;
end
```

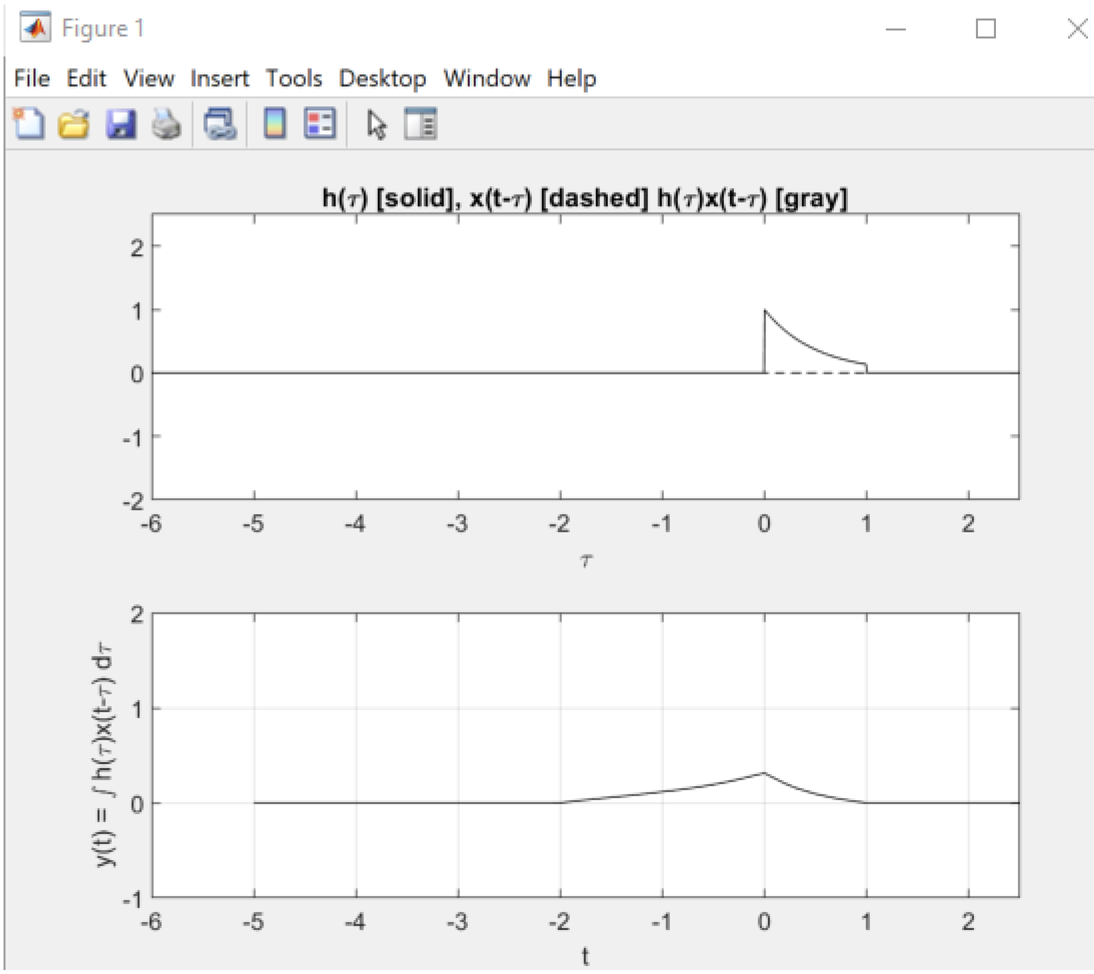
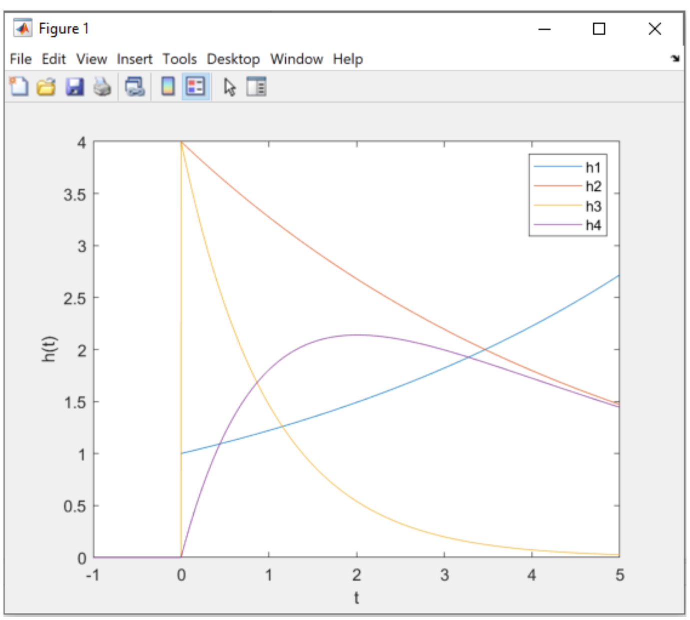


Figure 1
File Edit View Insert Tools Desktop Window Help
h(τ) [solid], x(t-τ) [dashed] h(τ)x(t-τ) [gray]
τ
y(t) = ∫ h(τ)x(t-τ) dτ
t

C1

```
%Bhavya

t = [-1:0.001:5];

%Creating the function itself
u = @(t) 1.0.*(t>=0);
h1 = @(t) exp(t/5).*u(t);
h2 = @(t) 4*exp(-t/5).*u(t);
h3 = @(t) 4*exp(-t).*u(t);
h4 = @(t) 4*(exp(-t/5)-exp(-t)).*u(t);

plot(t,h1(t));
xlabel("t");
ylabel("h(t)");
hold on;

plot(t,h2(t));
plot(t,h3(t));
plot(t,h4(t));

legend("h1","h2","h3","h4");

hold off;
```



C2:

Determining the Eigenvalues

S1: $\lambda 1 = \frac{1}{5}$
S2: $\lambda 1 = -\frac{1}{5}$
S3: $\lambda 1 = -1$
S4: $\lambda 1 = -\frac{1}{5}$
$\lambda 2 = -1$

C3:

H1

```
%Bhavya

%Creating the u(t) function
u = @(t) 1.0.*(t>=0);

%Creating the x(t) function
x = @(t) sin(5*t).*(u(t)-u(t-3));

%each impulse respone\se
h = @(t) exp(t/5).*(u(t)-u(t-20)); %creates h1

dtau = 0.005;
tau = 0:dtau:20; ti=0;
tvec = 0:.1:20; y = NaN*zeros(1,length(tvec));

%allocating the memory

for t = tvec,
    ti = ti+1; % Time index
    xh1 = x(t-tau).*h(tau);
    len = length(xh1);
    y(ti) = sum(xh1.*dtau);
    subplot(2,1,1),plot(tau,h(tau),"k-",tau,x(t-tau),"k--",t,0,"ok");
    axis([tau(1) tau(end) -2.0 2.5]);
    patch([tau(1:end-1);tau(1:end-1);tau(2:end);tau(2:end)],...
    [zeros(1,len-1);xh1(1:end-1);xh1(2:end);zeros(1,len-1)],...
    [0.8 0.8 0.8],"edgecolor","none");
```

```
tvec = 0:.1:20; y = NaN*zeros(1,length(tvec));

%allocating the memory


for t = tvec,
    ti = ti+1; % Time index
    xh1 = x(t-tau).*h(tau);
    len = length(xh1);
    y(ti) = sum(xh1.*dtau);
    subplot(2,1,1),plot(tau,h(tau),"k-",tau,x(t-tau),"k--",t,0,"ok");
    axis([tau(1) tau(end) -2.0 2.5]);
    patch([tau(1:end-1);tau(1:end-1);tau(2:end);tau(2:end)],...
    [zeros(1,len-1);xh1(1:end-1);xh1(2:end);zeros(1,len-1)],...
    [0.8 0.8 0.8],"edgecolor","none");
    xlabel("\tau"); title("h(\tau) , x(t-\tau) ,h(\tau)x(t-\tau) ");
    c = get(gca,'children'); set(gca,'children',[c(2);c(3);c(4);c(1)]);
    subplot(2,1,2),plot(tvec,y,"k",tvec(ti),y(ti),"ok");
    xlabel("t");
    ylabel("y(t) = \int h(\tau)x(t-\tau) d\tau");
    axis([tau(1) tau(end) -1.0 2.0]);
    grid;
    drawnow;
end
```

%Bhavya

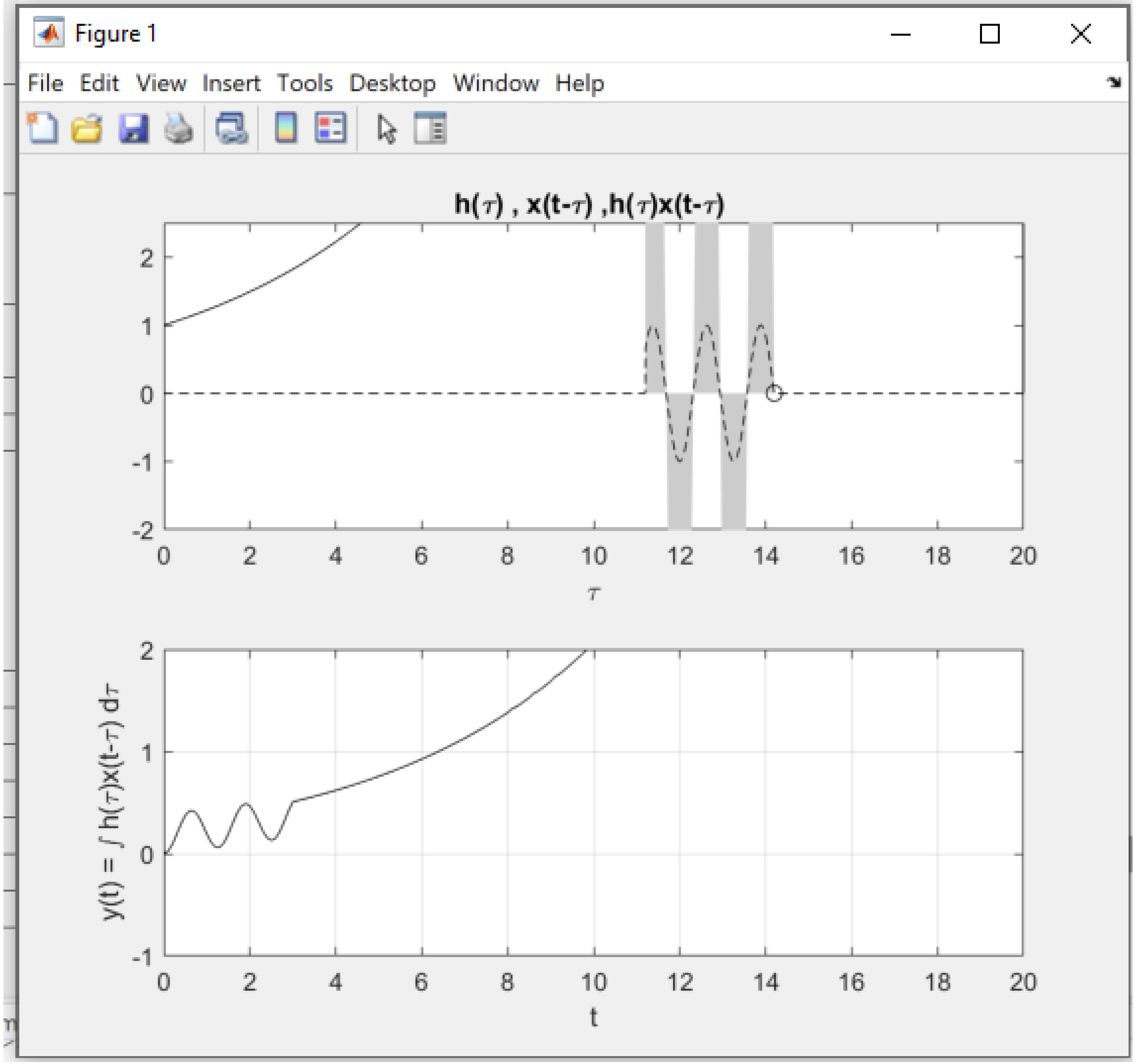


Figure 1
File Edit View Insert Tools Desktop Window Help
h(τ) , x(t-τ) ,h(τ)x(t-τ)
τ
y(t) = ∫ h(τ)x(t-τ) dτ
t

H2

```
%Bhavya
x = @(t) sin(5*t).*(u(t) - u(t-3));

h = @(t) 4*exp(-t/5).*(u(t)-u(t-20));

dtau = 0.005;
tau = 0:dtau:20; ti=0;
tvec = 0:.1:20; y = NaN*zeros(1,length(tvec));

for t = tvec,
    ti = ti+1; % Time index
    xh1 = x(t-tau).*h(tau);
    len = length(xh1);
    y(ti) = sum(xh1.*dtau);
    subplot(2,1,1),plot(tau,h(tau),"k-",tau,x(t-tau),"k--",t,0,"ok");
    axis([tau(1) tau(end) -2.0 2.5]);
    patch([tau(1:end-1);tau(1:end-1);tau(2:end);tau(2:end)],...
    [zeros(1,len-1);xh1(1:end-1);xh1(2:end);zeros(1,len-1)],...
    [0.8 0.8 0.8],"edgecolor","none");
    xlabel("\tau"); title("h(\tau) , x(t-\tau) ,h(\tau)x(t-\tau) ");
    c = get(gca,'children'); set(gca,'children',[c(2);c(3);c(4);c(1)]);
    subplot(2,1,2),plot(tvec,y,"k",tvec(ti),y(ti),"ok");
    xlabel("t");
    ylabel("y(t) = \int h(\tau)x(t-\tau) d\tau");
    axis([tau(1) tau(end) -1.0 2.0]);
    grid;
    drawnow;
end
```

%Bhavya

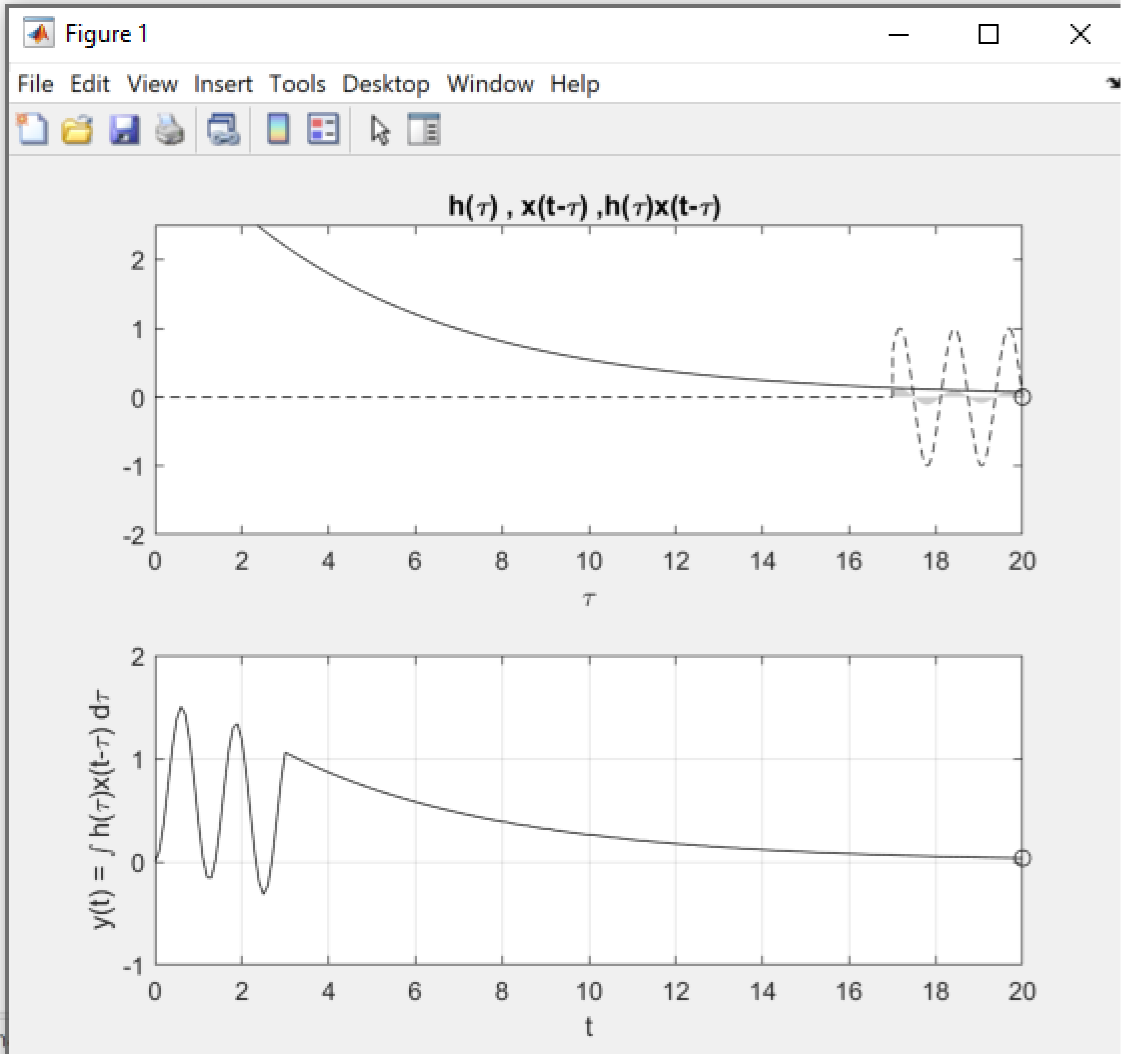


Figure 1
File Edit View Insert Tools Desktop Window Help
h(τ) , x(t-τ) ,h(τ)x(t-τ)
τ
y(t) = ∫ h(τ)x(t-τ) dτ
t

H3

```
u = @(t) 1.0.*(t>=0);

%Creating the x(t) function
x = @(t) sin(5*t).*(u(t)-u(t-3));

%each impulse respone\se
h = @(t) exp(-t).*(u(t)-u(t-20)); %creates h1

dtau = 0.005;
tau = 0:dtau:20; ti=0;
tvec = 0:.1:20; y = NaN*zeros(1,length(tvec));

for t = tvec,
    ti = ti+1; % Time index
    xh1 = x(t-tau).*h(tau);
    len = length(xh1);
    y(ti) = sum(xh1.*dtau);
    subplot(2,1,1),plot(tau,h(tau),"k-",tau,x(t-tau),"k--",t,0,"ok");
    axis([tau(1) tau(end) -2.0 2.5]);
    patch([tau(1:end-1);tau(1:end-1);tau(2:end);tau(2:end)],...
    [zeros(1,len-1);xh1(1:end-1);xh1(2:end);zeros(1,len-1)],...
    [0.8 0.8 0.8],"edgecolor","none");
    xlabel("\tau"); title("h(\tau) , x(t-\tau) ,h(\tau)x(t-\tau) ");
    c = get(gca,'children'); set(gca,'children',[c(2);c(3);c(4);c(1)]);
    subplot(2,1,2),plot(tvec,y,"k",tvec(ti),y(ti),"ok");
    xlabel("t");
    ylabel("y(t) = \int h(\tau)x(t-\tau) d\tau");
    axis([tau(1) tau(end) -1.0 2.0]);
    grid;
    drawnow;
end
```

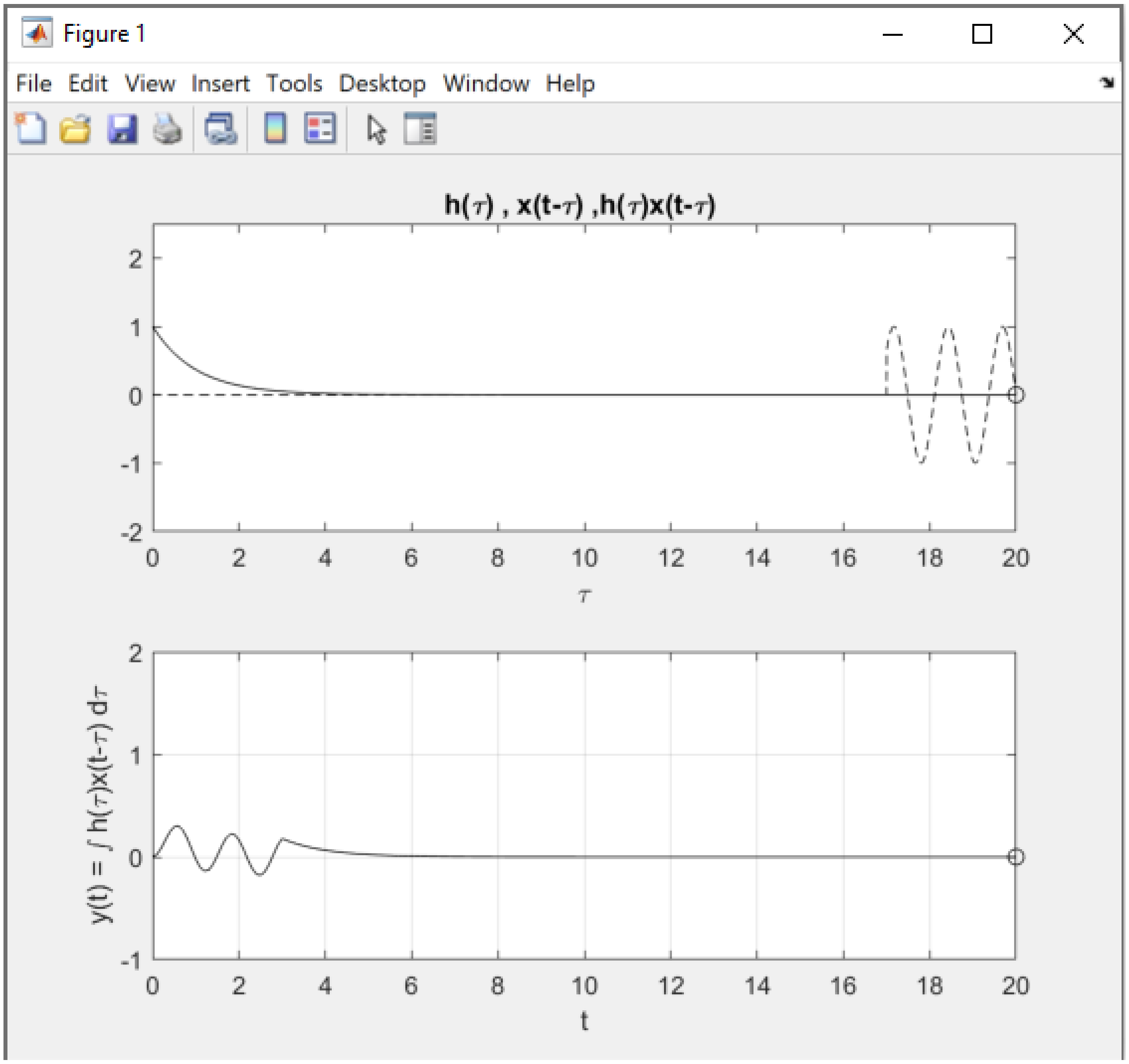


Figure 1
File Edit View Insert Tools Desktop Window Help
h(τ) , x(t-τ) ,h(τ)x(t-τ)
τ
y(t) = ∫ h(τ)x(t-τ) dτ
t

h4)

```
u = @(t) 1.0.*(t>=0);

%Creating the x(t) function
x = @(t) sin(5*t).*(u(t)-u(t-3));

%each impulse respone\se
h = @(t) exp(-t/5)-exp(-t)).*(u(t)-u(t-20)); %creates h1

dtau = 0.005;
tau = 0:dtau:20; ti=0;
tvec = 0:.1:20; y = NaN*zeros(1,length(tvec));

for t = tvec,
    ti = ti+1; % Time index
    xh1 = x(t-tau).*h(tau);
    len = length(xh1);
    y(ti) = sum(xh1.*dtau);
    subplot(2,1,1),plot(tau,h(tau),"k-",tau,x(t-tau),"k--",t,0,"ok");
    axis([tau(1) tau(end) -2.0 2.5]);
    patch([tau(1:end-1);tau(1:end-1);tau(2:end);tau(2:end)],...
    [zeros(1,len-1);xh1(1:end-1);xh1(2:end);zeros(1,len-1)],...
    [0.8 0.8 0.8],"edgecolor","none");
    xlabel("\tau"); title("h(\tau) , x(t-\tau) ,h(\tau)x(t-\tau) ");
    c = get(gca,'children'); set(gca,'children',[c(2);c(3);c(4);c(1)]);
    subplot(2,1,2),plot(tvec,y,"k",tvec(ti),y(ti),"ok");
    xlabel("t");
    ylabel("y(t) = \int h(\tau)x(t-\tau) d\tau");
    axis([tau(1) tau(end) -1.0 2.0]);
    grid;
    drawnow;
end
```

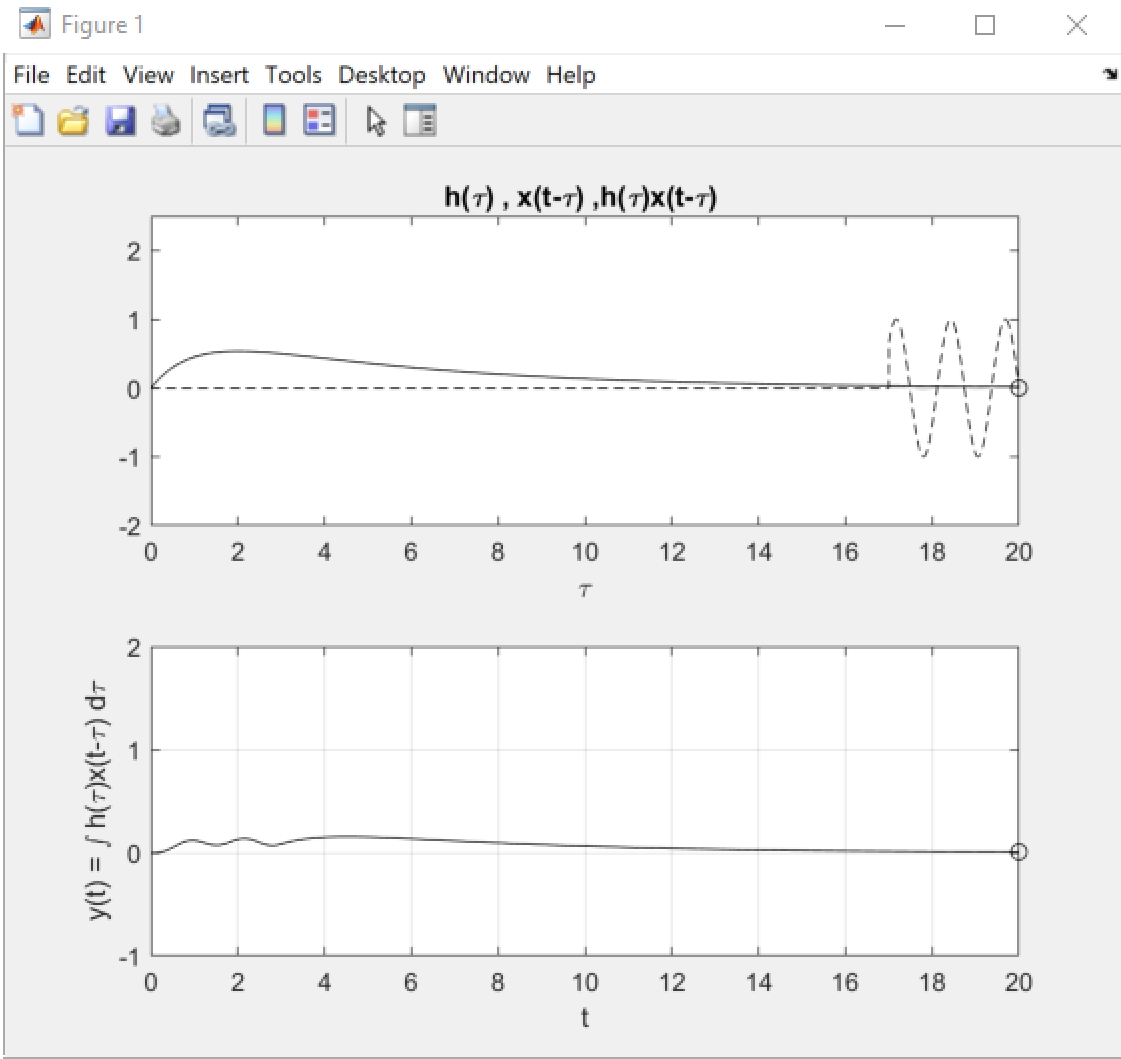


Figure 1
File Edit View Insert Tools Desktop Window Help
h(τ) , x(t-τ) ,h(τ)x(t-τ)
τ
y(t) = ∫ h(τ)x(t-τ) dτ
t

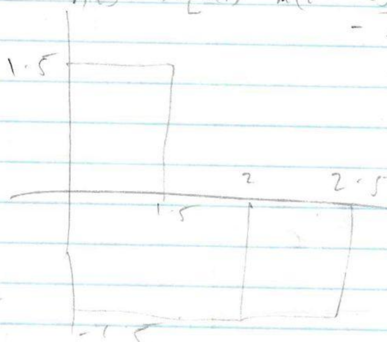
D1.

D.) Manually

B.)

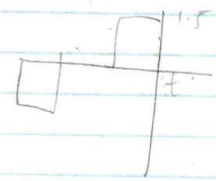
$x(t) = 1.5 \sin(\pi t)(u(t) - u(t-1))$

$h(t) = 1.5[u(t) - u(t-1.5)] - u(t-2) + u(t-2.5)$

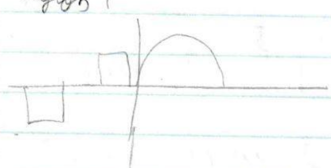


$y(t) = \int_{-\infty}^{\infty} x(z)\, h(t-z)\, dz$

$h(t-z) =$



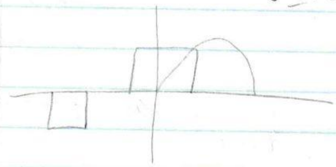
Region 1



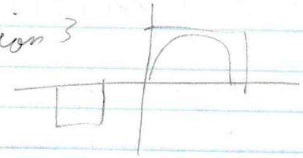
$t < 0 \;\therefore\; y(t) = 0$

Region 2

$0 \le t \le 1\; y(t) = \int_0^t \frac{3}{2}\left(\frac{3}{2} \sin \pi z\right) dz = -\frac{9}{4\pi} \cos(\pi t) + \frac{9}{4\pi}$

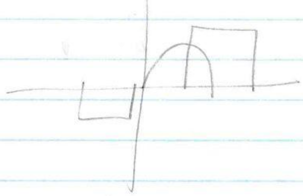


Region 3



$1 \le t \le 3/2,\; y(t) = \int_0^1 3/2\, dt = 3/2$

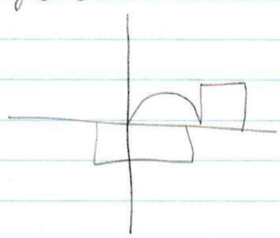
Region 4



$\frac{3}{2} \le t \le 2 \quad y(t) = \int_{t+1/2}^{1} \frac{3}{2}\left(\frac{3}{2}\sin(\pi\tau)\right) d\tau \quad \frac{9}{4\pi}\cos$

$= \frac{9}{4\pi}\left(1+\cos\left(\pi\left(\tau+\frac{3}{2}\right)\right)\right)$

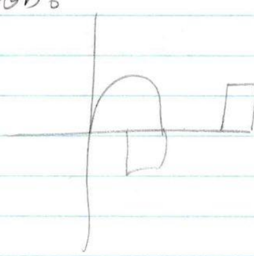
Region 5



$2 \le t \le 2.5 \quad y(t) = \int_{0}^{t+2} -\frac{3}{2}\sin(\pi\tau)\, d\tau$

$= \frac{3}{2\pi}\cos(\pi\tau)\Big|_{0}^{t+2} = \frac{3}{2\pi}\left(\cos(\pi(t+2))-1\right)$

Region 6

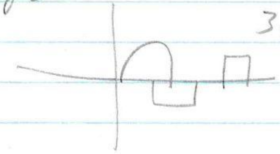


$2.5 \le t \le 3$

$y(t) = \int_{t+2.5}^{t+2} -\frac{3}{2}\sin(\pi\tau)\, d\tau$

$= \frac{3}{2\pi}\cos(\pi(t+2)) - \frac{3}{2\pi}\left(\cos(t+2.5)\pi\right)$

Region 7



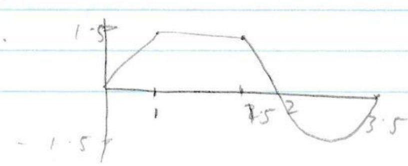
$3 \le t \le 3.5$

$y(t) = \int_{t+3.5}^{1} -\frac{3}{2}\sin(\pi\tau)\, d\tau$

$= -\frac{3}{2\pi}\left(1+\cos\left(\pi(t+2.5)\right)\right)$

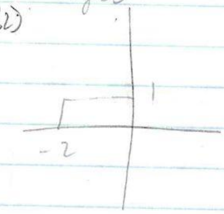
Region 8

$y(t) = 0$



B2)

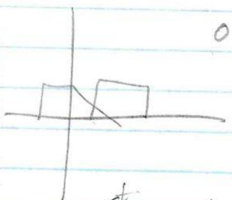
Region 1



$x(t) = u(t) - u(t-2)$

$h(t) = \left(1 - \frac{t}{2}\right)\left[u(t) - u(t-2)\right].$

Region 2.



$0 \le t-2 \le 2$

$2 \le t \le 4$

$\int_0^t 1 - \frac{t}{2} = \left. T - \frac{T^2}{4} \right|_0^t$

$= t - \frac{t^2}{4}.$

$y(t) = \int_t^2 \left(1 - \frac{t}{2}\right) dt$

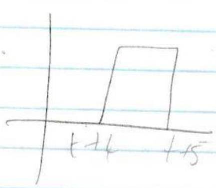
$= \left. T - \frac{T^2}{4} \right|_t^2$

$= 1 - (t-2) + \left(\frac{t^2}{4} - 2\right)^2$

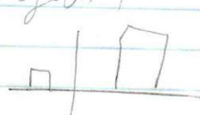
B3

a) $x_1(t) = A(u(t-4) - u(t-6))$

$x_2(t) = B(u(t-5) - u(t+7))$



Region 1

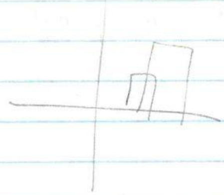


There is no overlap

$t+5 \le 4$

$t \le -1$

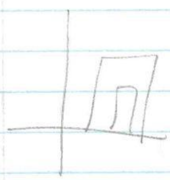
Region (2).



$4 \le t+5 \le 5$ $\quad y(t) = AB(t+1)$

$-1 \le t \le 0$

Region (3)



$0 \le t \le 1$, $y(t) = AB$.

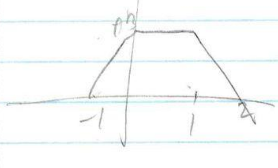
Region (4) $\quad 1 \le t \le 2$, $y(t) = \int_{t+4}^{6} AB\, d\tau$

$= 6-(t+4)AB$

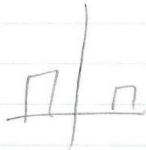
$= 2-t\, AB$

Region (5)

There is no overlap

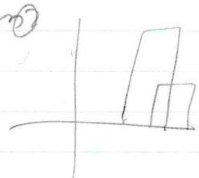


3b) Region ①



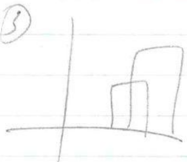
$t < -2$
$y(t) = 0$

Region ②



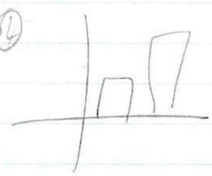
$-2 \le t \le 0$ $y(t) \int_{3}^{t+3} AB\, dt = AB(t+2)$

Region ③

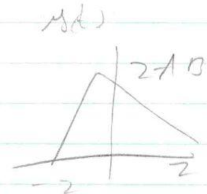


$0 \le t \le 2.$ $y(t) = \int_{2}^{t+2} AB\, dt = AB(2-t)$

Region ④

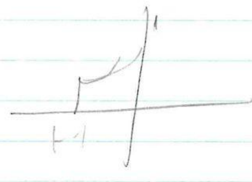


$t \ge 2.$ $y(t) = 0$

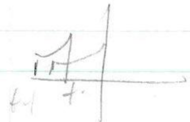


comparison

$x(t) = e^{t}[u(t+2) - u(t)]$

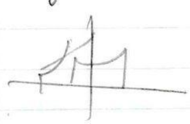


Region 1



$y(t) = \frac{e^{3t}}{3} - \frac{e^{-1}}{3}.$

Region 2.



$$y(t) = \int_{t-1}^{0} e^{3t}\, dt = \frac{1}{3} - \frac{e^{3(t-1)}}{3}.$$

D2.

We can say that the sum of the lengths of each function is equivalent to the length of the two functions.