RYERSON UNIVERSITY

Faculty of Engineering, Architecture and Science

Department of Electrical and Computer Engineering

Course Number	**ELE 532**
Course Title	**Signals and Systems 1**
Sem/Year	**Fall 2020**
Instructor	**Dr. Soosan Beheshti**

Lab/Tutorial Report # 1

Report Title	**System Properties and Convolution**

Submission Date	**12**
Due Date	**25th October 2020**

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Signature	

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http://www.ryerson.ca/senate/policies/pol60.pdf.

Problem A1 (C=1uF)

Code:

```
% CH2MP1.m : Chapter 2, MATLAB Program 1
% Script M-file determines characteristic roots of op-amp circuit.
% Set component values:
R = [1e4, 1e4, 1e4];
C = [1e-6, 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);
p = poly(A);
```

Command Window

```
>> CH2MP1
>> lambda

lambda =

 -261.8034
  -38.1966

>> p

p =

   1.0e+06 *

    0.0000   -0.0103    3.0103   -3.0000

>>
```

Problem A1 (C=1uF->1nF)

Code:

```
% CH2MP1.m : Chapter 2, MATLAB Program 1
% Script M-file determines characteristic roots of op-amp circuit.
% Set component values:
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);
p = poly(A);
```

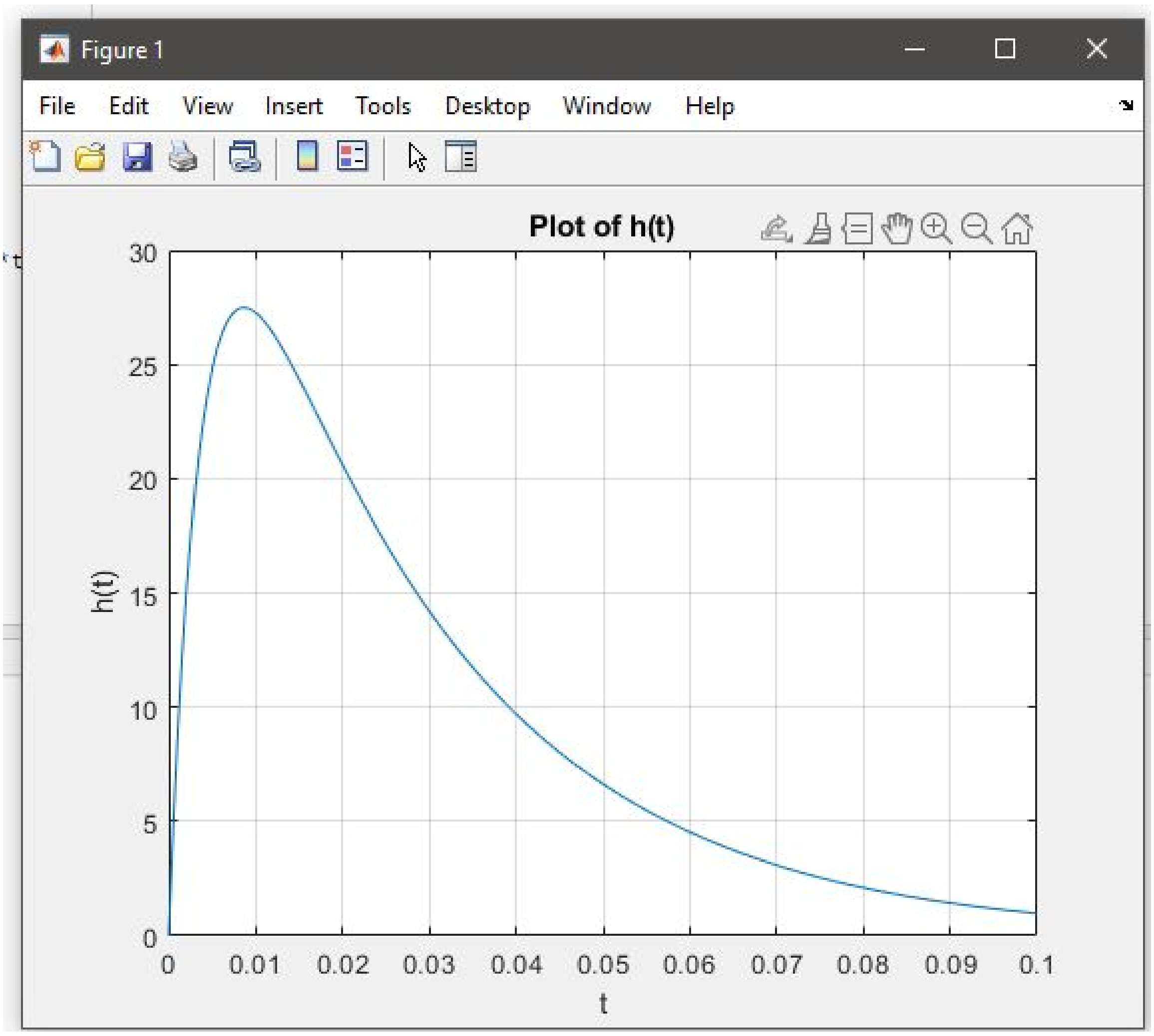
Command Window

```
>> CH2MP1
>> lambda

lambda =

   1.0e+03 *

  -0.1500 + 3.1587i
  -0.1500 - 3.1587i

>> p

p =

   1.0e+09 *

    0.0000   -0.0100    3.0100   -3.0000

>>
```

Problem A.2

Code:

```
% CH2MP1.m : Chapter 2, MATLAB Program 1
% Script M-file determines characteristic roots of op-amp circuit.
% Set component values:
R = [1e4, 1e4, 1e4];
C = [1e-6, 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);
p = poly(A);

% solve for LTE of h(t) function accordingly with roots given
t = (0:0.0005:0.1);
u = @(t) 1.0.*(t>=0);
h = @(t) -44.721359 .* exp(-261.8034 .*t)+ 44.721359 .* exp(-38.1966.*t).*u(t);

plot (t, h(t));
xlabel('t');
ylabel('h(t)');
title('Plot of h(t)');
axis ([0 0.1 0 30]);
grid;
```



Problem A3

Code:

```
function [lambda] = CH2MP2(R,C)
% CH2MP2.m : Chapter 2, MATLAB Program 2
% Function M-file finds characteristic roots of op-amp circuit.
% INPUTS: R = length-3 vector of resistances
% C = length-2 vector of capacitances
% OUTPUTS: lambda = characteristic roots
% 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);
```

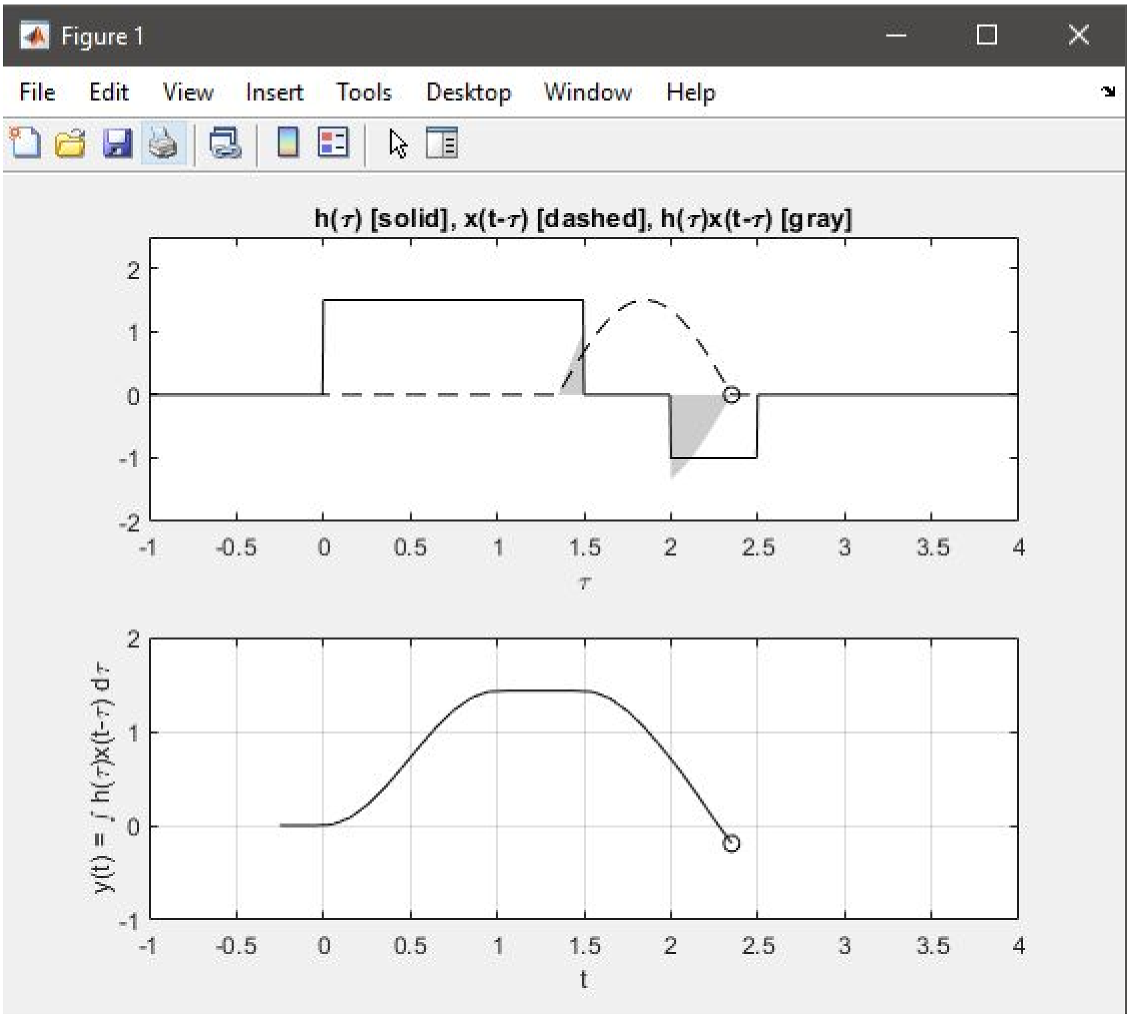
Command Window

```
>> lambda = CH2MP2([1e4, 1e4, 1e4],[1e-9, 1e-6])

lambda =

   1.0e+03 *

  -0.1500 + 3.1587i
  -0.1500 - 3.1587i
```

Problem B.1

Code:

```
% CH2MP4.m : Chapter 2, MATLAB Program 4
% Script M-file graphically demonstrates the convolution process.
figure(1) % Create figure window and make visible on screen
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;
drawnow;
end
```



Problem B.2

Convolute

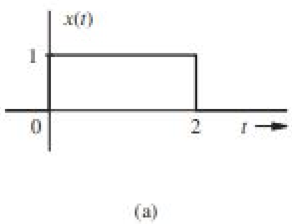
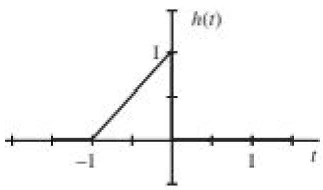


Figure P2.4-28

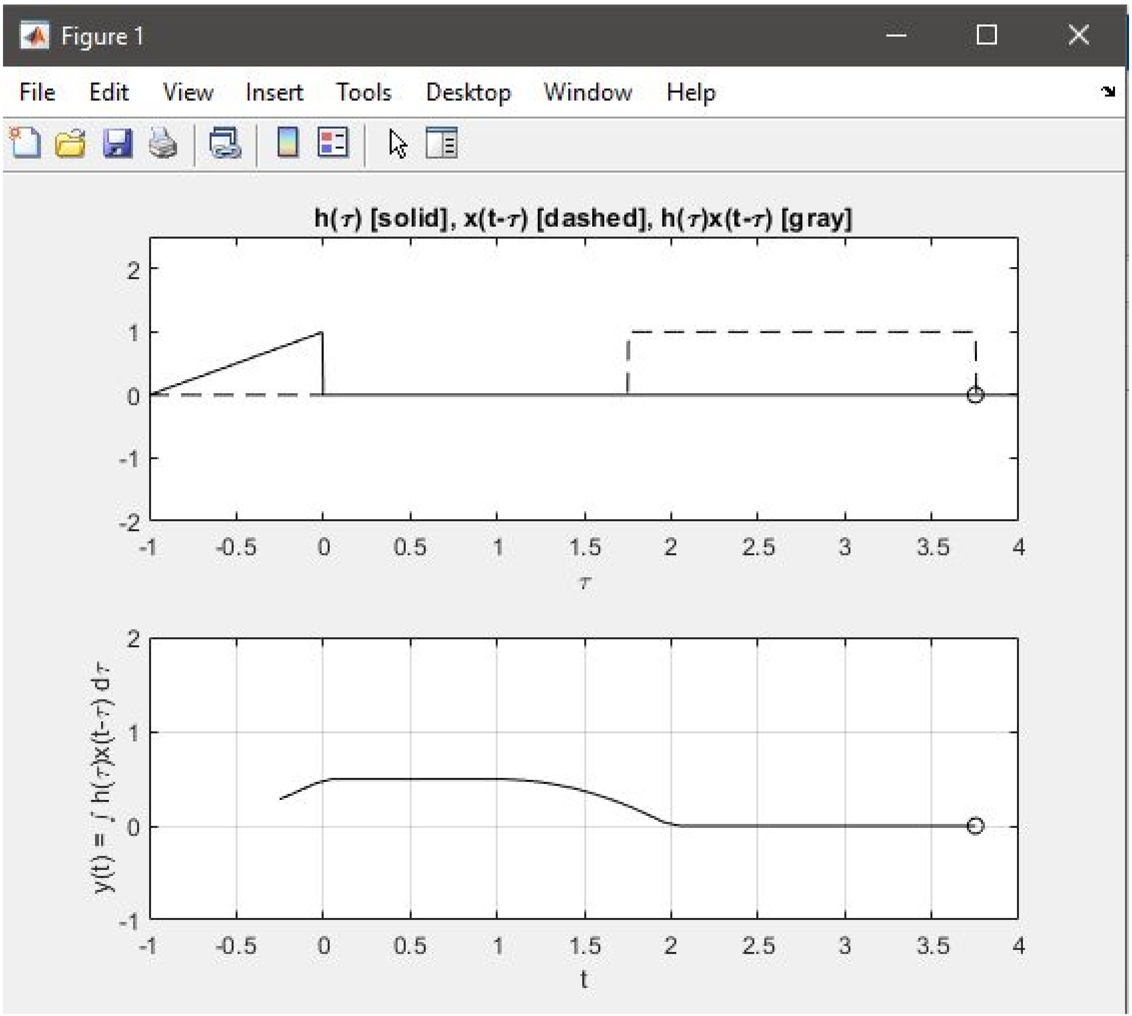
with



Code:

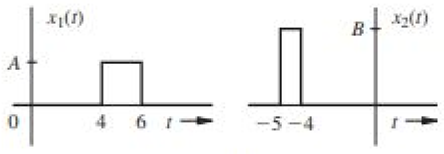
```
% CH2MP4.m : Chapter 2, MATLAB Program 4
% Script M-file graphically demonstrates the convolution process.
figure(1) % Create figure window and make visible on screen
u = @(t) 1.0.*(t>=0);
x = @(t) 1.0.*(u(t) - u(t-2));
h = @(t) 1.0.*(t+1).*(u(t+1)-u(t));
dtau = 0.005; tau = -1:dtau:4;
ti = 0; tvec = -.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;
drawnow;
end
```

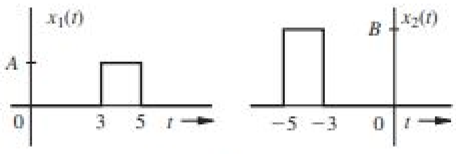


Problem B.3

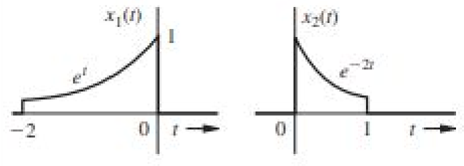
Convolute a, b, h



(a)



(b)

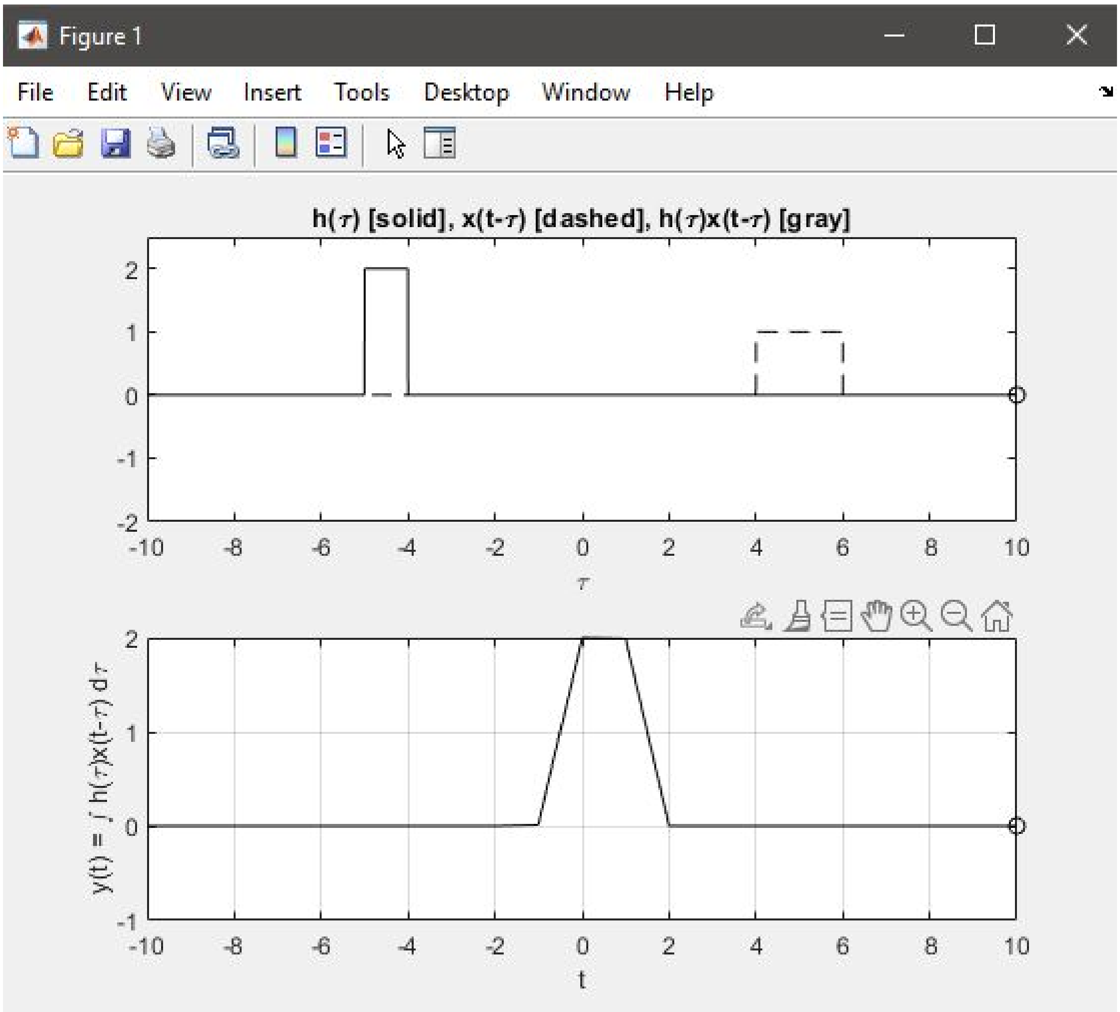


(h)

Convolute A:

Code:

```
% CH2MP4.m : Chapter 2, MATLAB Program 4
% Script M-file graphically demonstrates the convolution process.
figure(1) % Create figure window and make visible on screen
u = @(t) 1.0.*(t>=0);
x = @(t) 1.0.*(u(t-4) - u(t-6));
h = @(t) 2.0.*(u(t+5) - u(t+4));
dtau = 0.005; tau = -10:dtau:10;
ti = 0; tvec = [-10:1:10];
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;
drawnow;
end
```

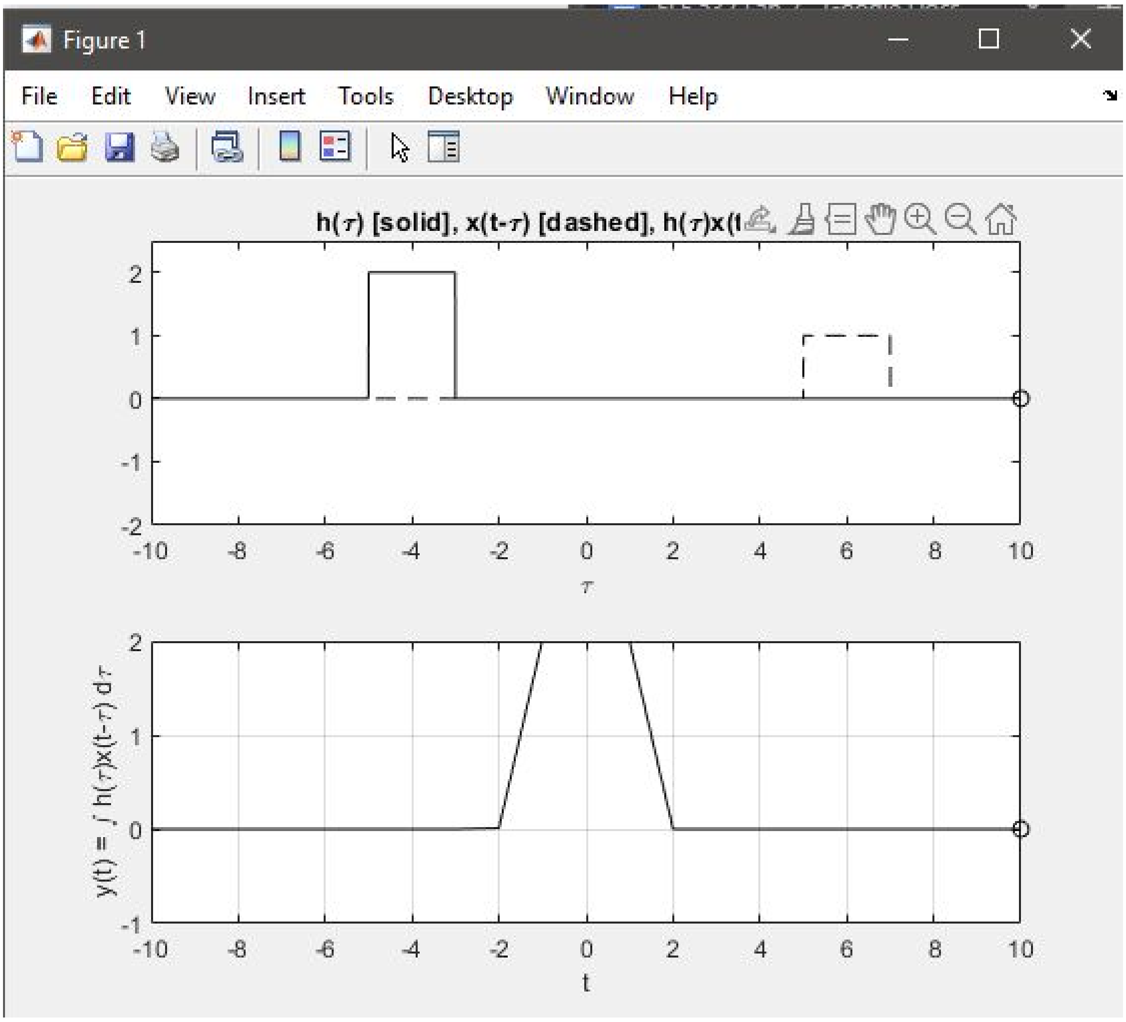


Convolute B

Code:

```
% CH2MP4.m : Chapter 2, MATLAB Program 4
% Script M-file graphically demonstrates the convolution process.
figure(1) % Create figure window and make visible on screen
u = @(t) 1.0.*(t>=0);
x = @(t) 1.0.*(u(t-3) - u(t-5));
h = @(t) 2.0.*(u(t+5) - u(t+3));
dtau = 0.005; tau = -10:dtau:10;
ti = 0; tvec = [-10:1:10];
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;
drawnow;
end
```

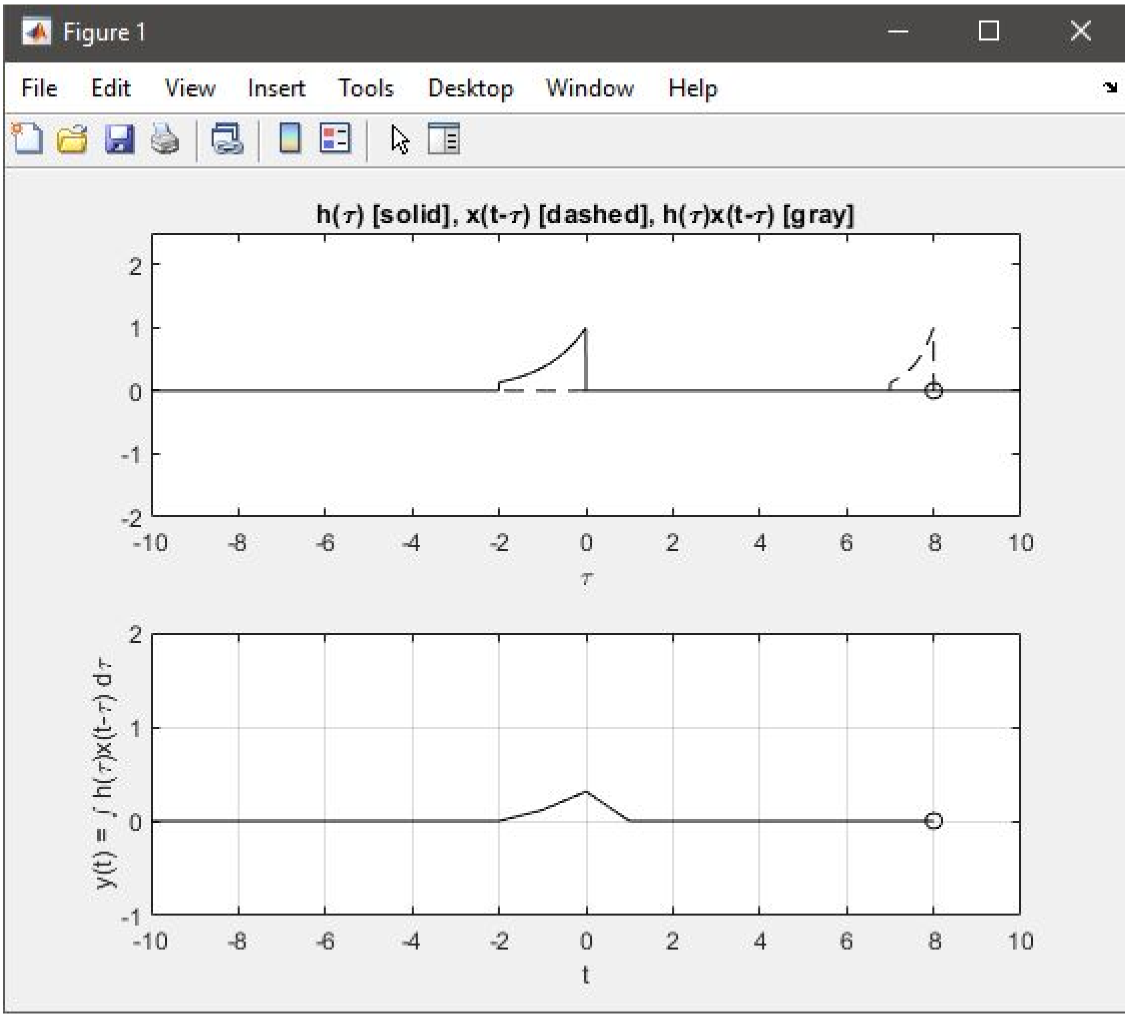


Convolute h

Code:

```
% CH2MP4.m : Chapter 2, MATLAB Program 4
% Script M-file graphically demonstrates the convolution process.
figure(1) % Create figure window and make visible on screen
u = @(t) 1.0.*(t>=0);
x = @(t) exp(-2*t).*(u(t) - u(t-1));
h = @(t) exp(t).*(u(t+2) - u(t));
dtau = 0.005; tau = -10:dtau:10;
ti = 0; tvec = [-10:1:8];
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;
drawnow;
end
```

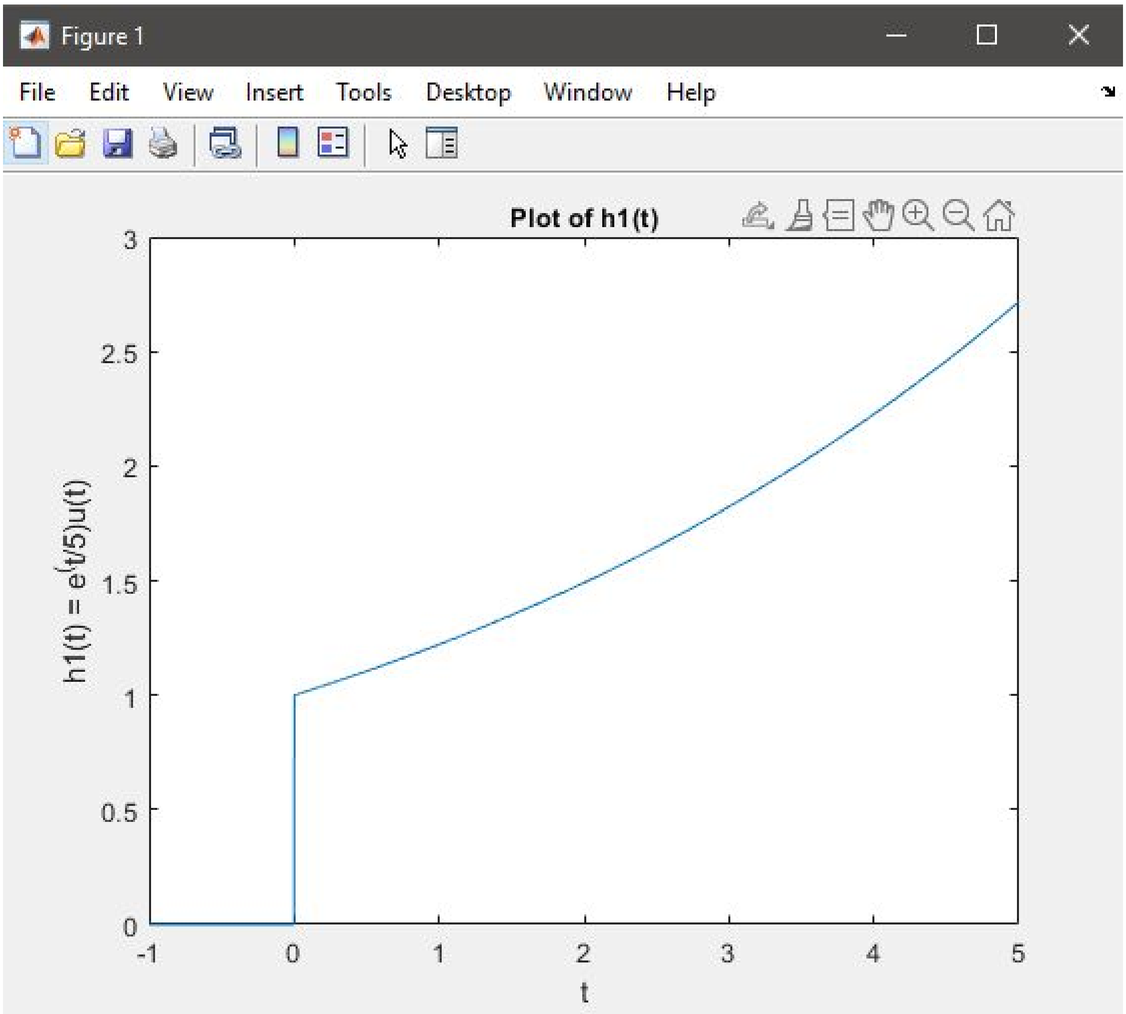


Problem C.1

Plot h1(t)

Code:

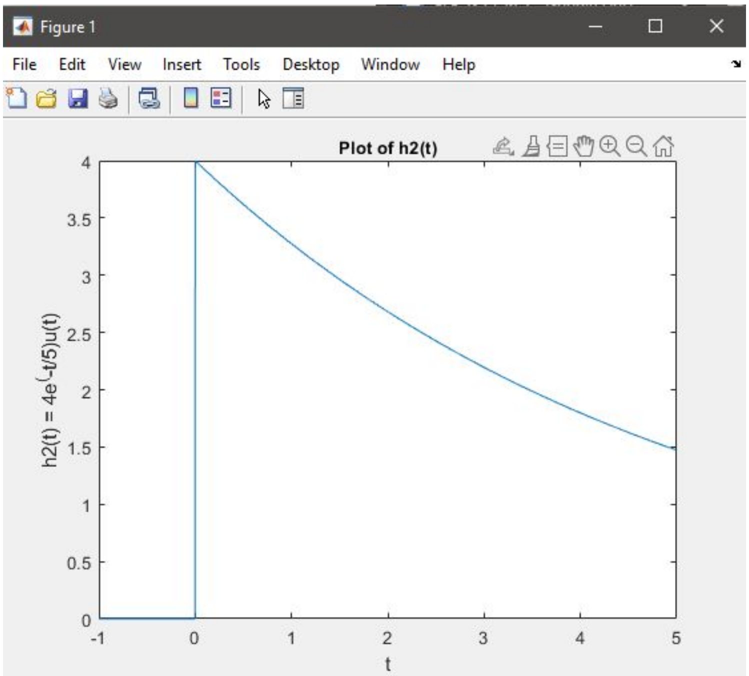
```
u = @(t) 1.0.*(t>=0);
t = (-1:0.001:5);
h1= @(t) exp(t/5).*u(t);
plot(t,h1(t));
xlabel('t');
ylabel('h1(t) = e^(t/5)u(t)');
title('Plot of h1(t)')
```



Plot h2(t):

Code:

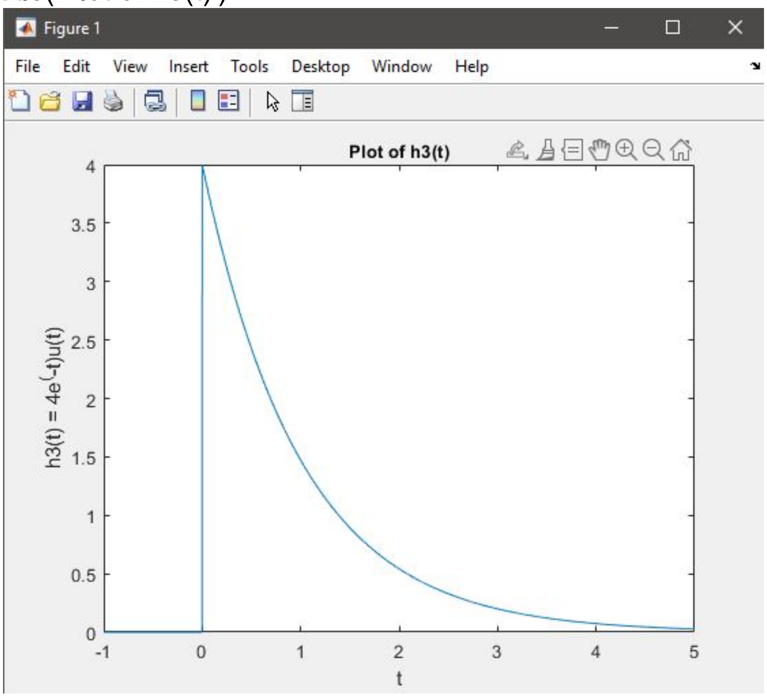
```
u = @(t) 1.0.*(t>=0);
t = (-1:0.001:5);
h2= @(t) 4*exp(-t/5).*u(t);
plot(t,h2(t));
xlabel('t');
ylabel('h2(t) = 4e^(-t/5)u(t)');
title('Plot of h2(t)')
```



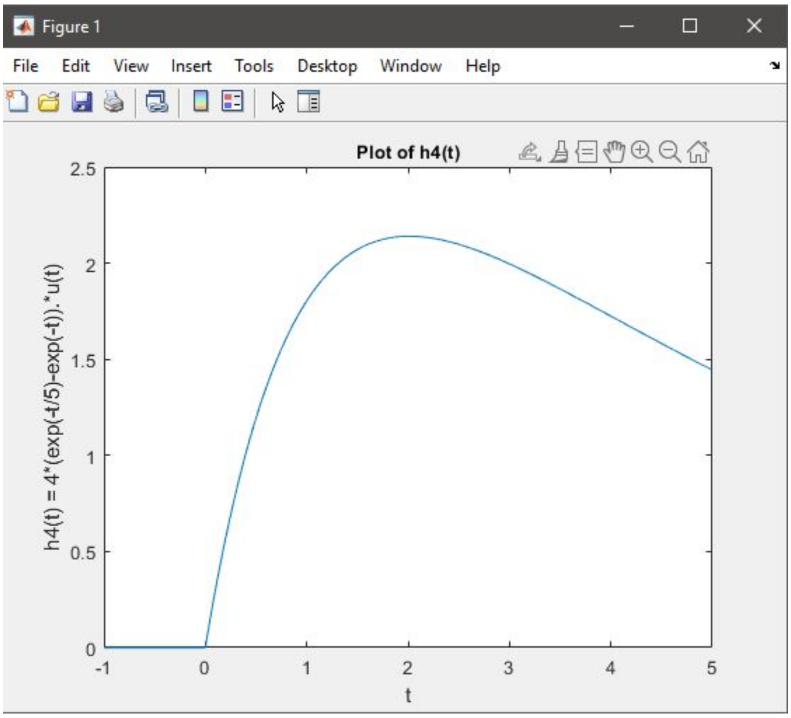
Plot h3(t)

Code:

```
u = @(t) 1.0.*(t>=0);
t = (-1:0.001:5);
h3= @(t) 4*exp(-t).*u(t);
plot(t,h3(t));
xlabel('t');
ylabel('h3(t) = 4e^(t)u(t)');
title('Plot of h3(t)')
```



Plot h4(t)
Code:
```
u = @(t) 1.0.*(t>=0);
t = (-1:0.001:5);
h4= @(t) 4*(exp(-t/5)-exp(-t)).*u(t);
plot(t,h4(t));
xlabel('t');
ylabel('h4(t) = 4*(exp(-t/5)-exp(-t)).*u(t)');
title('Plot of h4(t)')
```



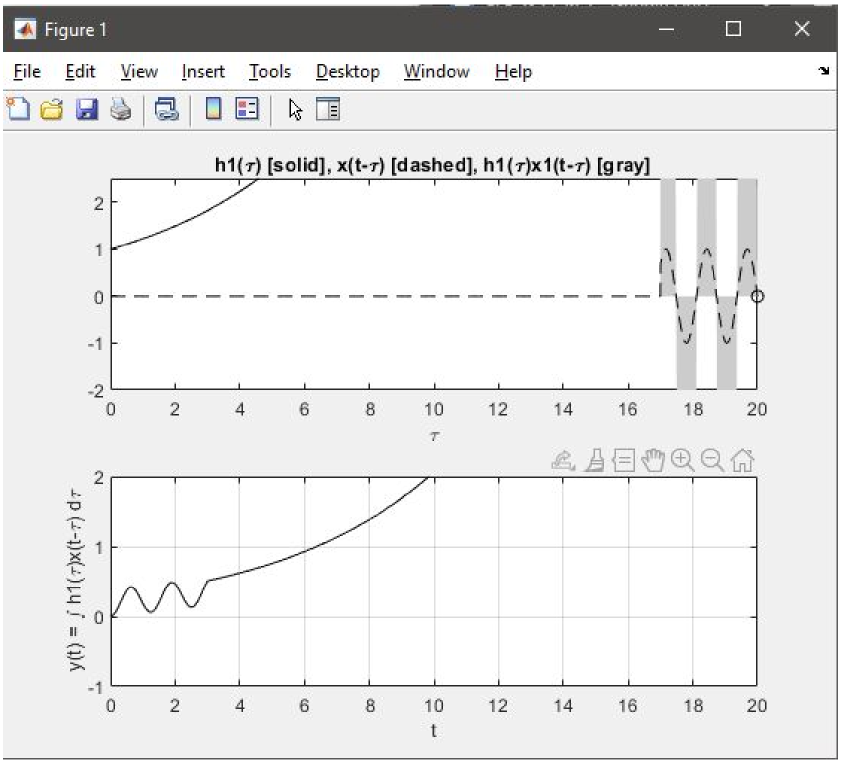
Problem C.2

Eigenvalues:
h1(t) = ⅕
h2(t) = -⅕
h3(t) = -1
h4(t) = -⅕ and -1

Problem C.3

For h1(t)
Code:
```
% CH2MP4.m : Chapter 2, MATLAB Program 4
% Script M-file graphically demonstrates the convolution process.
figure(1) % Create figure window and make visible on screen
u = @(t) 1.0.*(t>=0);
x = @(t) sin(5.*t).*(u(t)-u(t-3));
h = @(t) exp(t/5).*u(t);
dtau = 0.005; tau = 0:dtau:20;
ti = 0; tvec = [0:0.1:20];
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('h1(\tau) [solid], x(t-\tau) [dashed], h1(\tau)x1(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 h1(\tau)x(t-\tau) d\tau');
axis([tau(1) tau(end) -1.0 2.0]); grid;
drawnow
end
```

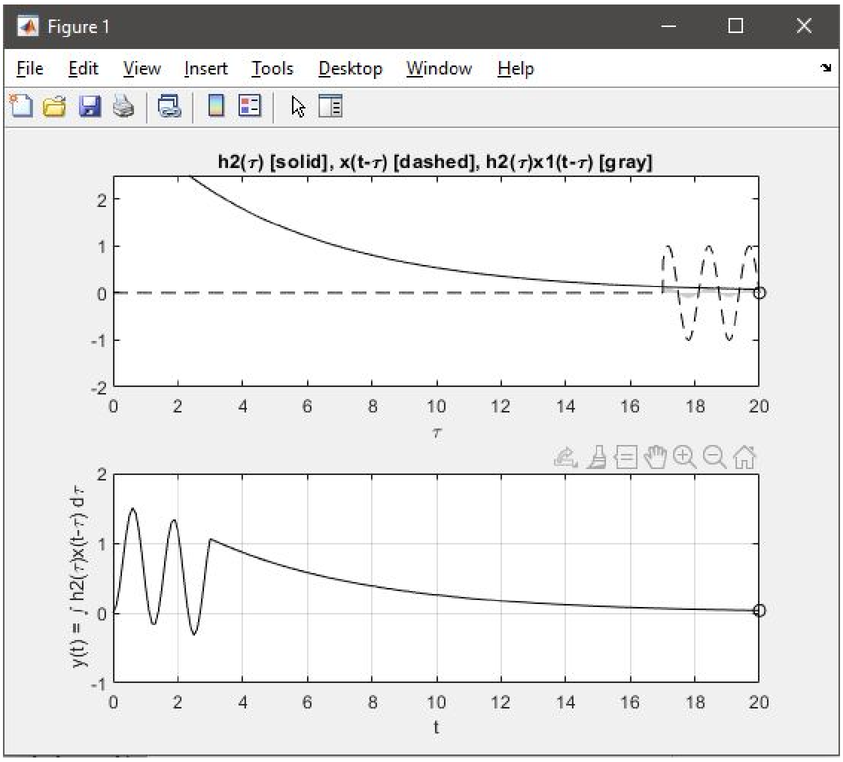


For h2(t)

Code:

```
% CH2MP4.m : Chapter 2, MATLAB Program 4
% Script M-file graphically demonstrates the convolution process.
figure(1) % Create figure window and make visible on screen
u = @(t) 1.0.*(t>=0);
x = @(t) sin(5.*t).*(u(t)-u(t-3));
h = @(t) 4*exp(-t/5).*u(t);
dtau = 0.005; tau = 0:dtau:20;
ti = 0; tvec = [0:0.1:20];
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('h2(\tau) [solid], x(t-\tau) [dashed], h2(\tau)x1(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 h2(\tau)x(t-\tau) d\tau');
axis([tau(1) tau(end) -1.0 2.0]); grid;
drawnow
end
```

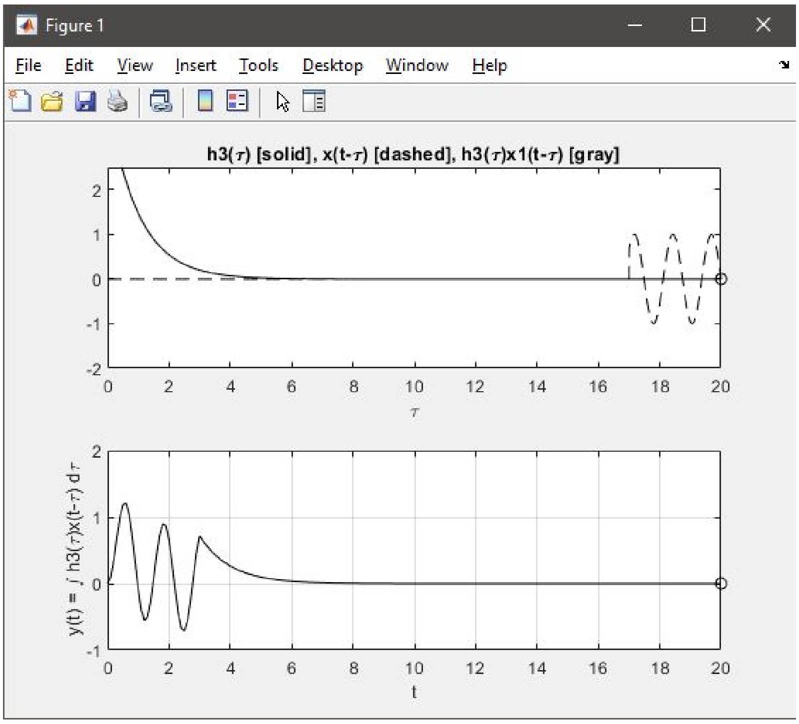


For h3(t)

Code:

```
% CH2MP4.m : Chapter 2, MATLAB Program 4
% Script M-file graphically demonstrates the convolution process.
figure(1) % Create figure window and make visible on screen
u = @(t) 1.0.*(t>=0);
x = @(t) sin(5.*t).*(u(t)-u(t-3));
h = @(t) 4*exp(-t).*u(t);
dtau = 0.005; tau = 0:dtau:20;
ti = 0; tvec = [0:0.1:20];
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('h3(\tau) [solid], x(t-\tau) [dashed], h3(\tau)x1(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 h3(\tau)x(t-\tau) d\tau');
axis([tau(1) tau(end) -1.0 2.0]); grid;
drawnow
end
```

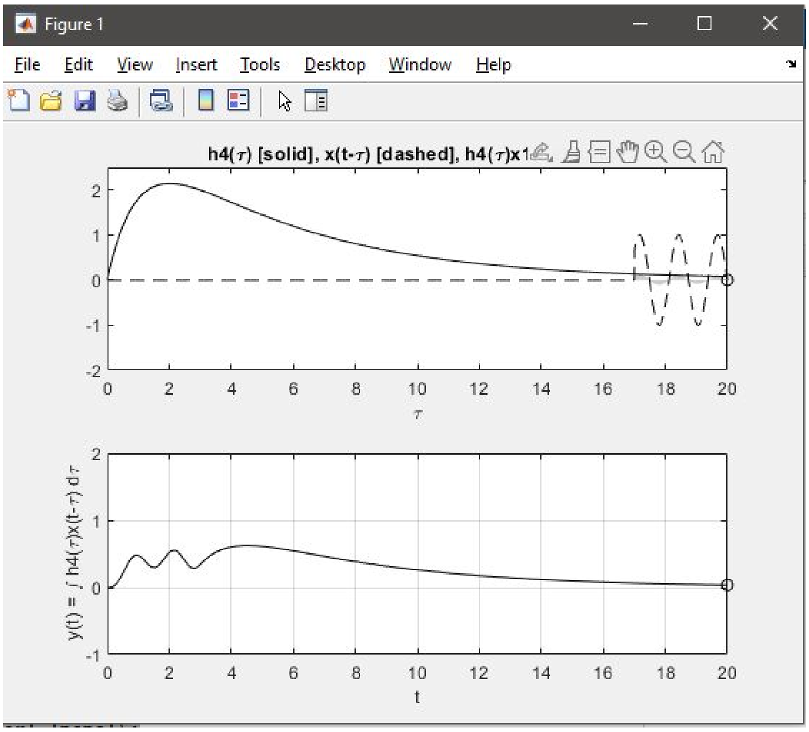


For h4(t)

Code:

```
% CH2MP4.m : Chapter 2, MATLAB Program 4
% Script M-file graphically demonstrates the convolution process.
figure(1) % Create figure window and make visible on screen
u = @(t) 1.0.*(t>=0);
x = @(t) sin(5.*t).*(u(t)-u(t-3));
h = @(t) 4*(exp(-t/5)-exp(-t)).*u(t);
dtau = 0.005; tau = 0:dtau:20;
ti = 0; tvec = [0:0.1:20];
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('h4(\tau) [solid], x(t-\tau) [dashed], h4(\tau)x1(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 h4(\tau)x(t-\tau) d\tau');
axis([tau(1) tau(end) -1.0 2.0]); grid;
drawnow
end
```



The relationship between these three systems is that y4(t) is an interconnected parallel system of y2(t) and the negative of y3(t). Thus y4(t) = y2(t) + (- y3(t))

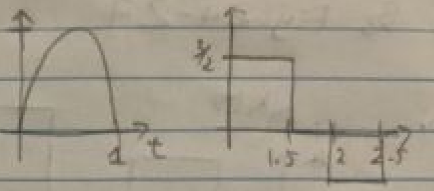
Problem D.1
B.1

D1 B1

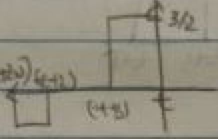
$x(t) = 1.5\sin(\pi t)[u(t) - u(t-1)]$

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

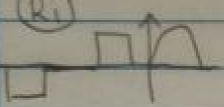
$y(t) = \int_{-\infty}^{\infty} x(\tau)h(t-\tau)d\tau$



$h(t-\tau)$:

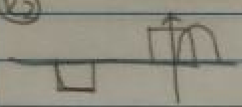


R1



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

R2

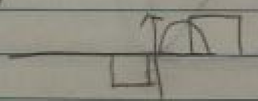


$0 \le t \le 1 \quad y(t) = \int_0^t \frac{3}{2}\left(\frac{3}{2}\sin(\pi\tau)d\tau\right) = -\frac{9}{4}\pi\cos(\pi\tau)\Big|_0^t = -\frac{9}{4\pi}\cos(\pi t) + \frac{9}{4\pi}$

R3

$1 \le t \le 3/2 \quad y(t) = \int^1 \frac{3}{2}d\tau = \frac{3}{2}$

R4



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

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

R5

$2 \le t \le 2.5 \quad y(t) = \int_0^{t+2} -\frac{3}{2}\sin(\pi\tau)d\tau$

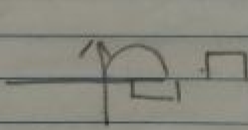
$= \frac{3}{2\pi}\cos(\pi\tau)\Big|_0^{t+2} = \frac{3}{2\pi}\cos(\pi(t+2)) - \frac{3}{2\pi}$

R6

$2.5 \le t \le 3 \quad y(t) = \int_{t+2.5}^{t+2} -3/2\sin(\pi\tau)d\tau = \frac{3}{2\pi}\cos(\pi\tau)\Big|_{t+2.5}^{t+2}$

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

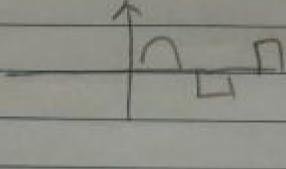
R7



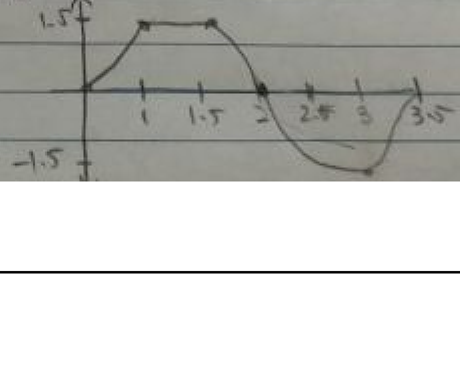
$3 \le t \le 3.5 \quad y(t) = \int_{t+2.5}^{1} -3/2\sin(\pi\tau)d\tau = \frac{3}{2\pi}\cos(\pi\tau)\Big|_{t+2.5}^{1}$

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

R8



$y(t) = 0$

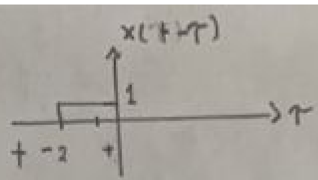


B.2

Doing B2

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

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



Region 2

$0 \le t-2 \le 2$

$2 \le t \le 4$

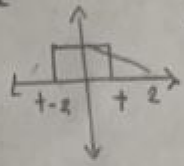
$y(t) = \int_t^2 (1 - \frac{t}{2}) d\tau = \tau - \frac{\tau^2}{4} \Big|_t^2$

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

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

Region 1

$0 \le t \le 2$



$\int_0^t 1 - \frac{t}{2} = \tau - \frac{\tau^2}{4} \Big|_0^t$

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

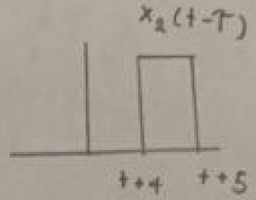
B.3a

B.3a

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

$x_2(t) = B[u(t+5) - u(t+4)]$

$x_2(t-\tau)$



Region 1

No overlap for $t+5 \leq 4$

$t < -1$

R2

$4 \leq t+5 \leq 5$

$-1 \leq t \leq 0$

$y(t) = \int_4^{t+5} AB\,d\tau$

$= AB\tau \Big|_4^{t+5}$

$= AB(t+1)$

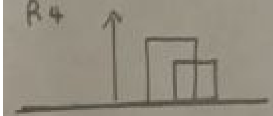
R3

$0 \leq t \leq 1$

$y(t) = \int_0^1 AB\,d\tau$

$= AB$

R4



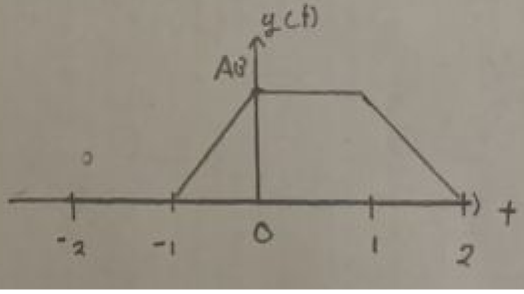
$1 \leq t \leq 2$

$y(t) = \int_{t+4}^{6} AB\,d\tau = 6-(t+4)AB$

$= (2-t)AB$

R5

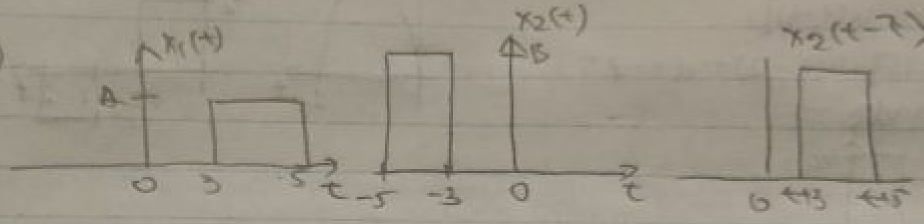
No overlap for $5 \leq t$



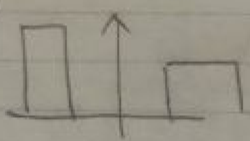
B.3b

D1 B3 Fig. 2.4-2.7

b)



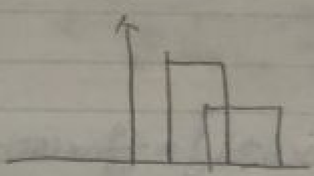
R1



$t < -2$

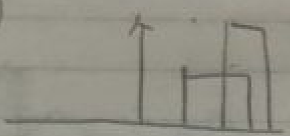
$y(t) = 0$

R2



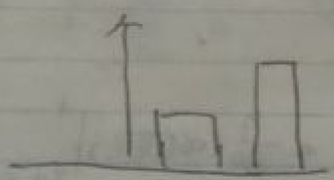
$-2 \le t \le 0$ $\quad y(t) = \int_3^{t+5} AB\,d\tau = AB\tau\Big|_3^{t+5} = AB(t+2)$

R3

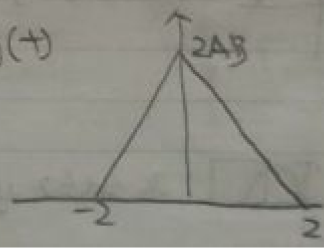


$0 \le t \le 2$ $\quad y(t) = \int_2^{t+2} AB\,d\tau = AB(2-t)$

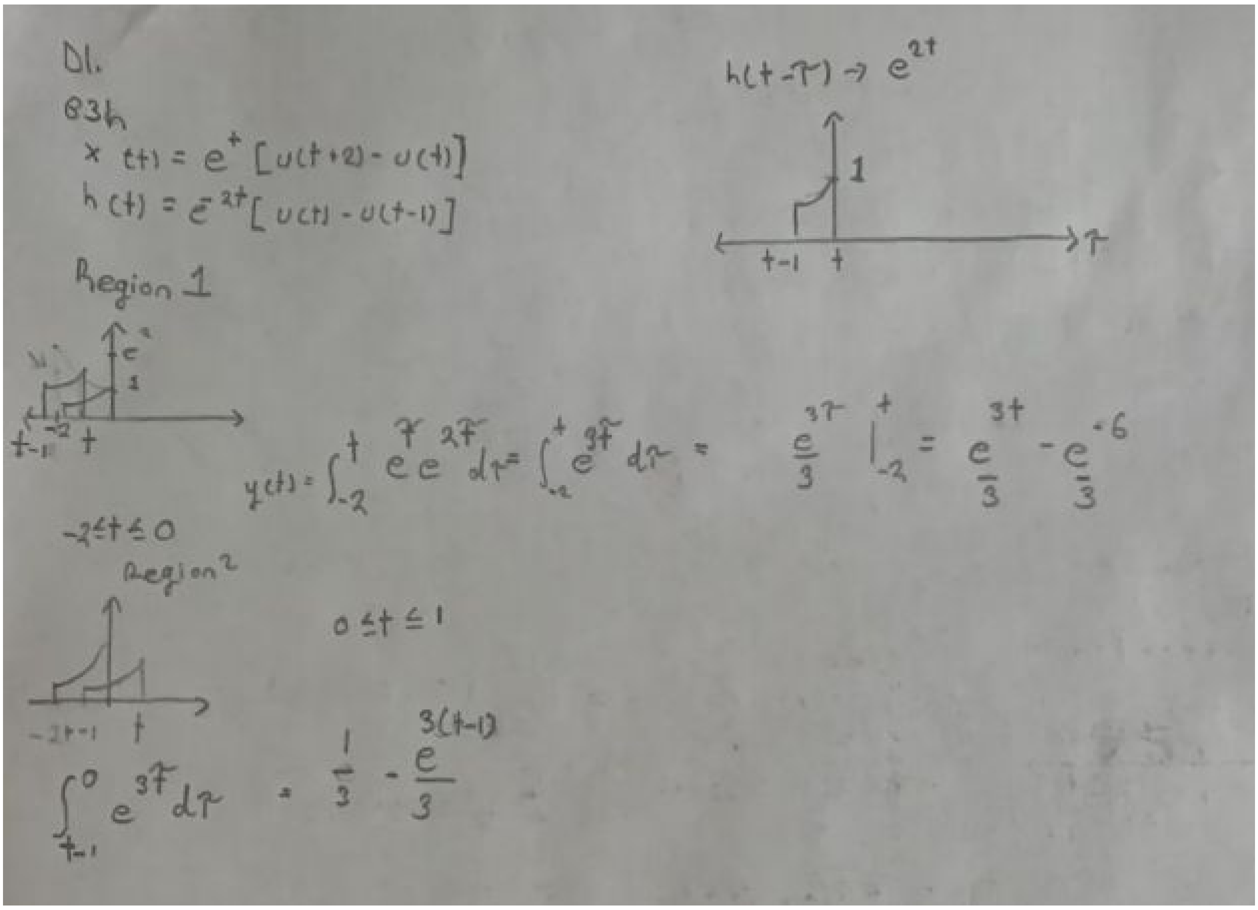
R4



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



B.3h



Problem D.2
The sum of the lengths of each function is equal to the length of the convolution of two functions