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% Name: Lamin Jammeh
% Class: EE480 Online
% Semster: Fall 2023
% HW_5

% Basic Problems
%%  ********** 3.5b **********
%finding x1(t)
clear;
clc;
syms t s;
X = (s+2)/(1+(2+s^2));
x = ilaplace(X)


%% ********** question 3.5(c) **********
clear;
clc;
syms t;
z = diff(exp(-t)*heaviside(t))
Z = laplace(z)
Z_simplify = simplifyFraction(Z)

%% ********** question 3.8 **********
clear;
clc;
% ***** Part a *****
% Step 1 define the syms variables
syms t s;
% Step 2 define the x(t)
x = heaviside(t) - 2*heaviside(t-1) + 2*heaviside(t-3) - heaviside(t-4);
% Step 3 plot x(t)
subplot(3,1,1);
fplot(x,[0,10],'r','LineWidth',2);
xlabel('Time (sec)');
ylabel('x(t)');
title('x(t) vs Time');
grid on

% Step 4 differentiate x
x_diff1 = diff(x);
subplot(3,1,2);
fplot(x_diff1,[0,10],'b','LineWidth',2);
xlabel('Time (sec)');
ylabel("d/dt(x(t))");
title("d/dt(x(t)) vs Time");
grid on

% Step 4 differentiate x_diff1
```

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x_diff2 = diff(x_diff1);
subplot(3,1,3);
fplot(x_diff2,[0,10],'g','LineWidth',2);
xlabel('Time (sec)');
ylabel("d2/dt2(x(t))");
title("d2/dt2(x(t)) vs Time");
grid on

% ***** Part b *****
X_s = laplace(x_diff2) % define Laplace transform of d2/dt2 (x(t)

%% ********** 3.9(a) **********
clear;
clc;
% Step 1 define Syms function as s
syms s;
% define Y(s)
Y = [exp(-2*s)/(s^2 +1)] + [((s+2)^2+2)/(s+2)^3];
y = ilaplace(Y);


%% ********** 3.9(c) **********
% finding the steady state and transient given the out laplace transform
% Y(s)

%find the steady state laplace transform
clear;
clc;
syms t s;
%define the output lapce transform Y(s)
Y = 1/(s*((s+1)^(2) + 4));
%define the inverse laplace transform of Y(s)
y = ilaplace(Y,s,t);
%define the steady steady using the lim as t approches inf
Y_ss = limit(y,t,inf);

%find the transient by subtracting output from steady state response
Y_transient = y - Y_ss;

%% *********** 3.13b **********
clear;
clc;
syms t s;
%define the H(s)
H = (s^2 + 4)/(s*((s+1)^2 + 1));
%define input x(t)
x = cos(2*t)*heaviside(t);
%define X(s)
X = laplace(x);
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```
% Y(s)=H(s)*X(s)
Y = H * X;
y = ilaplace(Y);
%define steady state by using the lim as t approches inf
y_ss = limit(y,t,inf);

%% *********** 3.13c **********
clear;
clc;
syms t s;
%define the H(s)
H = (s^2 + 4)/(s*((s+1)^2 + 1));
%define input x(t)
x = sin(2*t)*heaviside(t);
%define X(s)
X = laplace(x);
% Y(s)=H(s)*X(s)
Y = H * X;
y = ilaplace(Y);
%define steady state by using the lim as t approches inf
y_ss = limit(y,t,inf);

%% *********** 3.13d **********
clear;
clc;
syms t s;
%define the H(s)
H = (s^2 + 4)/(s*((s+1)^2 + 1));
%define input x(t)
x = heaviside(t);
%define X(s)
X = laplace(x);
% Y(s)=H(s)*X(s)
Y = H * X;
y = ilaplace(Y);
%define steady state by using the lim as t approches inf
y_ss = limit(y,t,inf);

%% ********** 3.15a ***********
clear;
clc;
% Note the H(s) =output(s) / input(s)
syms t s;

% Step find the output laplace S(s)
s_t = (0.5-exp(-t) + 0.5*exp(-2*t))*heaviside(t);% ouput in time domian
S = laplace(s_t);

% Step 2 find the input U(s)
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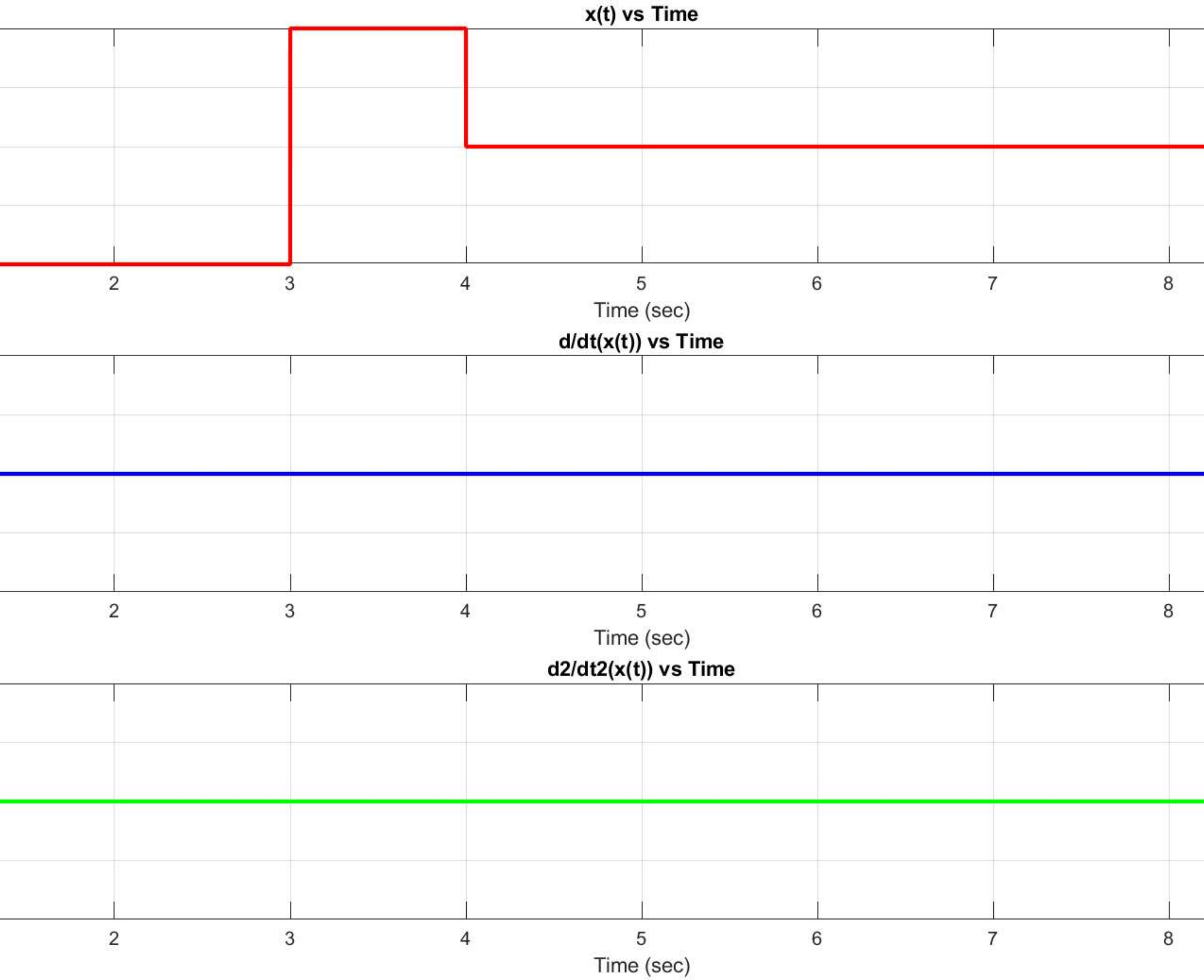
u_t = heaviside(t);
U = laplace(u_t);

% Step 3 find H(s)=S(s)/U(s)
H = S / U;
H_simplify = simplifyFraction(H); % simplified fraction of H(s)
```


x(t) vs Time
2
3
4
5
6
7
8
Time (sec)
d/dt(x(t)) vs Time
2
3
4
5
6
7
8
Time (sec)
d2/dt2(x(t)) vs Time
2
3
4
5
6
7
8
Time (sec)

3.5(b)

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b) $x_1(t)$ has Laplace Transform $X_1(s) = \dfrac{s+2}{(s+2)^2+1}$

$$X_1(s) = \frac{N(s)}{D(s)}$$

for zero $N(s) = 0 = s+2$

$s+2=0$

$\boxed{s=-2 \quad \text{OR} \quad s+2=0}$ zero

for poles $D(s) = 0 = (s+2)^2+1$

$(s+2)^2+1=0$

$(s+2)^2 = -1$

$s+2 = \pm\sqrt{-1}$

$s = -2 \pm \sqrt{-1}$

$s = -2 \pm j$

$\boxed{\begin{array}{ll} \therefore\ s=-2+j, & s=-2-j \\ s+2-j=0, & s+2+j=0 \end{array}}$ poles

3.5©

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1) $z(t) = \frac{d}{dt} e^{-t} u(t)$

let $a = e^{-t}$ & $b = u(t)$

Apply product Rule

$z'(t) = a'b + ab'$

$z'(t) = u(t) \frac{d}{dt} e^{-t} + e^{-t} \frac{d}{dt} u(t)$

$z'(t) = u(t)\left[-e^{-t}\right] + e^{-t}\left[\delta(t)\right]$

$z'(t) = -e^{-t} u(t) + \delta(t) e^{-t}$

$z'(t) = e^{-t} \delta(t) - e^{-t} u(t)$

$Z(s) = 1 - \frac{1}{s+1}$

$Z(s) = \frac{s+1-1}{s+1}$

$$\boxed{Z(s) = \frac{s}{s+1}}$$

3.13a

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$$H(s) = \frac{s^2+4}{s((s+1)^2+1)}$$

BIBO stable ⇒ Bounded input of Bounded output

⇒ One Condition is to have all poles of H(s) to have real negative real parts

$$s[(s+1)^2+1] = 0$$

$$s(s^2+2s+2) = 0 \Rightarrow \begin{array}{l} s=0 \\ s^2+2s+2=0 \end{array}$$

$$s = \frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{-2 \pm \sqrt{4-8}}{2} = \frac{-2 \pm j2}{2} = -1 + j$$

$$s = \begin{cases} 0 \Rightarrow H(s) \text{ is undefine} \\ -1 \pm j \Rightarrow H(s) \text{ is BIBO stable} \end{cases}$$

∴ System is not BIBO stable because one of the poles is zero

3.17a

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$$H(s) = \frac{1}{s^2+4} = \frac{Y(s)}{X(s)}$$

$$X(s) = \frac{Y_s}{H_s} = \frac{Y_s}{\frac{1}{s^2+4}} = Y(s)\left(s^2+4\right)$$

$$X(s) = Y(s)\left(s^2+4\right) = s^2 Y(s) + 4\,Y(s)$$

$$X(s) = s^2 Y(s) + 4\,Y(s)$$

note $s^n\left(F(s)\right) = \frac{d^n}{dt^n} f(t)$

$$\boxed{x(t) = \frac{d^2}{dt^2} y(t) + 4\,y(t)}$$

3.17b

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$$x(t) = \frac{d^2}{dt^2} y(t) + 4y(t)$$

$$x(t) = \frac{d^2}{dt^2} y(0) + 4y(0)$$

y $y(0) = 0$

$$x(t) = \frac{d^2}{dt^2} y(0) + 4(0)$$

$$x(t) = \frac{d^2}{dt^2} y(0) \quad \text{but} \quad \frac{d}{dt} y(0) = 1$$

$$x(t) = \frac{d^2}{dt^2}(1)$$

Relation $r(t)$ & $u(t)$ & $\delta(t)$

$$\frac{d\,r(t)}{dt} = u(t)$$

$$x(t) = \delta(t)$$

$$\frac{d^2 r(t)}{dt} = \delta(t)$$