E324, Control Systems Lab, Problem sheet 2

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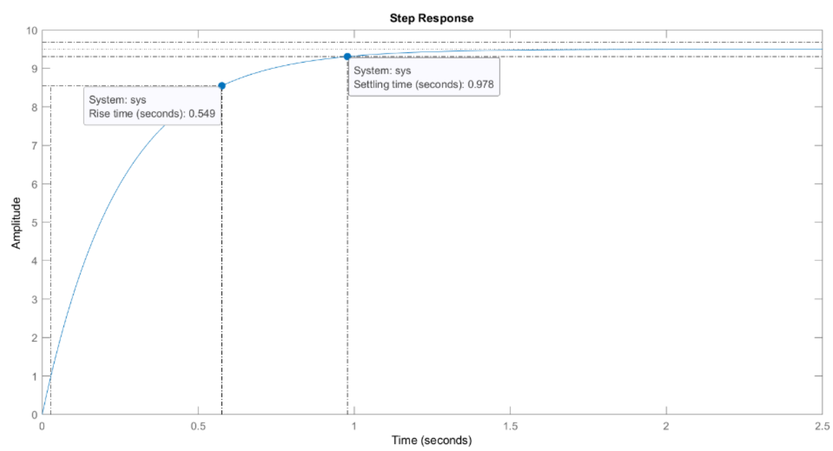
Q1]

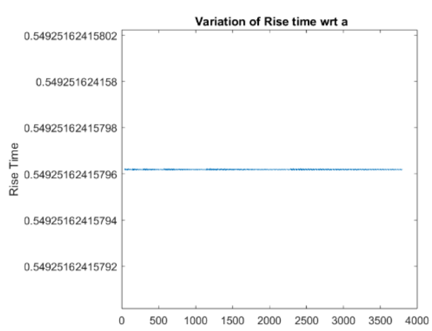
Here is the Matlab Code:

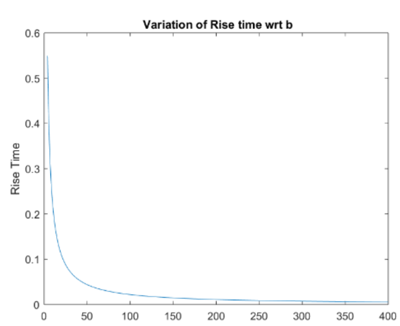
```
%% Q1 1st order system
sys = tf(38,[1 4]);
% step(sys);
S = stepinfo(sys);
for a = 38:38*100
    sys = tf([a],[1 4]);
    S = stepinfo(sys);
    x(a-37) = S.RiseTime;
end
for b = 4:4*100
    sys = tf([38],[1 b]);
    S = stepinfo(sys);
    y(b-3) = S.RiseTime;
end
plot(38:38*100,x);
title(" Variation of Rise time wrt a");
xlabel(" a ");
ylabel("Rise Time");

plot(4:4*100,y);
title(" Variation of Rise time wrt b");
xlabel(" b ");
ylabel("Rise Time");
```

a) Time Constant = b = ¼



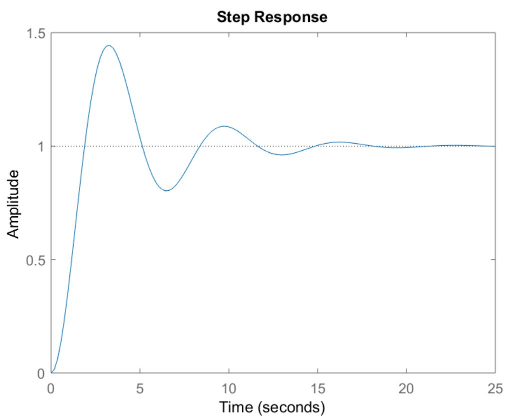



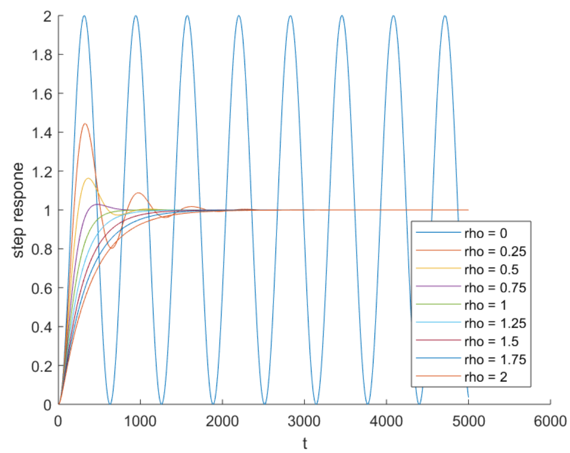



Conclusions:

- Rise Time does not depend on a
- Rise Time has an inverse relationship with b. (of the form 1/b)

Q2]




All the required information and steps required to reach the plots are mentioned in the code :

MATLAB Code:

```
%% Second Order System Time Domain Analysis
w = 1;
rho = 0.25;
t = 0:0.01:50;
sys = tf(w^2,[1 2*rho*w w^2]);
x = step(sys,t);
rho = 0:0.25:2;
Y = ones(length(rho),length(t));
hold on
for i = 1:length(rho)
    sys = tf(w^2,[1 2*rho(i)*w w^2]);
    Y(i,:) = step(sys,t);
    S = stepinfo(sys);
    rise_time(i) = S.RiseTime;
    Overshoot(i) = S.Overshoot;
    PeakTime(i) = S.PeakTime;
    SettlingTime(i) = S.SettlingTime;
    plot(Y(i,:))
    xlabel('t');
    ylabel('step respone');
end
legend( 'rho = 0','rho = 0.25','rho = 0.5','rho = 0.75','rho = 1','rho = 1.25','rho = 1.5','rho = 1.75' ,'rho = 
2' );
hold off
```

Conclusions:

As the damping ratio is increased the following trends are observed from the plot

- Percentage Overshoot reduces as rho increases from 0 to 1 and is zero for all rho >= 1.
- The peak time and rise time increase as rho increases
- The settling time reduces as rho goes from 0 to 1 but increases when rho > 1

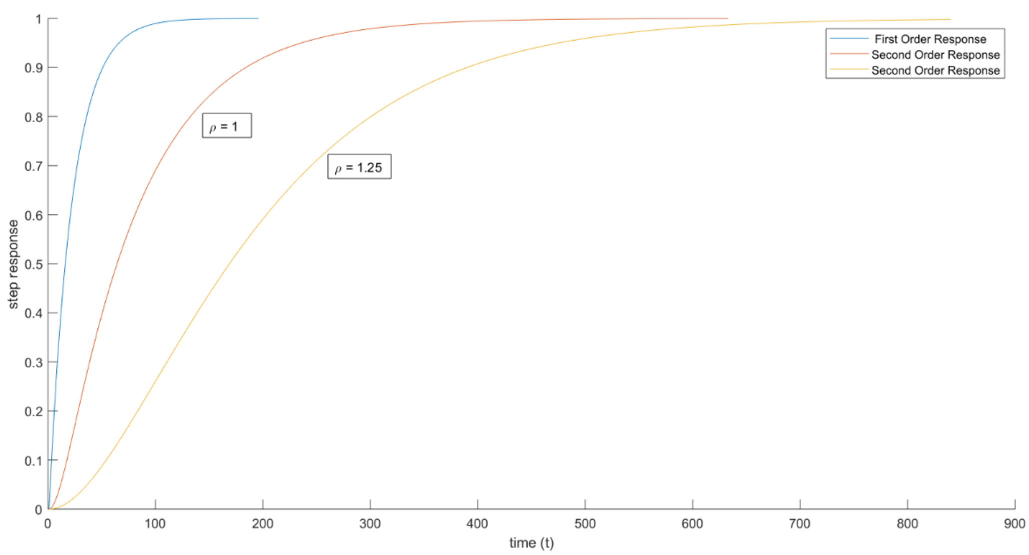
Q3]

MATLAB Code:

```
%% Differences in First and Second Order Responses

sys_first_order = tf(4,[1 4]);
w = 1;
rho = 1.5;
sys_second_order = tf(w^2,[1 2*rho*w w^2]);
rho = 1;
sys_second_order_critical = tf(w^2,[1 2*rho*w w^2]);
x = step(sys_first_order);
y = step(sys_second_order);
z = step(sys_second_order_critical);
hold on
plot(x);
plot(y);
plot(z);
xlabel('time (t)');
ylabel('step response');
legend(' First Order Response' ,'Second Order Response' ,'Second Order Response');
hold off

S = stepinfo(sys_second_order_critical);
S.Overshoot % Answer = 0
```




Conclusions:

- The second order responses are slower than the first order responses.
- The fastest response for the second order system is given by the critically damped system (rho = 1) (repeated poles) and the response becomes slower as we increase the damping constant.
- The percentage overshoot for rho = 1 response was calculated and the output was zero. Hence, the output is monotonic

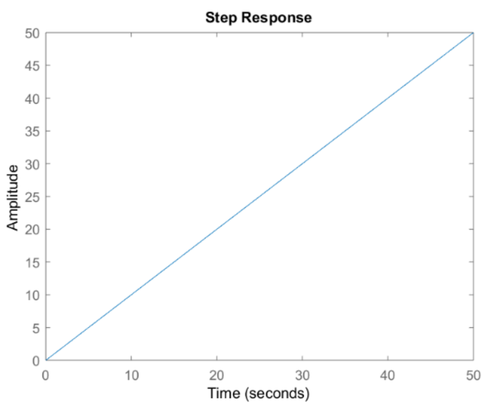
Q4]

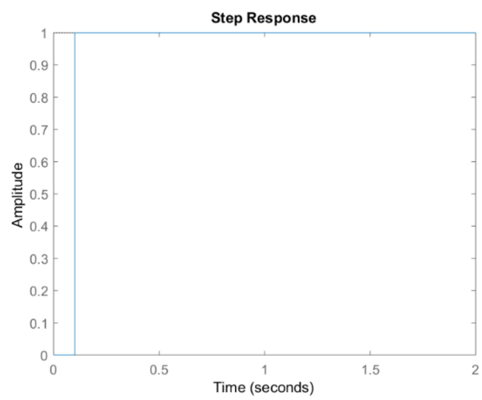
MATLAB Code:

```
%% Q4 Discrete and Continuous Time Transfer Functions
s = tf('s');
G = 1/s;
% step(G);
ts = 0.1;
z = tf('z',ts);
H = 1/z;
% step(H)
T = 1/(s+z); % This line gives an Error
step(T);
```

Scilab Code:

```
z = poly ( 0 , ’ z ’ ) ;
G = 1/ z ; s1 = tf2ss(G) ;
x = dsimul(s1,ones( 1 , 1 0 ) ) ;
plot( x ) ;
```




Conclusions:

- The plots are different because in the discrete case we have chosen a sampling time = 0.1
- On providing discrete as well as continuous variables in a single function, scilab throws the warning ”WARNING: csim: Input argument 1 is assumed continuous time.” and forces the other argument to continuous time
- However in Matlab , there is an error and the program doesn’t run.

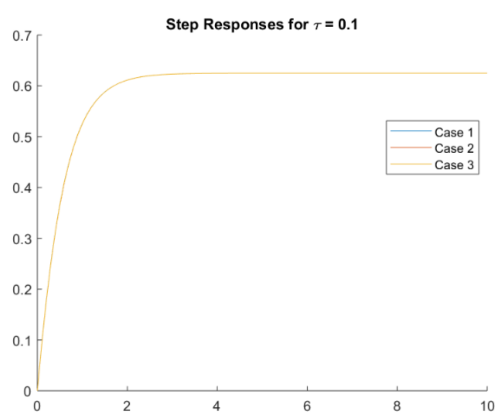
Q5]

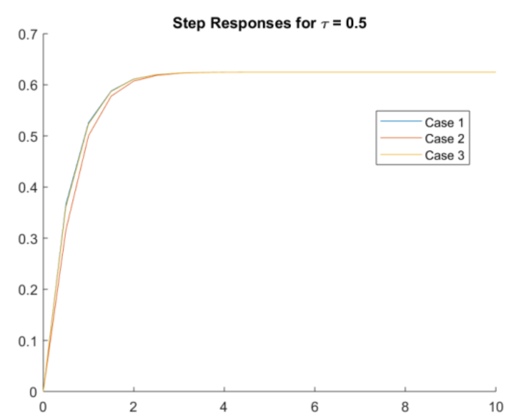
MATLAB Code:

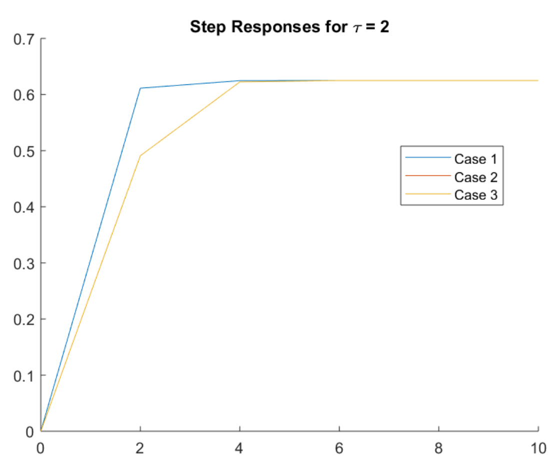
```
%% Q5 Order of Blocks
G1 = tf([1 5],[1 6 8]);
H1 = tf([1 5],[1 4]);
H2 = tf(1,[1 2]);

% tau = 0.1;
% tau = 0.5;
tau = 2;
t = [0:tau:10];
y1 = step(G1,t);
u1 = step(H1,t);
u2 = step(H2,t);
y2 = lsim(H2,u1,t);
y3 = lsim(H1,u2,t);

hold on
plot(t,y1);
plot(t,y2);
plot(t,y3);
legend('Case 1','Case 2','Case 3');
title('Step Responses for \tau = 2');
hold off
```



Conclusions:

- We observe that there is almost no error when tau = 0.1 and all the plots coincide
- However upon increasing the value of tau more error creeps in and the plots do not coincide.