Raghavv Goel
2016179
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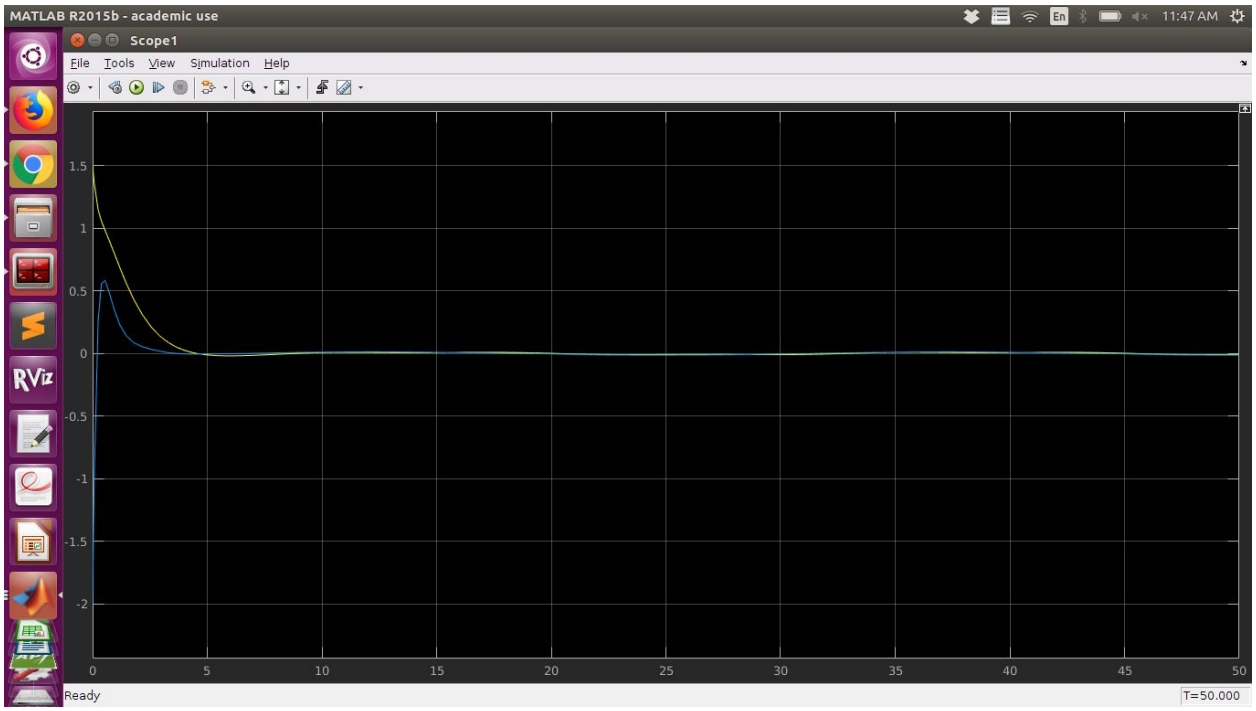
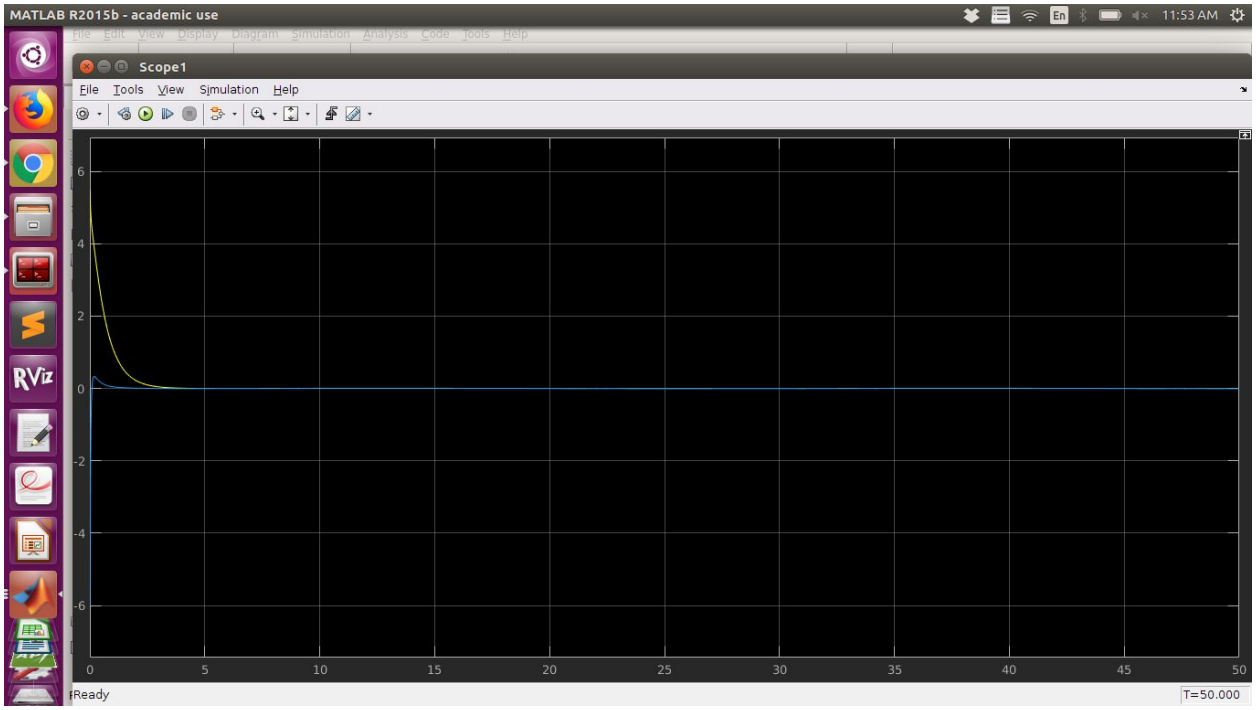
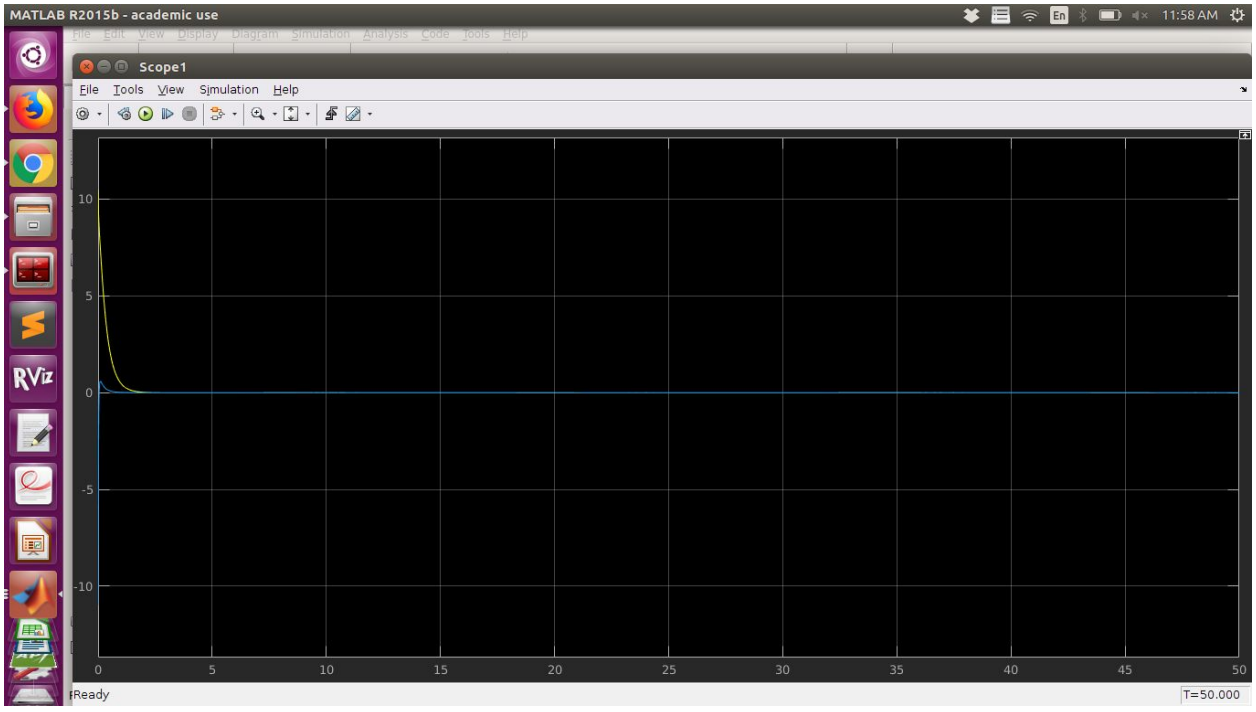
Question 1

Order : 1. alpha = 1 ; k=1
2. alpha = 5 ; k=5
3. alpha = 10; k=10

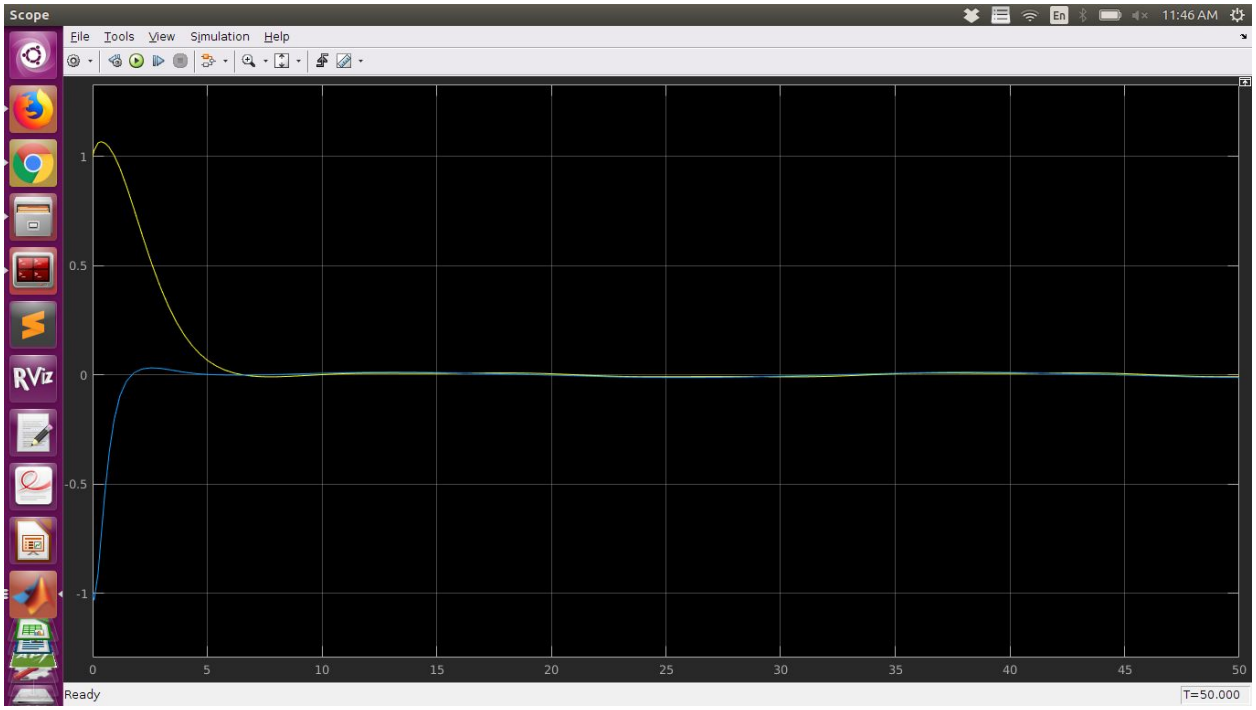
ERROR (e) :

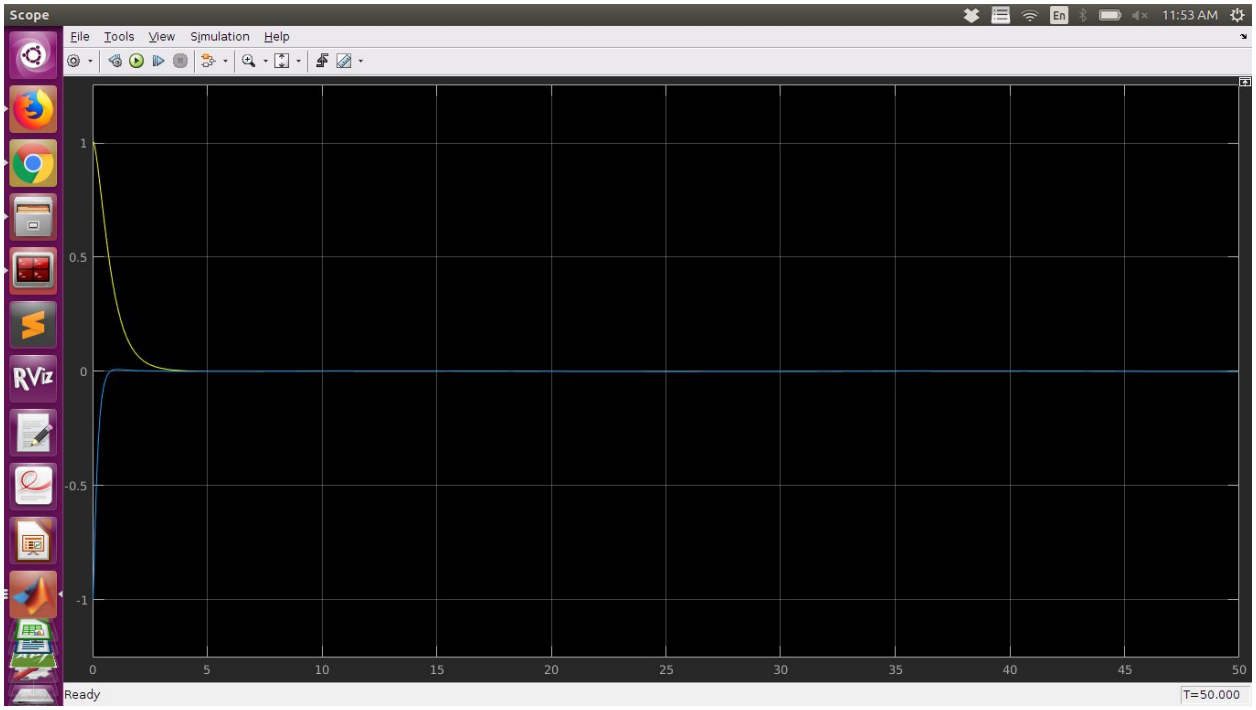


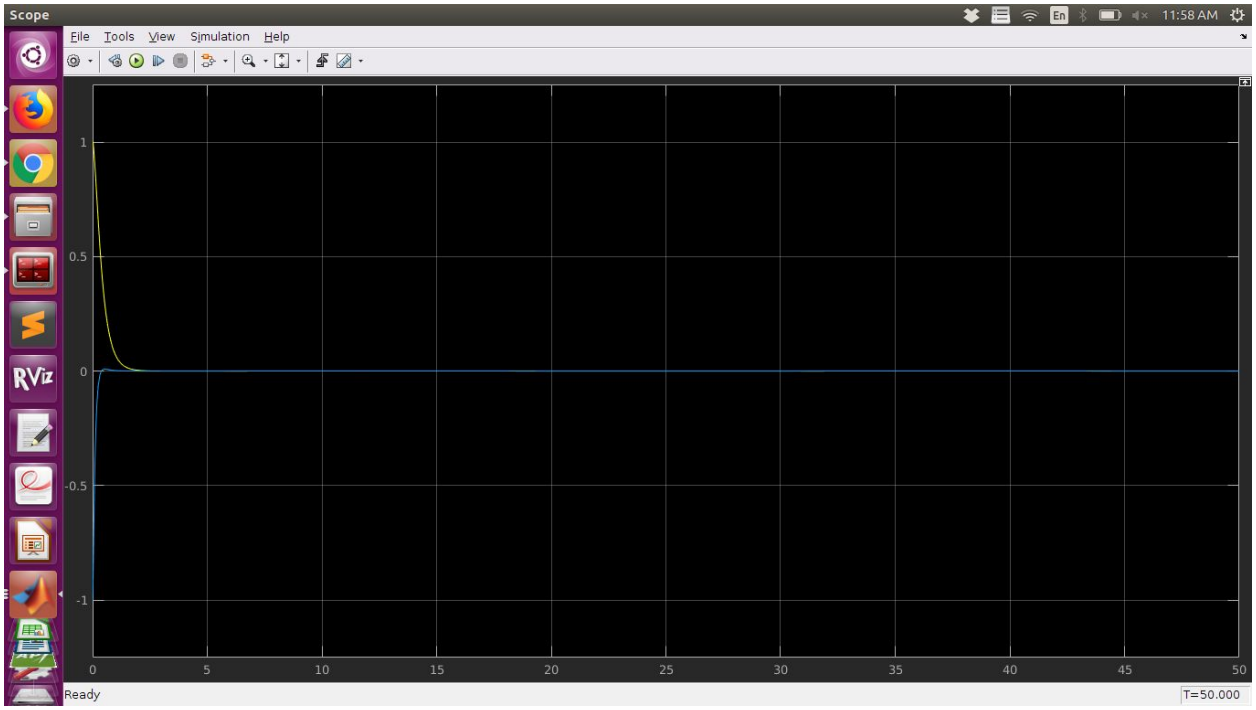

MATLAB R2015b - academic use
11:53 AM
Scope1
File Tools View Simulation Help
6
4
2
0
-2
-4
-6
0 5 10 15 20 25 30 35 40 45 50
Ready
T=50.000


MATLAB R2015b - academic use
11:58 AM
Scope1
File Tools View Simulation Help
10
5
0
-5
-10
0 5 10 15 20 25 30 35 40 45 50
Ready
T=50.000

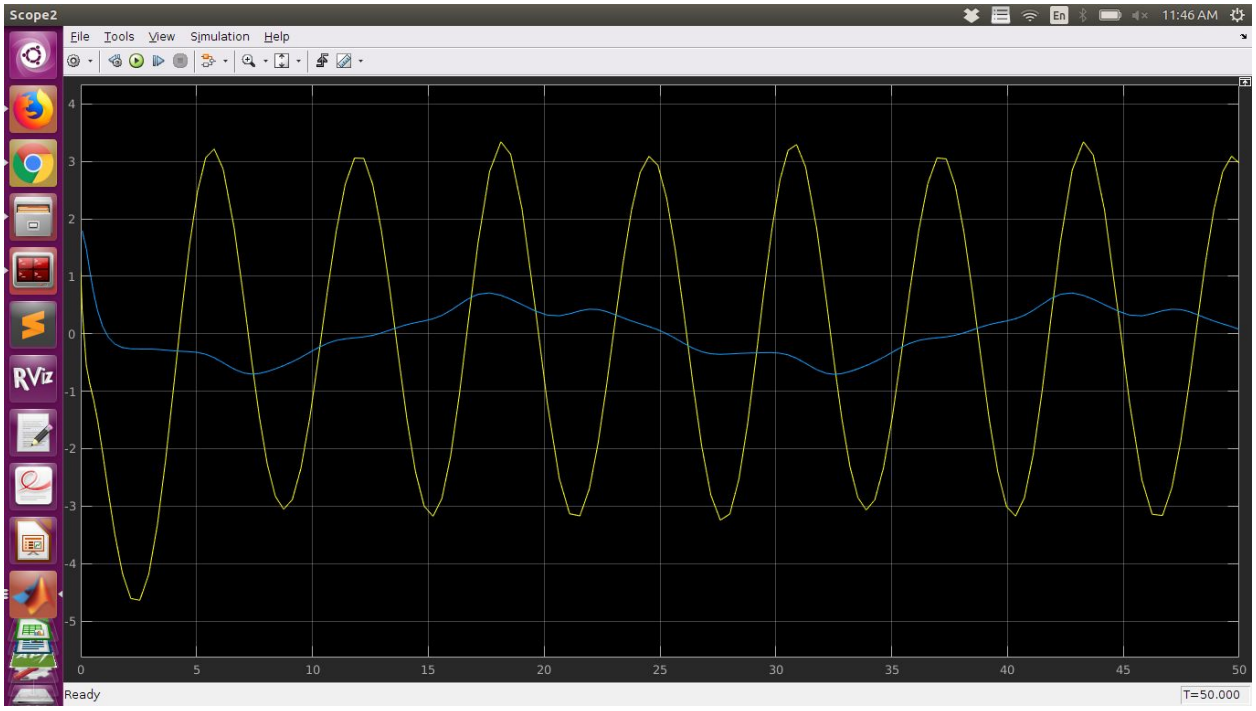
FILTER TRACKING ERROR(r)

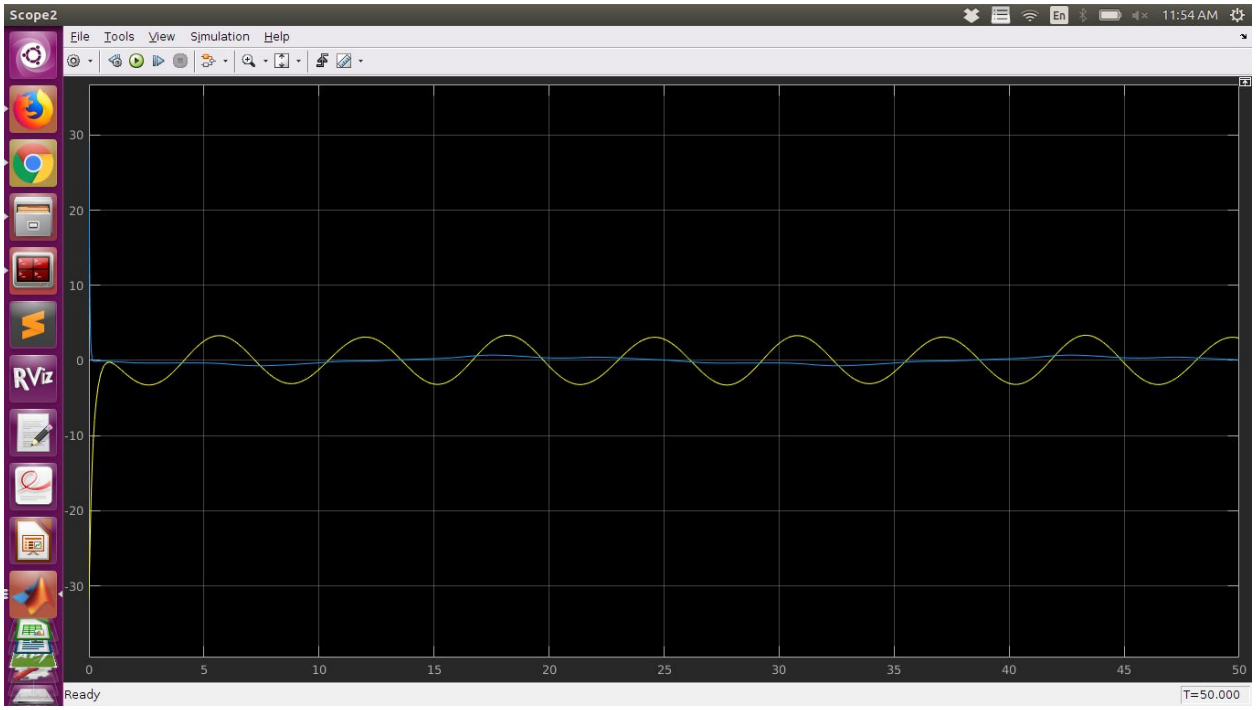


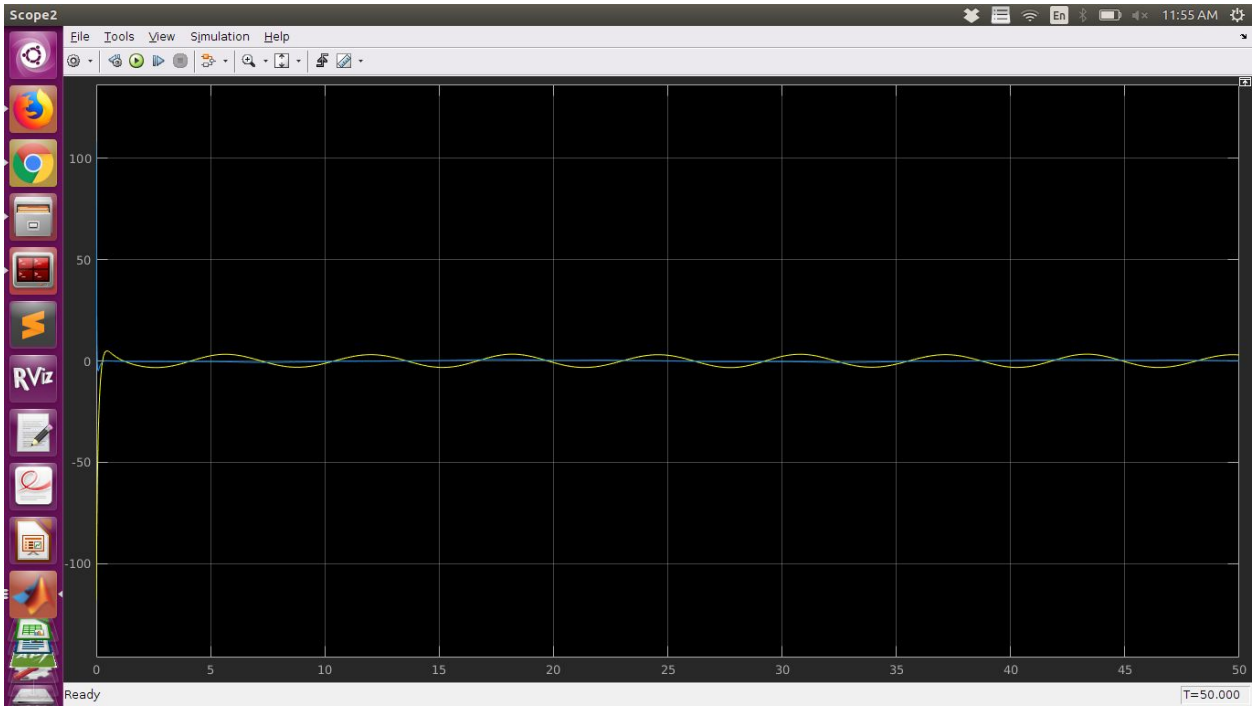



Scope
11:58 AM
File Tools View Simulation Help
1
0.5
0
-0.5
-1
0 5 10 15 20 25 30 35 40 45 50
Ready
T=50.000

TAU :


Scope2
11:46 AM
File Tools View Simulation Help
4
3
2
1
0
-1
-2
-3
-4
-5
0 5 10 15 20 25 30 35 40 45 50
Ready
T=50.000



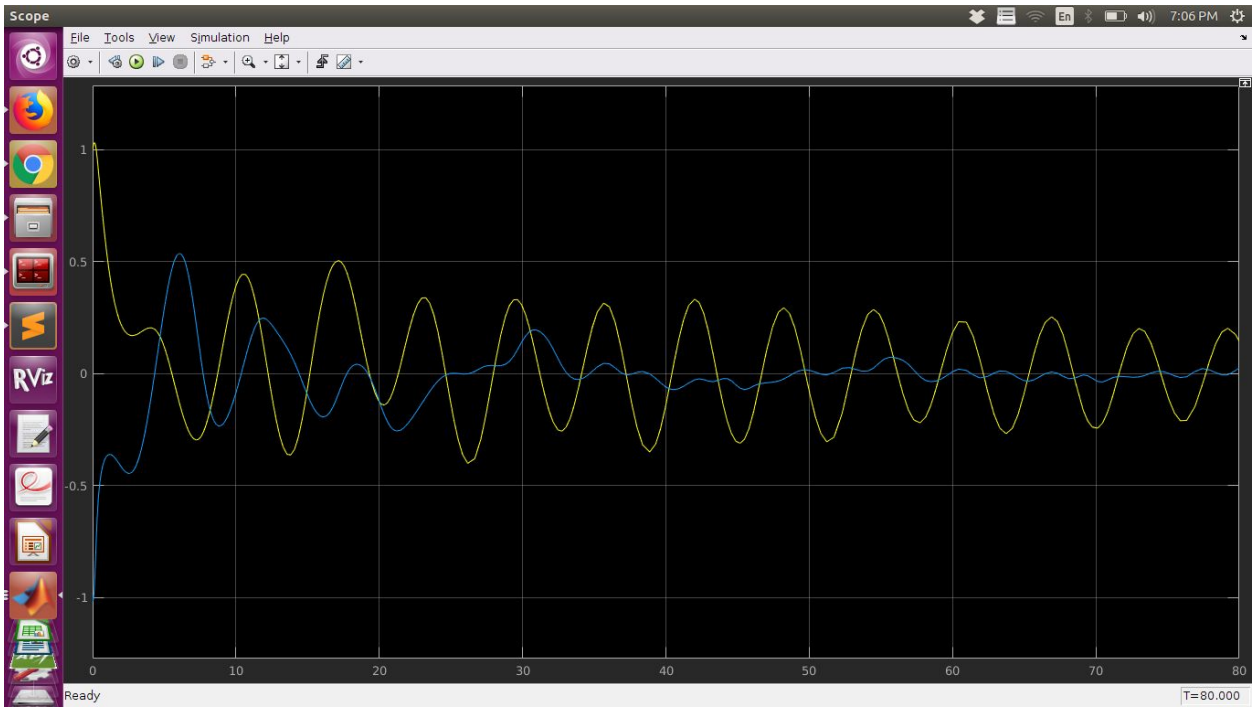


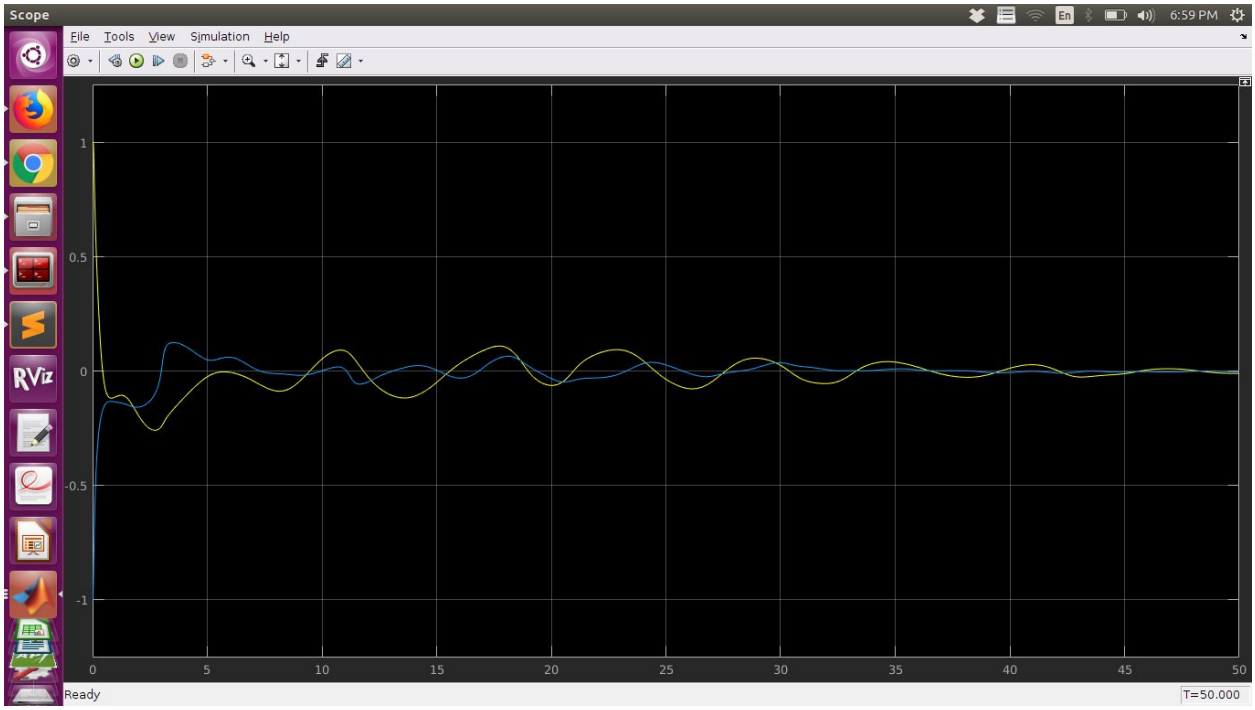
As the gains k and alpha increase the convergence of errors(e, r) to zero increases as can be seen.

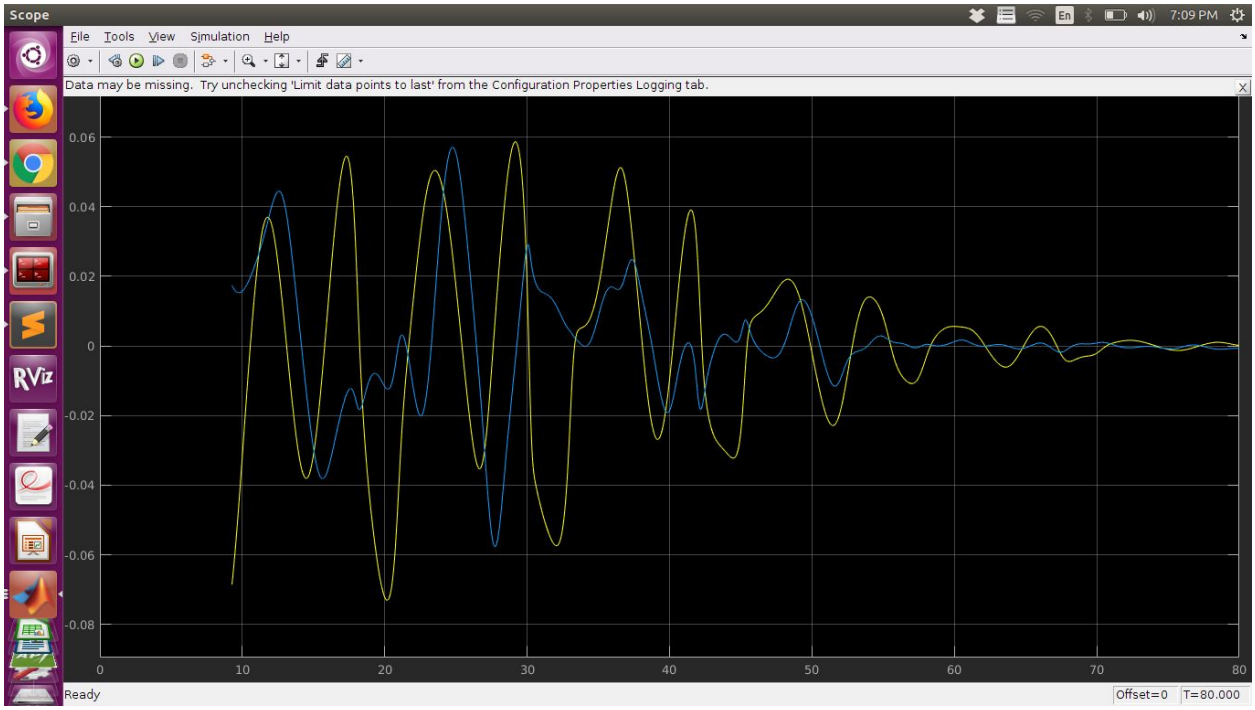
QUESTION 2:

Order : 1. alpha = 1 ; k=1 ; gamma = 1
2. alpha = 5 ; k=5 ; gamma = 5
3. alpha = 10; k=10; gamma = 10

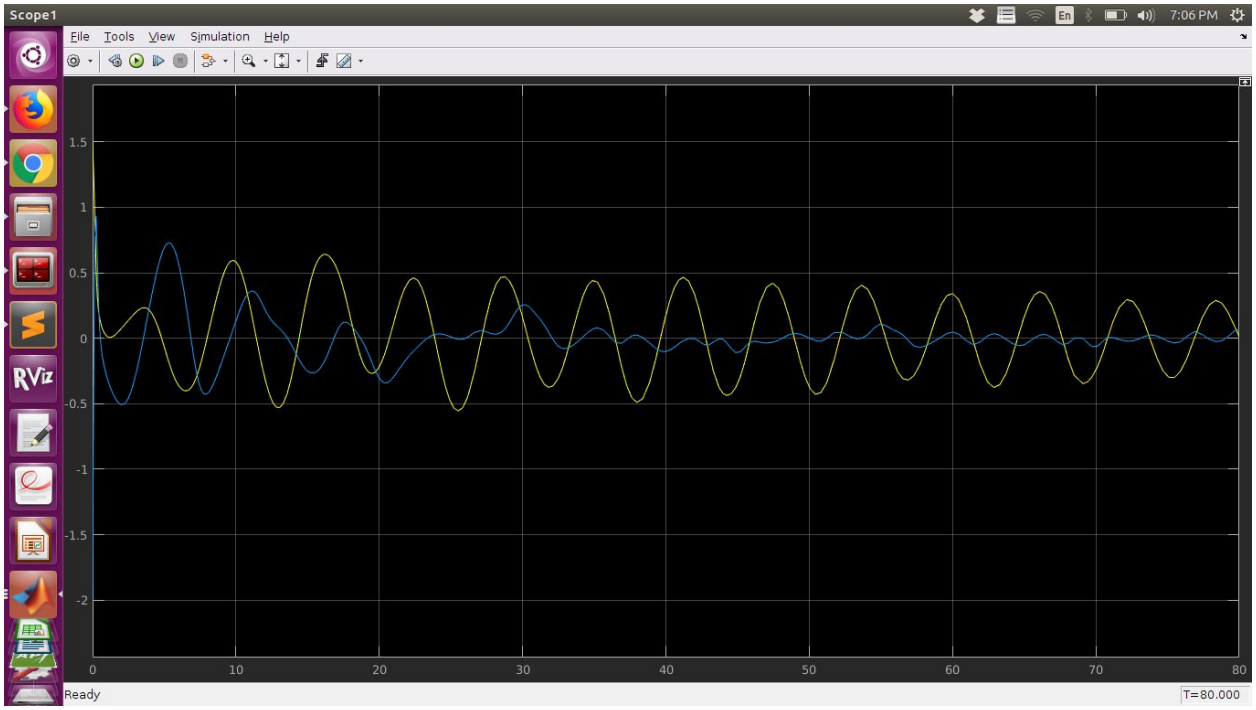
ERROR(e) :

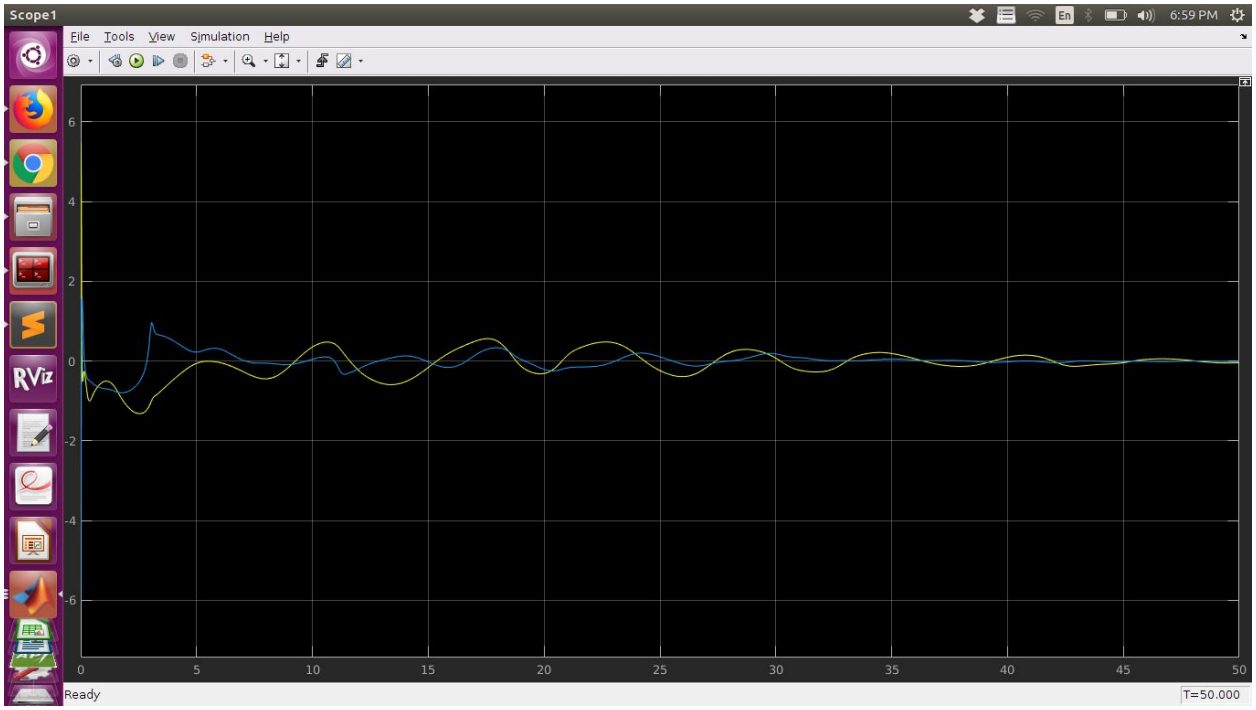


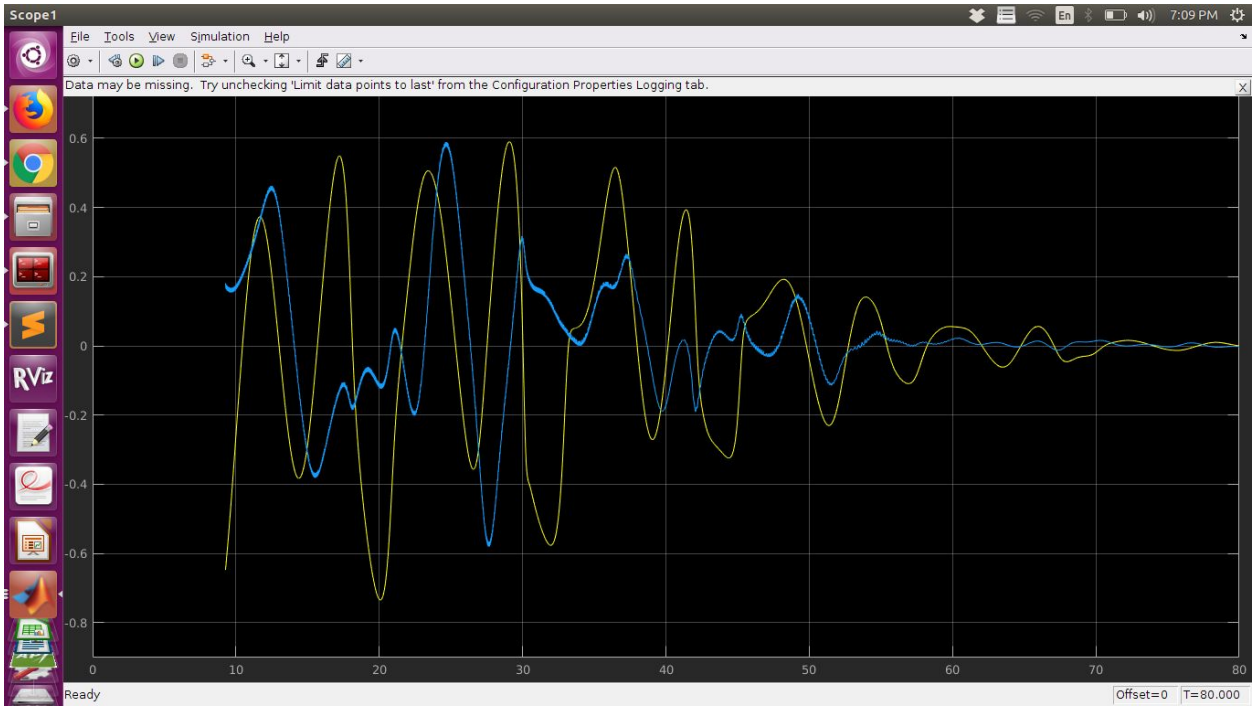

Scope
6:59 PM
File Tools View Simulation Help
1
0.5
0
-0.5
-1
0 5 10 15 20 25 30 35 40 45 50
Ready
T=50.000


Scope
7:09 PM
File Tools View Simulation Help
Data may be missing. Try unchecking 'Limit data points to last' from the Configuration Properties Logging tab.
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
0 10 20 30 40 50 60 70 80
Ready
Offset=0
T=80.000

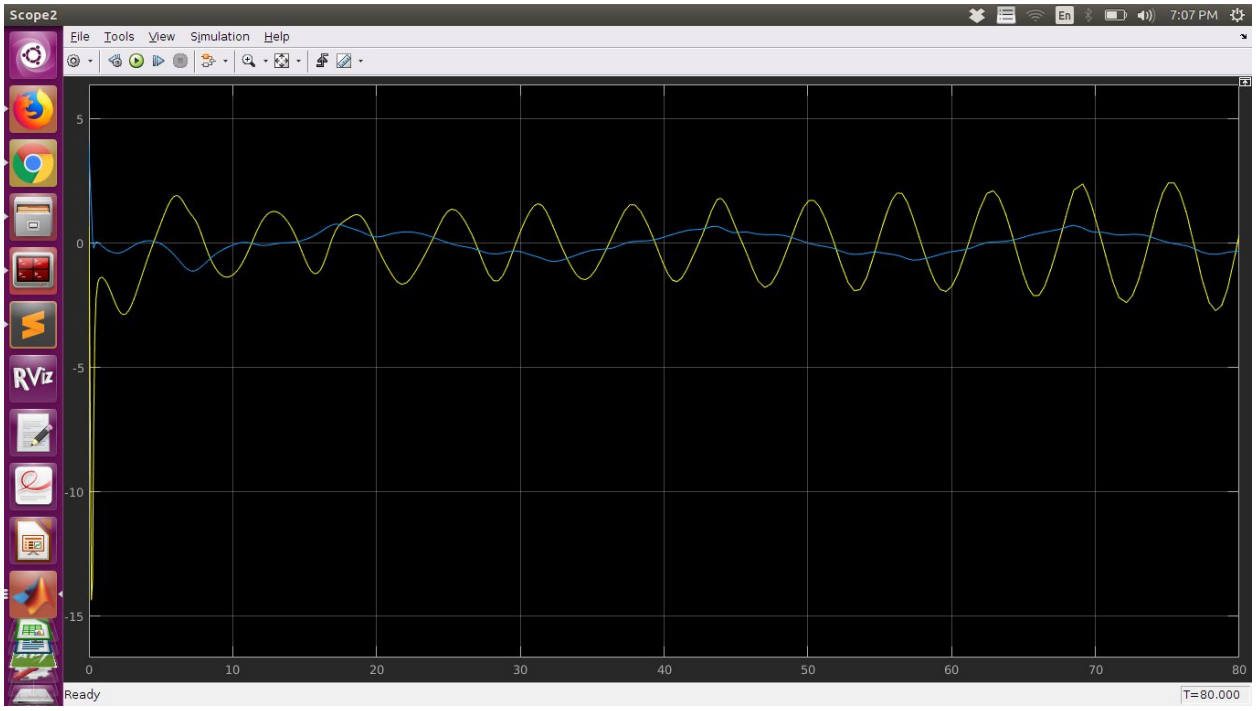
FILTER TRACKING ERROR(r):

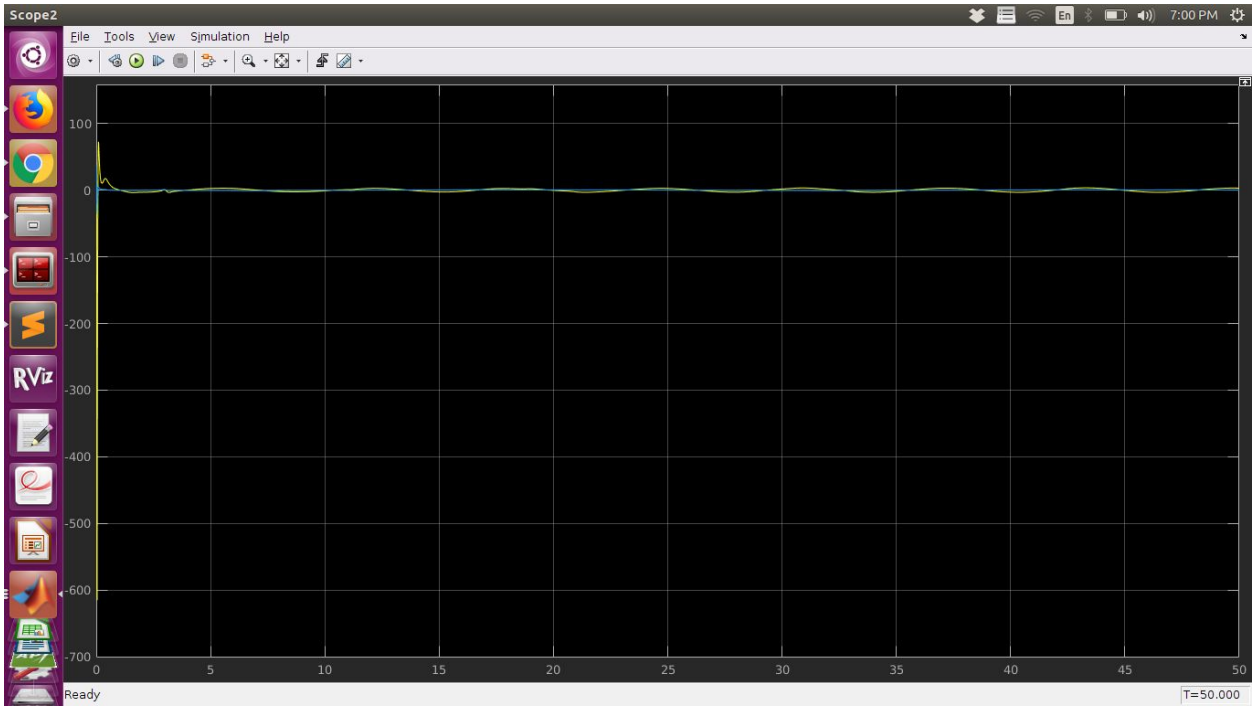


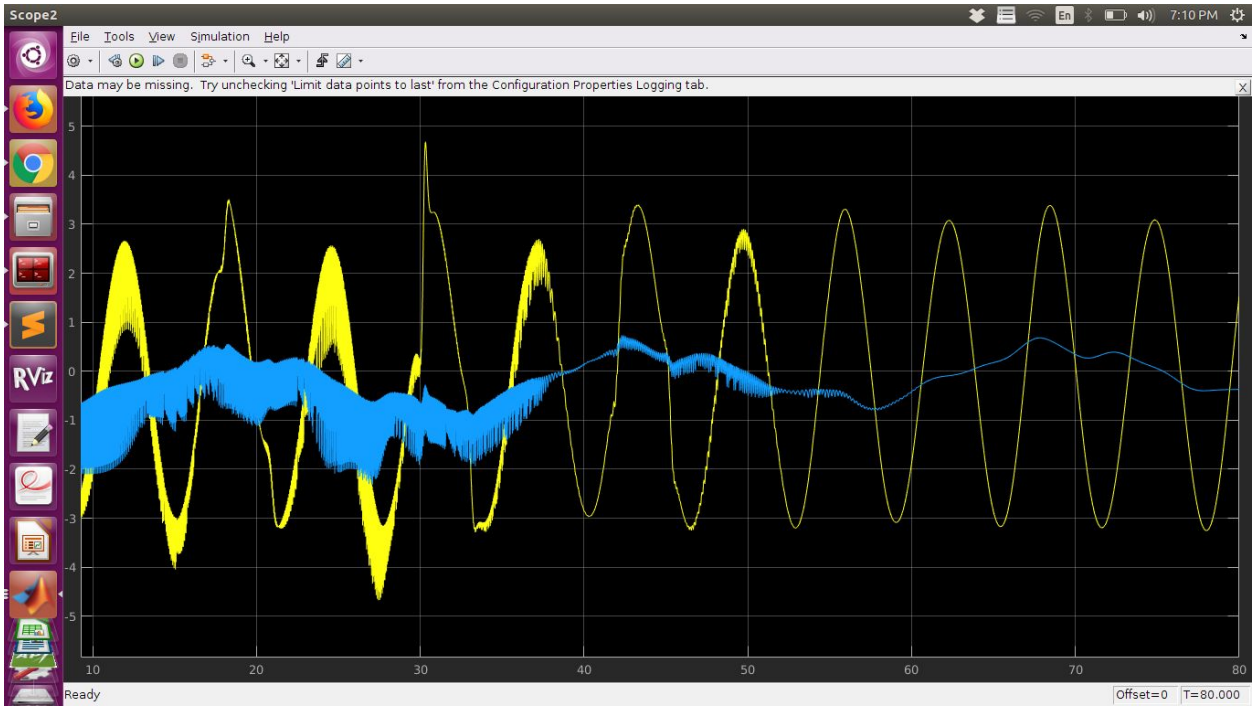



Scope1
File Tools View Simulation Help
Data may be missing. Try unchecking 'Limit data points to last' from the Configuration Properties Logging tab.
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0 10 20 30 40 50 60 70 80
Ready
Offset=0
T=80.000

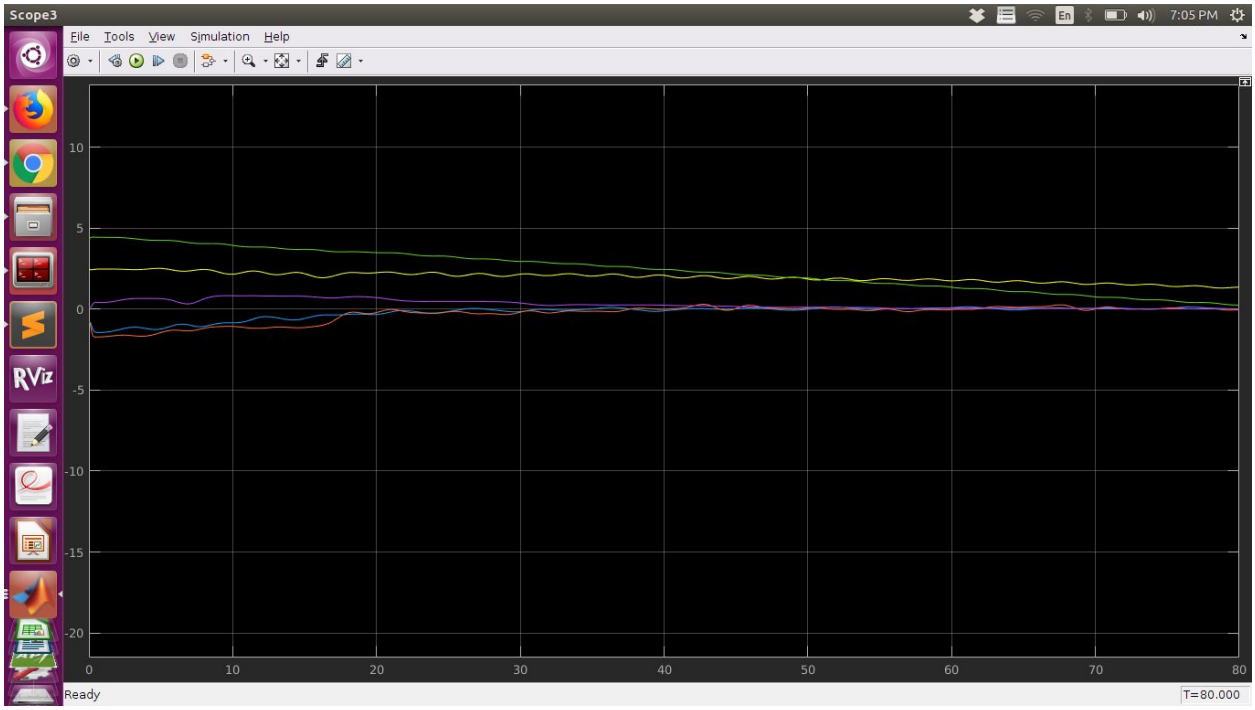
TAU :

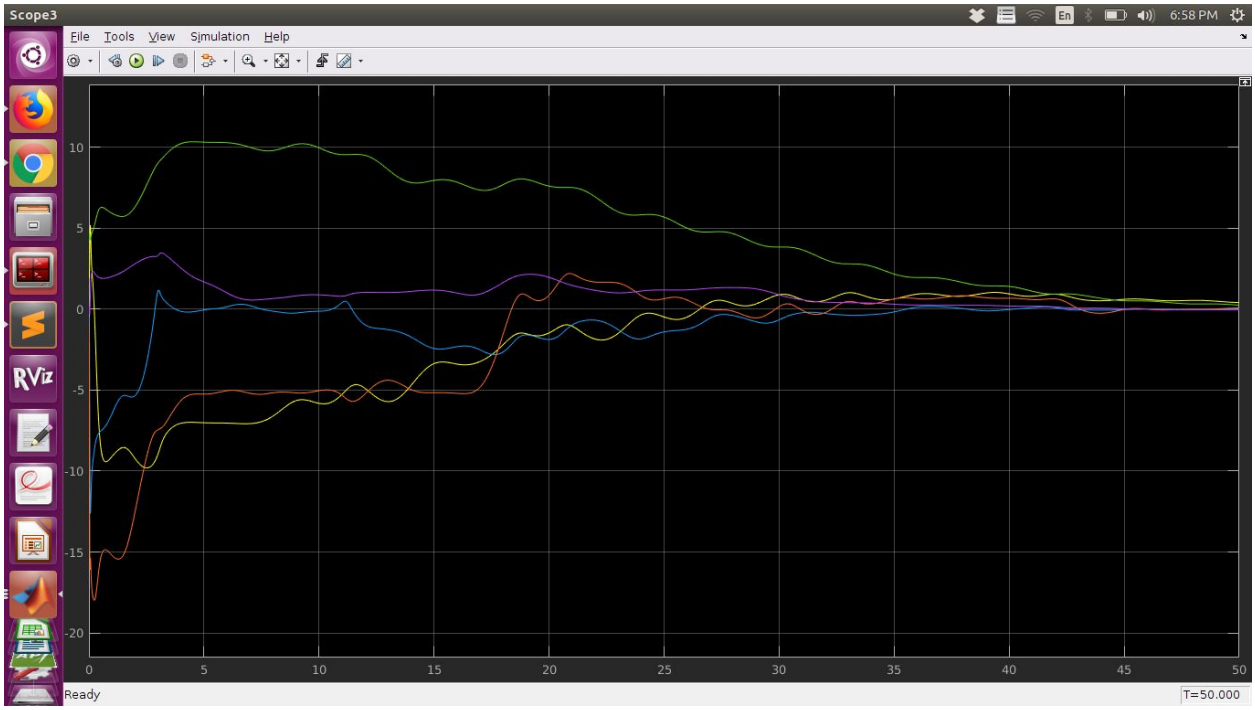

Scope2
File Tools View Simulation Help
5
0
-5
-10
-15
0 10 20 30 40 50 60 70 80
Ready
T=80.000

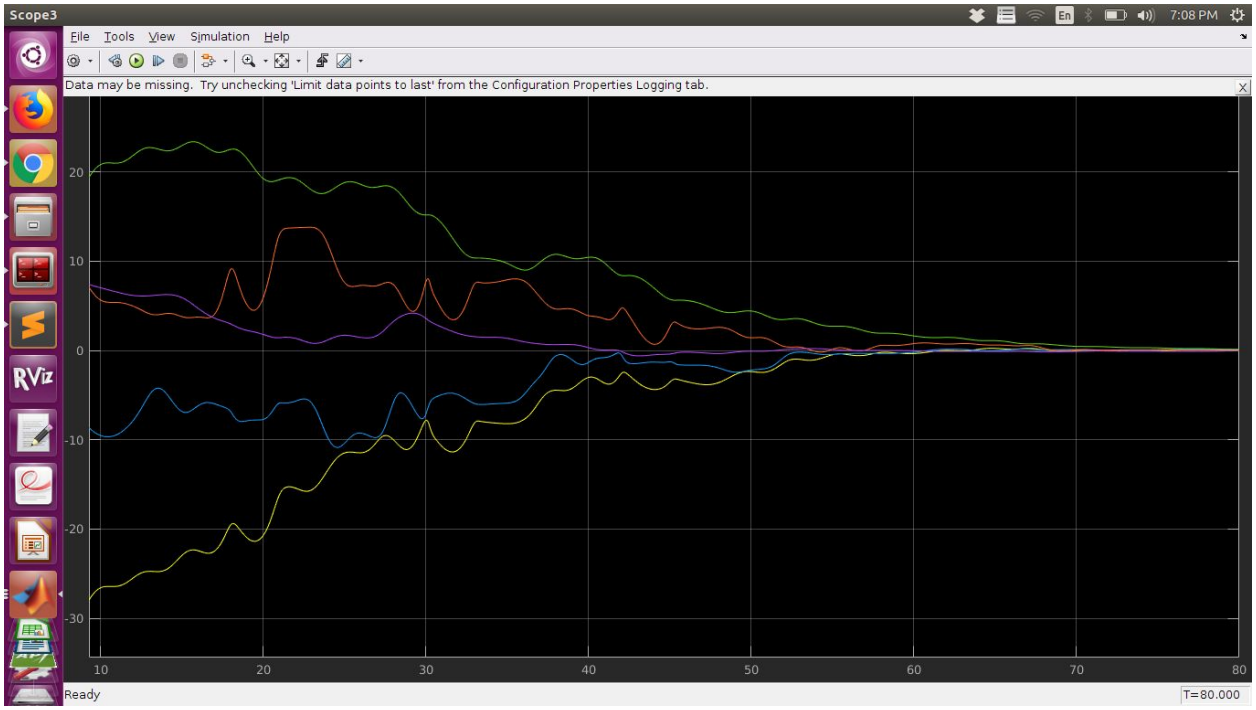

Scope2
7:00 PM
File Tools View Simulation Help
100
0
-100
-200
-300
-400
-500
-600
-700
0 5 10 15 20 25 30 35 40 45 50
Ready
T=50.000


Scope2
7:10 PM
File Tools View Simulation Help
Data may be missing. Try unchecking 'Limit data points to last' from the Configuration Properties Logging tab.
5
4
3
2
1
0
-1
-2
-3
-4
-5
10 20 30 40 50 60 70 80
Ready
Offset=0
T=80.000

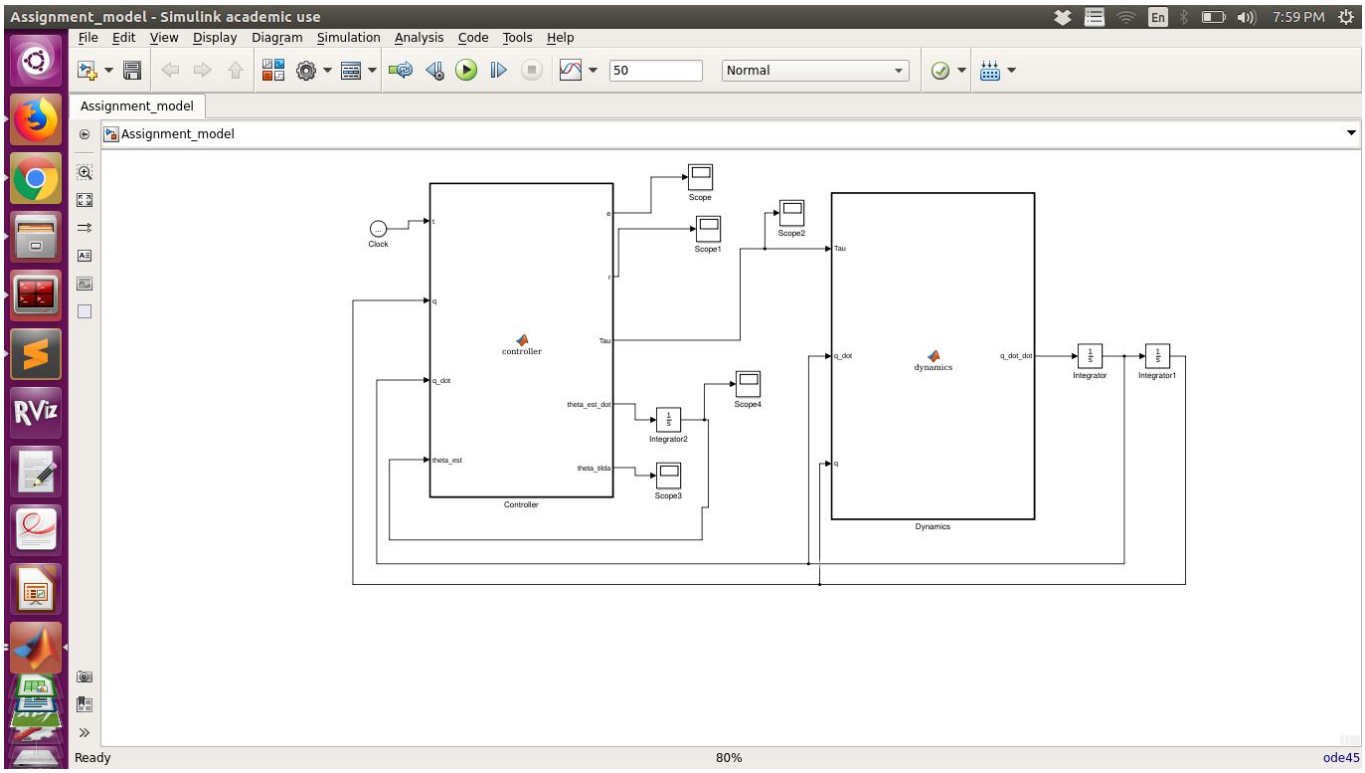
THETA TILDA(THETA - THETA_CAP) :







The best case is when all gains are = 5, theta_tilda converges at t=50 for gain = 5, while for gain = 1 and 10 it converges around t > 50.
The high gamma is taking longer time to converge due to high disturbance/steps in the initial stages.
5 is better than 10 is better than 1



CONTROLLER

```
function [e,r,Tau, theta_est_dot, theta_tilda] = controller(t,q,q_dot,theta_est)
%Raghavv Goel | 2016179
c2=cos(q(2));
s2=sin(q(2));
alpha=10;
k=10;

p1=3.473;
p2=0.196;
p3=0.242;
fd1=5.3;
fd2=1.1;

theta = [p1;p2;p3;fd1;fd2];

qd=[0.5*sin(t);2*cos(t/4)];
qd_dot=[0.5*cos(t);-0.5*sin(t/4)];
qd_ddot=[-0.5*sin(t);-0.25*cos(t/4)];
e=q-qd;     %Tracking Error
e_dot=q_dot-qd_dot;

r=e_dot+alpha*e;        %Filtered Tracking Error
```

```
y = 10*eye(5);
%-----------------------------------------------------------%
%M=[p1+2*p3*c2 p2+p3*c2;p2+p3*c2 p2];% Inertia matrix
%Vm=[-p3*s2*q_dot(2) -p3*s2*(q_dot(1)+q_dot(2));p3*s2*q_dot(1) 0];%Centripetal coriolis matrix
%fd=[fd1 0;0 fd2]; % Friction matrix

z1 = [-qd_ddot(1) + alpha*e_dot(1) ; 0];
z2 = [-qd_ddot(2) + alpha*e_dot(2) ; -qd_ddot(1) -  qd_ddot(2) + alpha*(e_dot(1) + e_dot(2))];
z3 = [2*c2*(-qd_ddot(1) + alpha*e_dot(1)) + c2*(-qd_ddot(2) + alpha*e_dot(2)) + s2*q_dot(2)*(q_dot(1)
+ r(1)) + s2*(q_dot(1) + q_dot(2))*(q_dot(2) + r(2)) ;
      c2*(-qd_ddot(1) + alpha*e_dot(1)) - s2*q(1)*(q_dot(1) + r(1))  ];
z4 = [-q_dot(1); 0];
z5 = [0; -q_dot(2)];

Z = [z1 z2 z3 z4 z5];
%Z = [-qd_ddot(1) + alpha*q_dot(1) - alpha*qd_dot(1), -qd_ddot(2) + alpha*(q_dot(2) - qd_dot(2)),
-2*c2*qd_ddot(1) - c2*qd_ddot(2) + 2*s2*q_dot(1)*q_dot(2) + s2*q_dot(2)*q_dot(2) +
2*alpha*c2*(q_dot(1) - qd_dot(1)) + alpha*c2*(q_dot(2) - qd_dot(2)), q_dot(1) , 0 ; 0, -qd_ddot(1) -
qd_ddot(2) + alpha*(q_dot(1) + q_dot(2) - qd_dot(1) - qd_dot(2)),  -c2*qd_ddot(1) -
s2*q_dot(1)*q_dot(1) + alpha*(q_dot(1) - qd_dot(1)), 0, q_dot(2)];

theta_est_dot = y*Z'*r;

%theta_est = integral(theta_est_dot,0,inf);

Tau = -Z*theta_est - k*r - e;
%tau=-k*r+Vm*q_dot+fd*q_dot+M*qd_ddot-alpha*M*e_dot-Vm*r-e;         % Controller
theta_tilda = theta - theta_est;
```