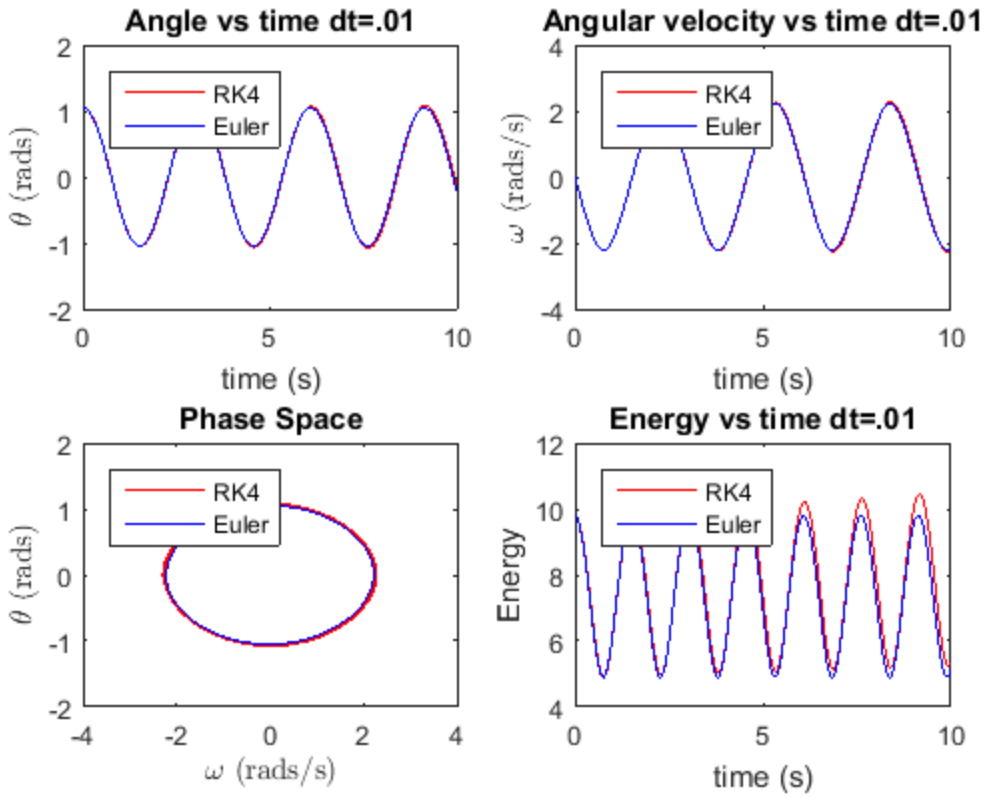
```
D1 = dlmread('RK4.txt');
D2 = dlmread('RK4Damp.txt');
D3 = dlmread('Euler.txt');
D4 = dlmread('EulerDamp.txt');
dt = D1(:,4);
%data goes theta, omega, E, dt, T, <v>, <E>

%RK4 sets
RK4_01 = D1(dt > 0.0001, :);
RK4_0001 = D1(dt < 0.01, :);
%RK4 damped sets
RK4d_01 = D2(dt > 0.0001, :);
RK4d_0001 = D2(dt < 0.01, :);

%Euler sets
Eul_01 = D3(dt > 0.0001, :);
Eul_0001 = D3(dt < 0.01, :);
%Euler damped sets
Euld_01 = D4(dt > 0.0001, :);
Euld_0001 = D4(dt < 0.01, :);



%angle vs time, energy vs time, omega vs angle, E and <E> vs t
%undamped 0.01 plots
subplot(2,2,1)
plot(RK4_01(:,5),RK4_01(:,1),'Color','r'); hold on
plot(Eul_01(:,5),Eul_01(:,1),'Color','b');
xlabel('time (s)')
ylabel('$\theta$ (rads)','interpreter','latex')
title('Angle vs time dt=.01')
legend('RK4','Euler','Location','northwest')
subplot(2,2,2)
plot(RK4_01(:,5), RK4_01(:,2),'Color','r');hold on
plot(Eul_01(:,5), Eul_01(:,2),'Color','b');
xlabel('time (s)')
ylabel('$\omega$ (rads/s)','interpreter','latex')
title('Angular velocity vs time dt=.01')
legend('RK4','Euler','Location','northwest')
subplot(2,2,3)
plot(RK4_01(:,2),RK4_01(:,1),'Color','r'); hold on
plot(Eul_01(:,2),Eul_01(:,1),'Color','b');
xlabel('$\omega$ (rads/s)','interpreter','latex')
ylabel('$\theta$ (rads)','interpreter','latex')
title('Phase Space')
legend('RK4','Euler','Location','northwest')
subplot(2,2,4)
plot(RK4_01(:,5),RK4_01(:,3),'Color','r'); hold on
plot(Eul_01(:,5),Eul_01(:,3),'Color','b');
xlabel('time (s)')
ylabel('Energy')
title('Energy vs time dt=.01')
```

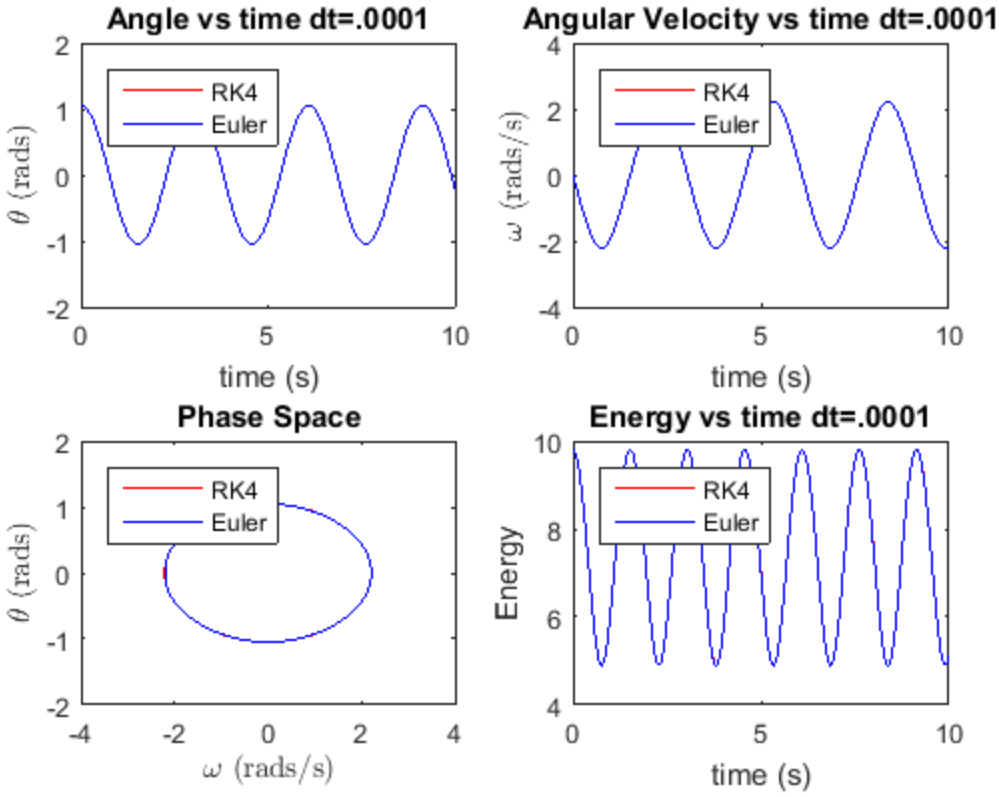
```
 legend('RK4','Euler','Location','northwest')


%undamped 0.0001 plots
figure();
subplot(2,2,1)
plot(RK4_0001(:,5),RK4_0001(:,1),'Color','r'); hold on
plot(Eul_0001(:,5),Eul_0001(:,1),'Color','b');
xlabel('time (s)')
 ylabel('$\theta$ (rads)','interpreter','latex')
 title('Angle vs time dt=.0001')
 legend('RK4','Euler','Location','northwest')
subplot(2,2,2)
plot(RK4_0001(:,5), RK4_0001(:,2),'Color','r');hold on
plot(Eul_0001(:,5), Eul_0001(:,2),'Color','b');
xlabel('time (s)')
 ylabel('$\omega$ (rads/s)','interpreter','latex')
 title('Angular Velocity vs time dt=.0001')
 legend('RK4','Euler','Location','northwest')
subplot(2,2,3)
plot(RK4_0001(:,2),RK4_0001(:,1),'Color','r'); hold on
plot(Eul_0001(:,2),Eul_0001(:,1),'Color','b');
xlabel('$\omega$ (rads/s)','interpreter','latex')
 ylabel('$\theta$ (rads)','interpreter','latex')
 title('Phase Space')
 legend('RK4','Euler','Location','northwest')
subplot(2,2,4)
plot(RK4_0001(:,5),RK4_0001(:,3),'Color','r'); hold on
plot(Eul_0001(:,5),Eul_0001(:,3),'Color','b');
xlabel('time (s)')
 ylabel('Energy')
 title('Energy vs time dt=.0001')
 legend('RK4','Euler','Location','northwest')

%damped 0.01 plots
 figure();
 subplot(2,2,1)
 plot(RK4d_01(:,5),RK4d_01(:,1),'Color','r'); hold on
 plot(Euld_01(:,5),Euld_01(:,1),'Color','b');
  xlabel('time (s)')
 ylabel('$\theta$ (rads)','interpreter','latex')
 title('Damped angle vs time dt=.01')
 legend('RK4','Euler','Location','northwest')
 subplot(2,2,2)
 plot(RK4d_01(:,5), RK4d_01(:,2),'Color','r');hold on
 plot(Euld_01(:,5), Euld_01(:,2),'Color','b');
 xlabel('time (s)')
 ylabel('$\omega$ (rads/s)','interpreter','latex')
 title('Damped angular velocity vs time dt=.01')
 legend('RK4','Euler','Location','northwest')
 subplot(2,2,3)
 plot(RK4d_01(:,2),RK4d_01(:,1),'Color','r'); hold on
 plot(Euld_01(:,2),Euld_01(:,1),'Color','b');
 xlabel('$\omega$ (rads/s)','interpreter','latex')
```

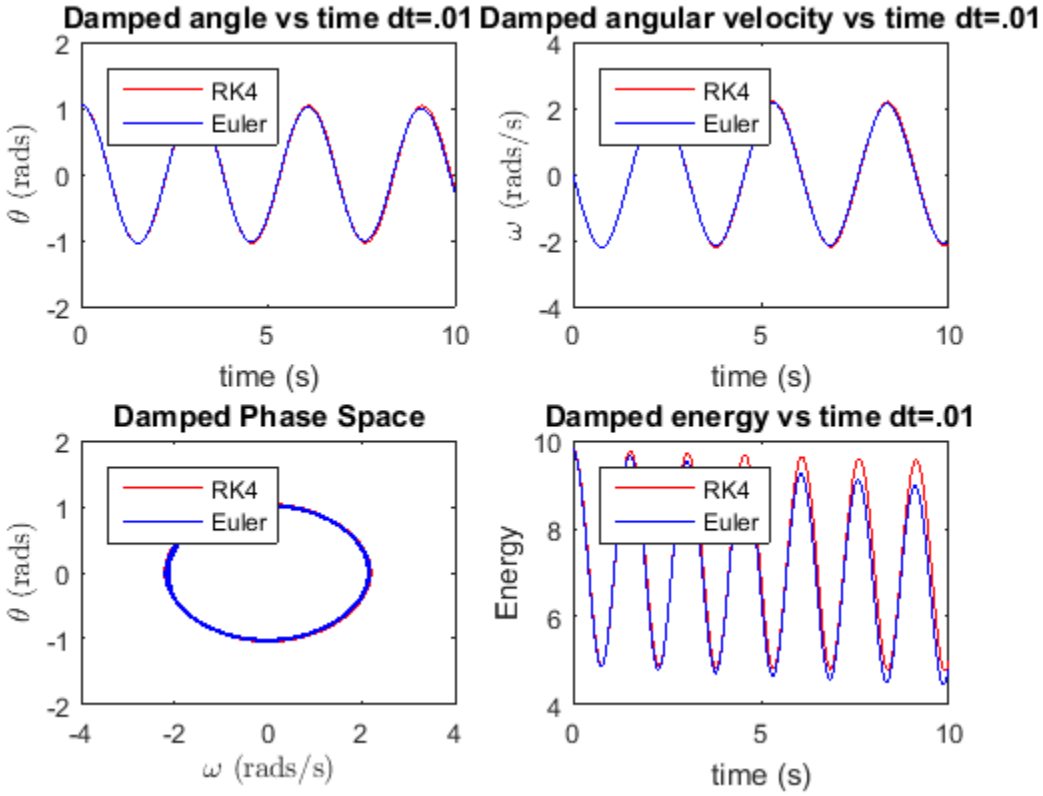
```
 ylabel('$\theta$ (rads)','interpreter','latex')
 title('Damped Phase Space')
 legend('RK4','Euler','Location','northwest')
 subplot(2,2,4)
 plot(RK4d_01(:,5),RK4d_01(:,3),'Color','r'); hold on
 plot(Euld_01(:,5),Euld_01(:,3),'Color','b');
  xlabel('time (s)')
 ylabel('Energy')
 title('Damped energy vs time dt=.01')
 legend('RK4','Euler','Location','northwest')
 %damped 0.0001 plots
 figure();
subplot(2,2,1)
plot(RK4d_0001(:,5),RK4d_0001(:,1),'Color','r'); hold on
plot(Euld_0001(:,5),Euld_0001(:,1),'Color','b');
xlabel('time (s)')
 ylabel('$\theta$ (rads)','interpreter','latex')
 title('Damped angle vs time dt=.0001')
 legend('RK4','Euler','Location','northwest')
subplot(2,2,2)
plot(RK4d_0001(:,5), RK4d_0001(:,2),'Color','r');hold on
plot(Euld_0001(:,5), Euld_0001(:,2),'Color','b');
xlabel('time (s)')
 ylabel('$\omega$ (rads/s)','interpreter','latex')
 title('Dmp angular velocity vs time dt=.0001')
 legend('RK4','Euler','Location','northwest')
subplot(2,2,3)
plot(RK4d_0001(:,2),RK4d_0001(:,1),'Color','r'); hold on
plot(Euld_0001(:,2),Euld_0001(:,1),'Color','b');
 xlabel('$\omega$ (rads/s)','interpreter','latex')
 ylabel('$\theta$ (rads)','interpreter','latex')
 title('Damped Phase Space')
 legend('RK4','Euler','Location','northwest')
subplot(2,2,4)
 plot(RK4d_0001(:,5),RK4d_0001(:,3),'Color','r'); hold on
 plot(Euld_0001(:,5),Euld_0001(:,3),'Color','b');
  xlabel('time (s)')
 ylabel('Energy')
 title('Dmp energy vs time dt=.0001')
 legend('RK4','Euler','Location','northwest')


 %0.01 and 0.0001 |omega - <omega>| vs time , | E - <E> | vs time
 undamped
 %                   2         6         5      3    7         5
 figure();
 subplot(2,2,1)
 plot(RK4_01(:,5), abs( abs(RK4_01(:,2)) -
 abs(RK4_01(:,6))), 'Color','r'); hold on
 plot(Eul_01(:,5), abs( abs(Eul_01(:,2)) -
 abs(Eul_01(:,6))), 'Color','b');
 xlabel('time (s)')
 ylabel('Absolute Error')
```

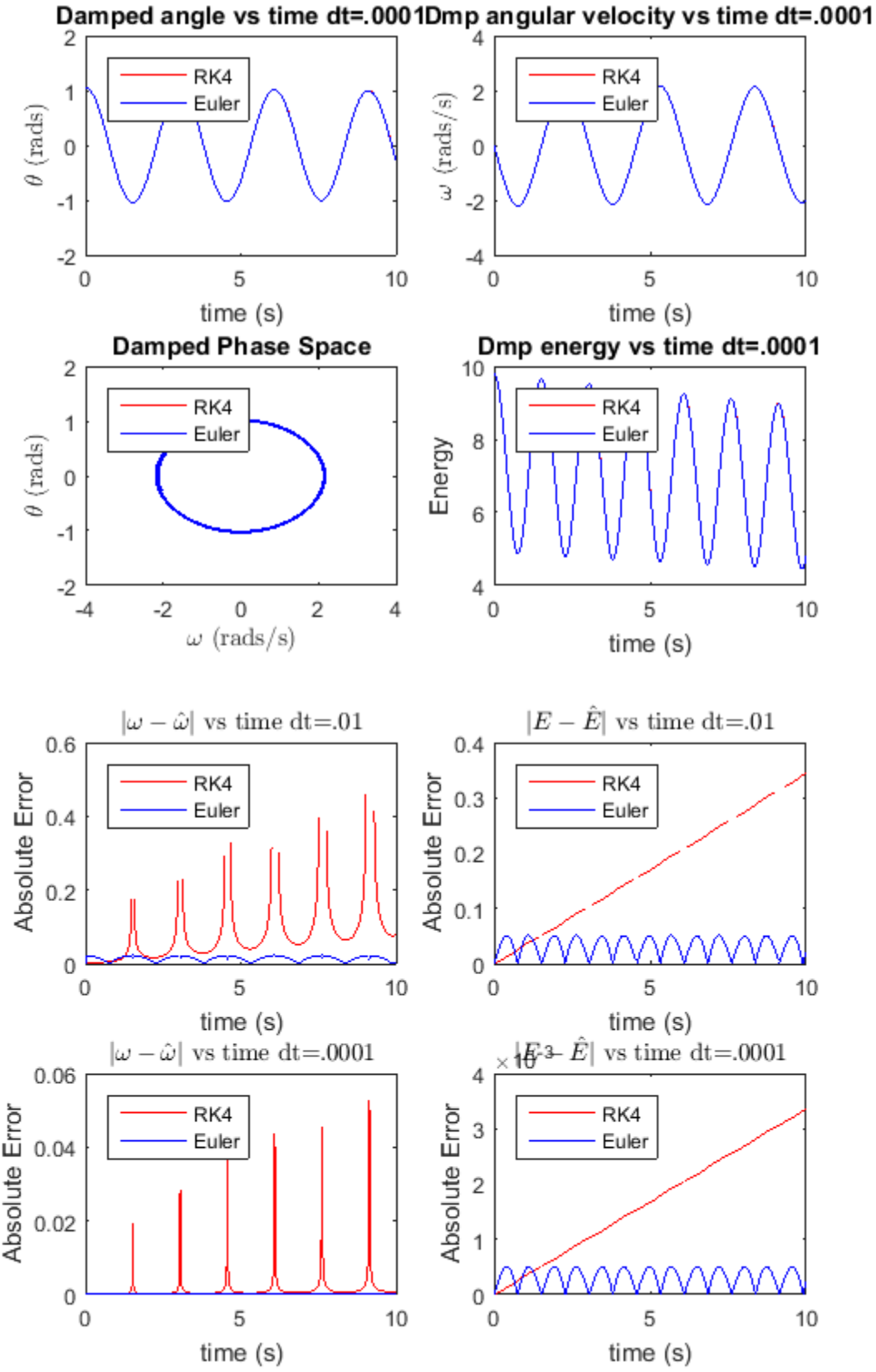
```
title('$|\omega - \hat{\omega}|$ vs time
dt=.01','interpreter','latex')
legend('RK4','Euler','Location','northwest')
subplot(2,2,2)
plot(RK4_01(:,5), abs( abs(RK4_01(:,3)) -
abs(RK4_01(:,7))), 'Color','r'); hold on
plot(Eul_01(:,5), abs( abs(Eul_01(:,3)) -
abs(Eul_01(:,7))), 'Color','b');
xlabel('time (s)')
ylabel('Absolute Error')
title('$|E - \hat{E}|$ vs time dt=.01','interpreter','latex')
legend('RK4','Euler','Location','northwest')
subplot(2,2,3)
plot(RK4_0001(:,5), abs( abs(RK4_0001(:,2)) -
abs(RK4_0001(:,6))), 'Color','r'); hold on
plot(Eul_0001(:,5), abs( abs(Eul_0001(:,2)) -
abs(Eul_0001(:,6))), 'Color','b');
 xlabel('time (s)')
ylabel('Absolute Error')
title('$|\omega - \hat{\omega}|$ vs time
dt=.0001','interpreter','latex')
legend('RK4','Euler','Location','northwest')
subplot(2,2,4)
 plot(RK4_0001(:,5), abs( abs(RK4_0001(:,3)) -
abs(RK4_0001(:,7))), 'Color','r'); hold on
plot(Eul_0001(:,5), abs( abs(Eul_0001(:,3)) -
abs(Eul_0001(:,7))), 'Color','b');
xlabel('time (s)')
ylabel('Absolute Error')
title('$|E - \hat{E}|$ vs time dt=.0001','interpreter','latex')
legend('RK4','Euler','Location','northwest')

 %0.01 and 0.0001 |omega - <omega>| vs time , | E - <E> | vs time
damped
%                   2         6         5      3    7         5
figure();
subplot(2,2,1)
plot(RK4d_01(:,5), abs( abs(RK4d_01(:,2)) -
abs(RK4d_01(:,6))), 'Color','r'); hold on
plot(Euld_01(:,5), abs( abs(Euld_01(:,2)) -
abs(Euld_01(:,6))), 'Color','b');
xlabel('time (s)')
ylabel('Absolute Error')
title('Damped $|\omega - \hat{\omega}|$ vs time
dt=.01','interpreter','latex')
legend('RK4','Euler','Location','northwest')
subplot(2,2,2)
plot(RK4d_01(:,5), abs( abs(RK4d_01(:,3)) -
abs(RK4d_01(:,7))), 'Color','r'); hold on
plot(Euld_01(:,5), abs( abs(Euld_01(:,3)) -
abs(Euld_01(:,7))), 'Color','b');
 xlabel('time (s)')
ylabel('Absolute Error')
title('Damped $|E - \hat{E}|$ vs time dt=.01','interpreter','latex')
```

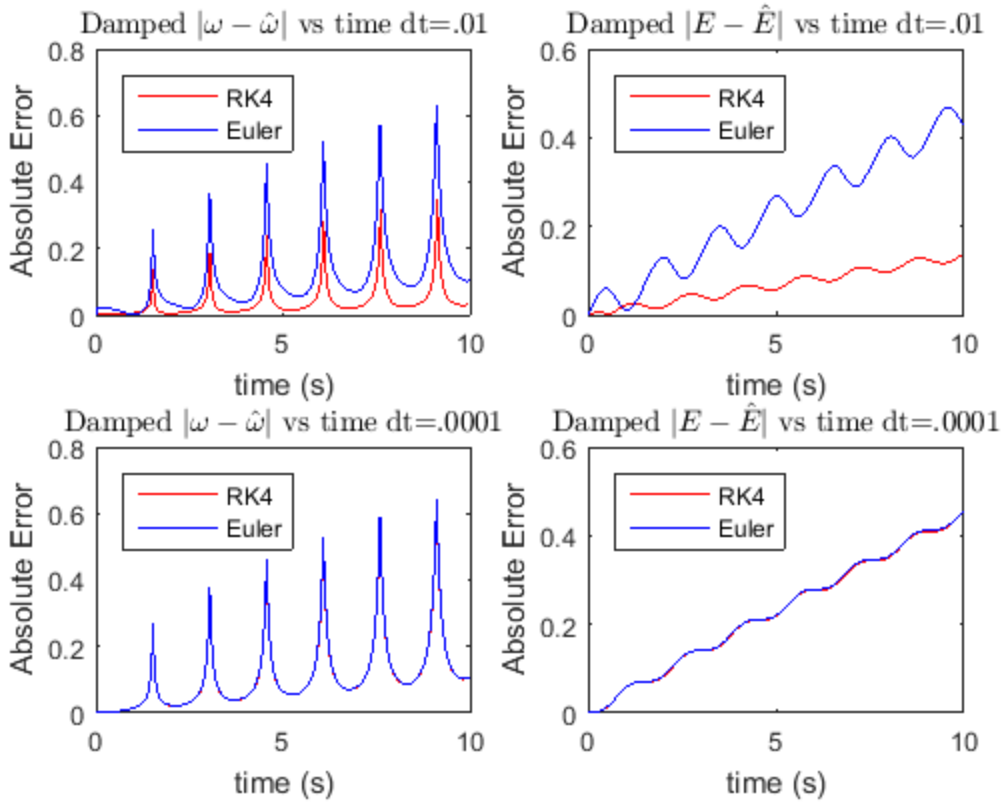
```
legend('RK4','Euler','Location','northwest')
subplot(2,2,3)
plot(RK4d_0001(:,5), abs( abs(RK4d_0001(:,2)) -
abs(RK4d_0001(:,6))), 'Color','r'); hold on
plot(Euld_0001(:,5), abs( abs(Euld_0001(:,2)) -
abs(Euld_0001(:,6))), 'Color','b');
 xlabel('time (s)')
ylabel('Absolute Error')
title('Damped $|\omega - \hat{\omega}|$ vs time
dt=.0001','interpreter','latex')
legend('RK4','Euler','Location','northwest')
subplot(2,2,4)
 plot(RK4d_0001(:,5), abs( abs(RK4d_0001(:,3)) -
abs(RK4d_0001(:,7))), 'Color','r'); hold on
plot(Euld_0001(:,5), abs( abs(Euld_0001(:,3)) -
abs(Euld_0001(:,7))), 'Color','b');
xlabel('time (s)')
ylabel('Absolute Error')
title('Damped $|E - \hat{E}|$ vs time
dt=.0001','interpreter','latex')
legend('RK4','Euler','Location','northwest')
```




Angle vs time dt=.0001
RK4
Euler
θ (rads)
time (s)
Angular Velocity vs time dt=.0001
RK4
Euler
ω (rads/s)
time (s)
Phase Space
RK4
Euler
θ (rads)
ω (rads/s)
Energy vs time dt=.0001
RK4
Euler
Energy
time (s)


Damped angle vs time dt=.01
RK4
Euler
θ (rads)
time (s)
Damped angular velocity vs time dt=.01
RK4
Euler
ω (rads/s)
time (s)
Damped Phase Space
RK4
Euler
θ (rads)
ω (rads/s)
Damped energy vs time dt=.01
RK4
Euler
Energy
time (s)


Damped angle vs time dt=.0001
Dmp angular velocity vs time dt=.0001
Damped Phase Space
Dmp energy vs time dt=.0001
$|\omega - \hat{\omega}|$ vs time dt=.01
$|E - \hat{E}|$ vs time dt=.01
$|\omega - \hat{\omega}|$ vs time dt=.0001
$|E - \hat{E}|$ vs time dt=.0001
RK4
Euler
θ (rads)
ω (rads/s)
Energy
Absolute Error
time (s)



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