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% Joshua Oates - Aero 300 - lab 7

## section 0 - clean up

```
close all;
clear all;
clc;
```

## section 1 - use rkf45 and ode45 on ode

```
% y(0)=1
y0 = 1; % use given intital conditions
tspan = [0,pi/3]; % set domain to plot over
rTol = 1e-6;
opts = odeset('AbsTol',rTol);
[T1,Y1] = rkf45(@my_ode, tspan, y0,.1 ,rTol); % get output from rkf45
[T2,Y2] = ode45(@my_ode, tspan, y0, opts); % get output from ode45

figure
hold on
plot(T1, Y1)
plot(T2, Y2) % create and label plots

legend("y-rkf45","y-ode45")
xlabel("t axis")
ylabel("y axis")
title("y' =(y-t-1)^2 +2")

y = @(t) 1+t+tan(t); % true solution
e1 = abs(Y1-y(T1));
e2 = abs(Y2-y(T2));

figure
hold on
plot(T1, e1)
plot(T2, e2) % create and label plots
ax = gca();
ax.YScale = "log";

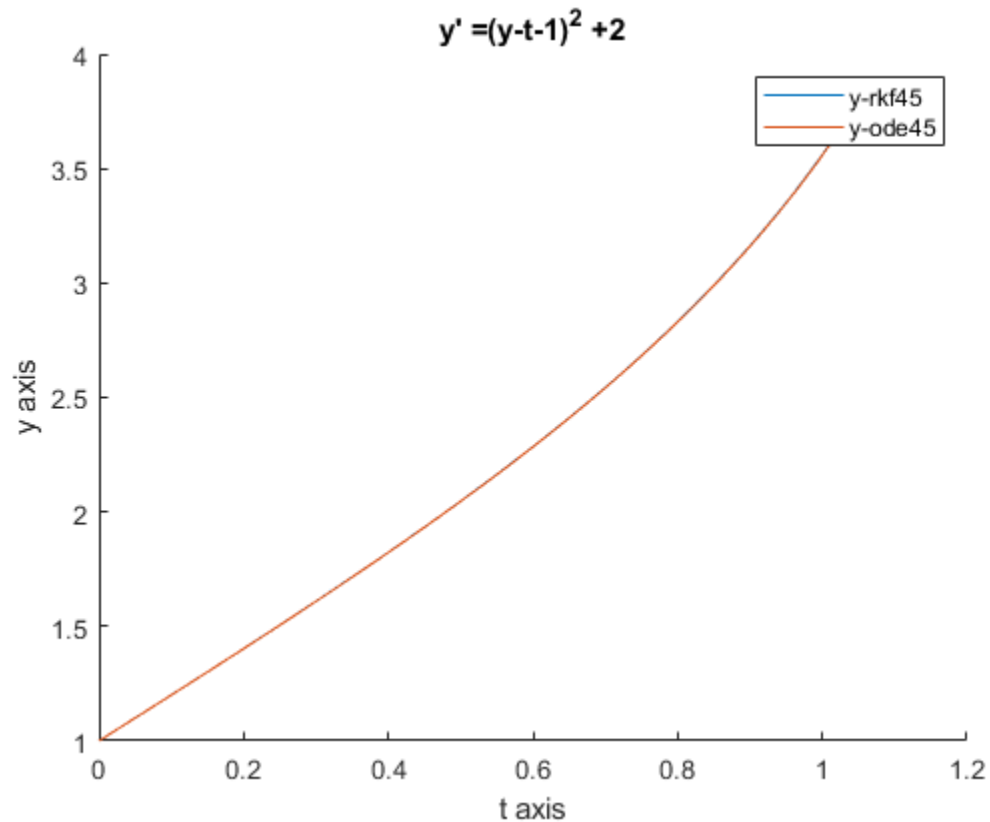
legend("y-rkf45","y-ode45")
```

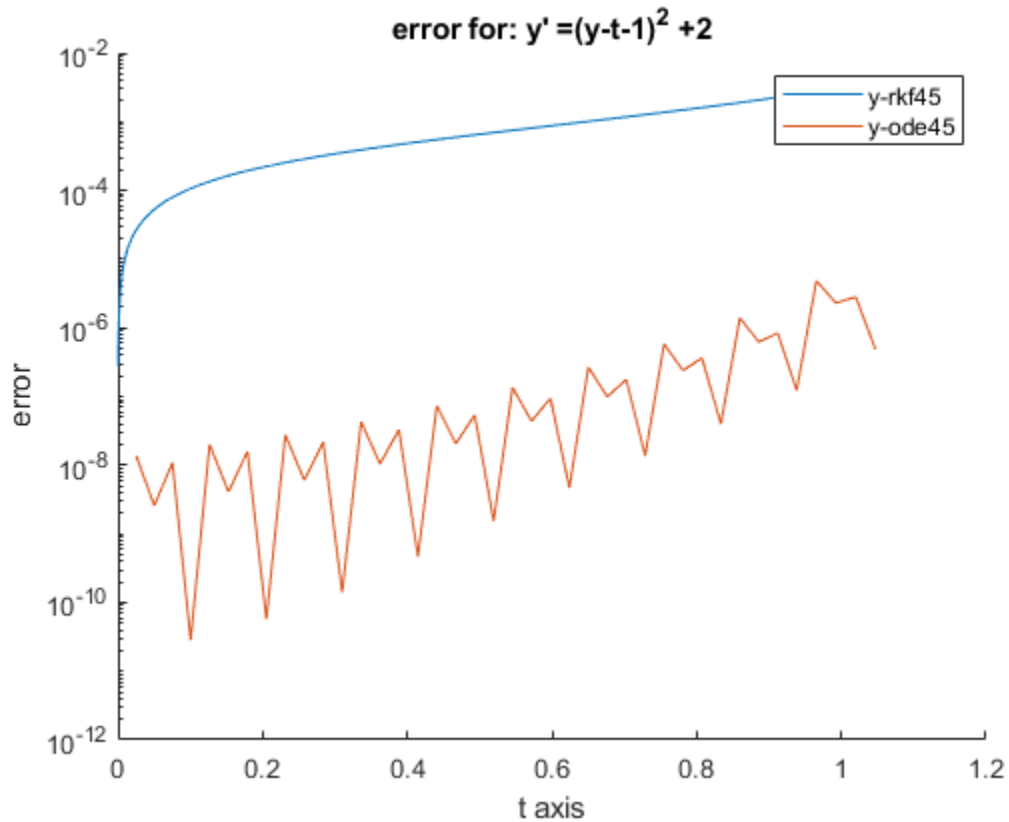
---

```
xlabel("t axis")
ylabel("error")
title("error for: y' =(y-t-1)^2 +2")
```

```
disp("My function has aproximately 100 times more absolute error than ode45.
Additionally, ode45 has a much less constant error than rkf45. This is likely
becuase ODE 45 will increase h again after the relative error is sufficently
low where as my rkf 45 will only ever decrease h.")
```

```
clear all
```





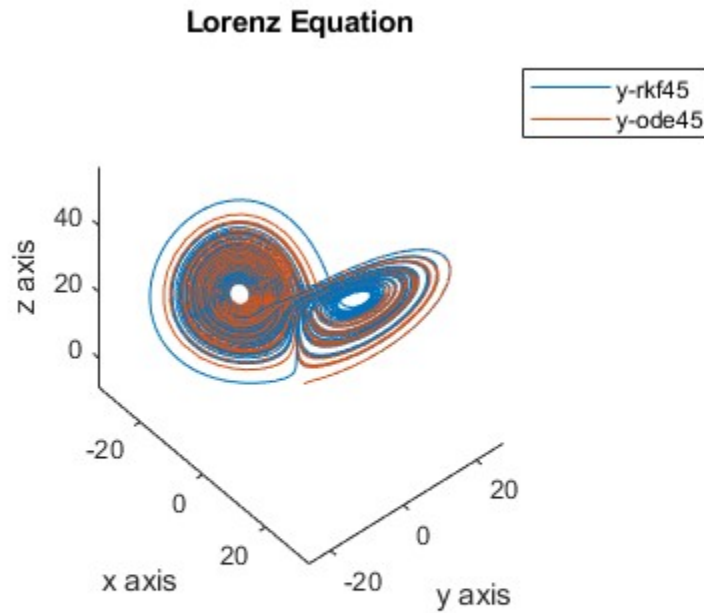
## section 2 - Lorenz equation

```
y0 = [1,1,1];
tspan = [0,50];
rTol = 1e-4;

opts = odeset('AbsTol',1e-6);
[T1,Y1] = rkf45(@lorenz_ode,tspan,y0,.001,rTol);
[T2,Y2] = ode45(@lorenz_ode,tspan,y0,opts); % Runge-Kutta 4th/5th order ODE
solver

figure
hold on
plot3(Y1(1,:),Y1(2,:),Y1(3,:))
plot3(Y2(:,1),Y2(:,2),Y2(:,3))
axis("equal")
campos([30,-25,40])
camtarget([1,0,0])

legend("y-rkf45","y-ode45")
xlabel("x axis")
ylabel("y axis")
zlabel("z axis")
title("Lorenz Equation")
```



## - function def

```
function [dydt] = my_ode(t,Y)

y = Y(1);
yp = (y-t-1)^2 + 2;

dydt = yp;
end
```

*My function has approximately 100 times more absolute error than ode45. Additionally, ode45 has a much less constant error than rkf45. This is likely because ODE 45 will increase h again after the relative error is sufficiently low whereas my rkf 45 will only ever decrease h.*

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```
function [dydt] = lorenz_ode(t,Y)
sigma = 10;
beta = 8/3;
rho = 28;
dydt = [-sigma*Y(1) + sigma*Y(2); rho*Y(1) - Y(2) - Y(1)*Y(3); -beta*Y(3) +
        Y(1)*Y(2)];
end
```

Not enough input arguments.

Error in lorenz\_ode (line 5)  
dydt = [-sigma\*Y(1) + sigma\*Y(2); rho\*Y(1) - Y(2) - Y(1)\*Y(3); -beta\*Y(3) +  
 Y(1)\*Y(2)];

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```

function [t,y] = rkf45(f, tspan, y0, h, rTol)
% f is a function of (t,Y)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
i = 1;
w(:,1) = y0;
t(1) = tspan(1);
while t(i) < tspan(2)
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    s1 =f(t(i) ,w(:,i));
    s2 =f(t(i)+ .25 *h ,w(:,i)+ .25 *h* s1);
    s3 =f(t(i)+(3/8) *h ,w(:,i)+(3/32) *h* s1+(9/32) *h* s2);
    s4 =f(t(i)+(12/13)*h ,w(:,i)+(1932/2197)*h* s1-(7200/2197) *h*
s2+(7296/2197) *h*s3);
    s5 =f(t(i)+1 *h ,w(:,i)+(439/216) *h* s1-(8) *h*
s2+(3680/513) *h*s3 - (845/4104) *h* s4);
    s6 =f(t(i)+(1/2) *h ,w(:,i)-(8/27) *h* s1+(2) *h* s2-
(3544/2565) *h*s3 + (1859/4104)*h* s4 - (11/40) *h* s5);
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    w(:,i+1) = w(:,i) + h*((25/216)*s1+(1408/2565)*s3+(2197/4104)*s4-
(1/5)*s5);
    z = w(:,i) + h*((16/135)*s1+(6656/12812)*s3+(28561/56430)*s4-
(9/50)*s5+(2/55)*s6);
    wMax = max(abs(w(:,i+1)));
    e = max(abs(z-w(:,i+1)));

    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    if e/(wMax) < rTol
        t(i+1) = t(i) + h;
        w(:,i+1) = z;
        i = i+1;

    else
        h = .8*h*(rTol*wMax)^(1/5);

    end
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
end
y = w;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
end

```

Not enough input arguments.

Error in rkf45 (line 5)

w(:,1) = y0;

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