%%%Analytical Solution based on the calculation%%%%%%%%%

% Define the range of x values

x\_values = 0:0.5:5;

% Define the constants C1 and C2

C1 = 1 + 1/999;

C2 = -1/999;

% Calculate the y values for the given x range

y\_values = (C1 \* exp(-x\_values)) - (C2 \* exp(-1000 \* x\_values));

% Plot the solution

figure;

plot(x\_values, y\_values, 'yellow', 'LineWidth', 3);

xlabel('x');

ylabel('y(x)');

grid on;

hold on

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Implicit Euler Method

% Define the step size and time span

h = 0.5;

x\_span = 0:h:5;

% Initialize arrays to store the results

y\_implicit = zeros(size(x\_span));

% Set initial conditions

y\_implicit(1) = 1;

% Define the parameters for the implicit Euler method

a = 1001;

b = 1000;

% Apply implicit Euler method

for n = 1:length(x\_span) - 1

x\_n = x\_span(n);

% Implicit Euler method

y\_implicit(n+1) = (y\_implicit(n) + h \* (y\_implicit(n+1) - y\_implicit(n)));

end

plot(x\_span, y\_implicit, 'r', 'LineWidth', 2);

grid on;

hold on

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

syms y1 y2 y z t t1 t2 h z1 z2

S1 = z;

S2 = -1001\*z-1000\*y;

SS1 = y2- y1 - h\*subs(S1,{y z},[y2 z2]);

SS2 = z2- z1 - h\*subs(S2,{y z},[y2 z2]);

EQN1 = SS1 ==0;

Y = solve(EQN1,y2);

EQN2 = SS2 ==0;

Z = solve(EQN2,z2);

H=0.5;

T=0:H:5;

YN(1)=1;

ZN(1)=0;

for i=2:length(T)

EQ1=subs(EQN1,{y1 z1 h},[YN(i-1) ZN(i-1) H]);

EQ2=subs(EQN2,{y1 z1 h},[YN(i-1) ZN(i-1) H]);

[solx,soly] = solve(EQ1,EQ2);

YN(i) = double(solx);

ZN(i) = double(soly);

end

plot(T, YN, 'black', 'LineWidth', 2);

grid on;

hold on

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Define the ODE as a function

ode = @(x, Y) [Y(2); -1001 \* Y(2) - 1000 \* Y(1)];

% Define the initial conditions

initial\_conditions = [1; 0]; % y(0) = 1, and dy/dx(0) = 0

% Define the range of x values

x\_range = 0:0.5:5; % Adjust the range as needed

% Use ode23 to solve the ODE

[x, Y] = ode23(ode, x\_range, initial\_conditions);

% Extract the solutions for y and z

y = Y(:, 1);

y=y';

x=x';

% Plot the solution

plot(x, y, '--', 'LineWidth', 1);

legend ('Analytical Solution','Implicit Method','Explicit Method','ode23 method')

% Print the results

fprintf('------------------------------------------------------------\n');

fprintf('Solutions with different methods with step size,h=0.5 \n')

fprintf('------------------------------------------------------------\n');

fprintf('x-value\t y-analytical\t y-implicit\t y-explicit\t y-ode\n');

fprintf('----------------------------------------------------------\n');

for i = 1:length(T)

fprintf('%4.1f\t\t %4.4f\t\t %4.4f\t\t %4.4f\t\t %4.4f\n', T(i),y\_values(i),y\_implicit(i),YN(i), y(i));

end

A table of numbers and letters

Description automatically generated

A graph of a method

Description automatically generated

A graph of a function

Description automatically generated