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%Methode Des Elements Finis Lineaires De Lagrange(1st Order FEM)
%Probléme De Depart : -((1+t).y'(t))' = t    ,Omega=]0,1[
%Avec Les Conditions Aux Limites : y(1)+y'(1)=0 , y(0)=0
%a(y,v)=int((1+t).y'.v') + 2y(1).v(1)
%l(v)=int(t.v)
clc;
clear all;
close all;
a=0;           %Discretisation
b=1;
k=1/5;
interval = a:k:b;   %Le Maillage
n=length(interval); %nbr Des Noeuds
N=n-1;              %Dimension De L'espace V_h
syms f(t) g(t) t h   % Definition Des Variables
g = @(t) 1+t;  %Fonction g(t)
f = @(t) t;    %Fonction f(t)
h = k;        %Pour Exécuter Les Calcules de "h", supprimer "%"

            % Definition Les Fonctions De Base
phi_i         =(t-h*(i-1))/h;%ph(i)   si   t(i-1) <= t <= t(i)
phi_ii        =(h*(i+1)-t)/h;%ph(i)   si   t(i)   <= t <= t(i+1)
phi_i_minus_1 =(h*i-t)/h;    %ph(i-1) si   t(i-1) <= t <= t(i)
phi_i_plus_1  =(t-h*i)/h;    %ph(i+1) si   t(i)   <= t <= t(i+1)
phi_0         =(h-t)/h;      %ph(0)   si   t(0)   <= t <= t(1)
phi_n_plus_1  =(t-(1-h))/h;  %ph(n+1) si   t(n)   <= t <= t(n+1)
            %Creation De La Matrice "A" Et Le Vecteur "B"
A = sym(zeros(N,N));
B = sym(zeros(N,1));
A(N,N)=int(g*diff(phi_n_plus_1,t)^2,[1-h 1])+2;
p = diff(phi_i,t)^2;
q = diff(phi_i,t)*diff(phi_i_minus_1,t);
            %calcul diagonal Principale De La Matrice "A"
for i=1:N-1
t(1)=h;
t(i+1)=t(i)+h;
A(i,i) = p*[h*(g(t(i)-h)+g(t(i+1)))]; %Approximation Par Trappeze
end
            %calcul diagonal Inf De La Matrice "A"
for i=2:N
A(i,i-1) = q*[h/2*(g(t(i-1))+g(t(i)))]; %Approximation Par Trappeze
end
            %calcul diagonal Supp De La Matrice "A"
for i=1:N-1
A(i,i+1) = A(i+1,i);%Puisque A est symetrique
end
            %calcul Vecteur B
for i=1:N
B(i)  = h*f(t(i));
end
A=A     %Affichage La Matrice A Et Le Vecteur B
B=B
Y=A\B   %Resoudre Le Systeme D'Equations A.Y=B
%Y=double(Y) %Pour convertir Resultat en Decimal,supprimer "%"
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A =

[       (2*h + 2)/h, -(3*h + 2)/(2*h),                0,                0,                0]
[ -(3*h + 2)/(2*h),       (4*h + 2)/h, -(5*h + 2)/(2*h),                0,                0]
[                0, -(5*h + 2)/(2*h),       (6*h + 2)/h, -(7*h + 2)/(2*h),                0]
[                0,                0, -(7*h + 2)/(2*h),       (8*h + 2)/h, -(9*h + 2)/(2*h)]
[                0,                0,                0, -(9*h + 2)/(2*h),         2/h + 3/2]
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h = 1/5

A =

[12, -13/2, 0, 0, 0]

[-13/2, 14, -15/2, 0, 0]

[0, -15/2, 16, -17/2, 0]

[0, 0, -17/2, 18, -19/2]

[0, 0, 0, -19/2, 23/2]

B =

1/25

2/25

3/25

4/25

1/5

Y =

0.0599

0.1044

0.1323

0.1428

0.1354