% **TP N°4** Numerical methods:

Dr. Rezzoug Imad

% Partial Differential Equations

% Finite-Difference Method for Parabolic PDEs: **Heat equation**

```
clc;
clear all;
close all;
%Input
f_fun = input('\n Input Function f=u(x,0) = ','s');
f=inline(f_fun,'x');
c1 = input('\n Enter c1=u(0,t) = ');
c2 = input('\n Enter c2=u(a,t) = ');
a =  input('\n Enter right pt. of [0,a] = ');
b =  input('\n Enter right pt. of [0,b] = ');
c = input('\n Enter the constant in the heat eqn. (c)= ');
n = input ('\n Enter No. of grid pts. over [0,a] (n)= ');
m = input ('\n Enter No. of grid pts. over [0,b] (m)= ');
%Initialize parameters
h=a/(n-1);
k=b/(m-1);
r=c^2*k/h^2;
s=1-2*r;
U=zeros(n,m);
%Boundary conditions
U(1,1:m)=c1;
U(n,1:m)=c2;
%Generate first row
U(2:n-1,1)=feval(f,h:h:(n-2)*h)';
%Generate remaining rows of U
for j=2:m
  for i=2:n-1
    U(i,j)=s*U(i,j-1)+r*(U(i-1,j-1)+U(i+1,j-1));
  end
end
U=U'
% Plotting the Approximate solution of the PDE.
t=0:h:a ; x=0:k:b; mesh(t,x,U)
```

% **TP N°6** Numerical methods:

Dr. Rezzoug Imad

% Partial Differential Equations

% Finite-Difference Method for Hyperbolic PDEs: **Wave equation**

```
clc;
clear all;
close all;
%Input
f_fun = input('\n Input Function f=u(x,0) = ','s');
f=inline(f_fun,'x');
g_fun = input('\n Input Function g=u_t(x,0) = ','s');
g=inline(g_fun,'x');
a = input('\n Enter right pt. of [0,a] = ');
b = input('\n Enter right pt. of [0,b] = ');
c = input('\n Enter the constant in the wive eqn. (c)= ');
n = input ('\n Enter No. of grid pts. over [0,a], (n) = ');
m = input ('\n Enter No. of grid pts. over [0,b], (m) = ');
%Initialize parameters
h=a/(n-1);
k=b/(m-1);
r=c*k/h;
r2=r^2;
r22=r^2/2;
s1=1-r^2;
s2=2-2*r^2;
U=zeros(n,m);
%Generate first and second rows
for i=2:n-1
  U(i,1)=feval(f,h*(i-1));
  U(i,2)=s1*feval(f,h*(i-1))+k*feval(g,h*(i-
1))+r22*(feval(f,h*i)+feval(f,h*(i-2)));
end
%Generate remaining rows of U
for j=3:m
   for i=2:(n-1)
      U(i,j)=s2*U(i,j-1)+r2*(U(i-1,j-1)+U(i+1,j-1))-U(i,j-2);
   end
end
U=U'
% Plotting the Approximate solution of the PDE.
t=0:h:a ; x=0:k:b; mesh(t,x,U)
```

% **TP N°5** Numerical methods:

Dr. Rezzoug Imad

% Partial Differential Equations

% Finite-Difference Method for Parabolic PDEs: **Heat equation**

% **Crank-Nicholson Method**

```
clc;
clear all;
close all;
%Input
f_fun = input('\n Input Function f=u(x,0) = ','s');
f=inline(f_fun,'x');
c1 = input('\n Enter c1=u(0,t) = ');
c2 = input('\n Enter c2=u(a,t) = ');
a =  input('\n Enter right pt. of [0,a] = ');
b =  input('\n Enter right pt. of [0,b] = ');
c = input('\n Enter the constant in the heat eqn. (c)= ');
n = input ('\n Enter No. of grid pts. over [0,a] (n)= ');
m = input ('\n Enter No. of grid pts. over [0,b] (m)= ');
%Initialize parameters
h=a/(n-1);
k=b/(m-1);
r=c^2*k/h^2;
s1=2+2/r;
s2=2/r-2;
U=zeros(n,m);
%Boundary conditions
U(1,1:m)=c1;
U(n,1:m)=c2;
%Generate first row
U(2:n-1,1)=feval(f,h:h:(n-2)*h)';
%Form and solve tridiagonal system AX=B
Vd(1,1:n)=s1*ones(1,n);
Vd(1)=1;
Vd(n)=1;
Va=-ones(1,n-1);
Va(n-1)=0;
Vc=-ones(1,n-1);
Vc(1)=0;
Vb(1)=c1;
Vb(n)=c2;
for j=2:m
   for i=2:n-1
      Vb(i)=U(i-1,j-1)+U(i+1,j-1)+s2*U(i,j-1);
   end
   X=trisys(Va,Vd,Vc,Vb);
   U(1:n,j)=X';
end
U=U'
% Plotting the Approximate solution of the PDE.
t=0:h:a ; x=0:k:b; mesh(t,x,U)
```

% **TP N°5** Numerical methods:

Dr. Rezzoug Imad

% Partial Differential Equations

```
function X = trisys(A,D,C,B)
%---------------------------------------------------------------------------
%TRISYS   Solution of a triangular linear system.
%         It is assumed that D and B have dimension n,
%         and that A and C have dimension n-1;
% Sample call
%   X = trisys(A,D,C,B)
% Inputs
%   A   sub diagonal vector
%   D   diagonal vector
%   C   super diagonal vector
%   B   right hand side vector
% Return
%   X   solution vector
%
% NUMERICAL METHODS: MATLAB Programs, (c) John H. Mathews 1995
% To accompany the text:
% NUMERICAL METHODS for Mathematics, Science and Engineering, 2nd Ed, 1992
% Prentice Hall, Englewood Cliffs, New Jersey, 07632, U.S.A.
% Prentice Hall, Inc.; USA, Canada, Mexico ISBN 0-13-624990-6
% Prentice Hall, International Editions:   ISBN 0-13-625047-5
% This free software is compliments of the author.
% E-mail address:      in%"mathews@fullerton.edu"
%
% Algorithm 9.10. (Finite-Difference Method).
% Section   9.9, Finite-Difference Method, Page 496
%---------------------------------------------------------------------------

n = length(B);
for k = 2:n,
  mult = A(k-1)/D(k-1);
  D(k) = D(k) - mult*C(k-1);
  B(k) = B(k) - mult*B(k-1);
end
X(n) = B(n)/D(n);
for k = (n-1):-1:1,
  X(k) = (B(k) - C(k)*X(k+1))/D(k);
end
```