MA322 Lab 07

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Question 1

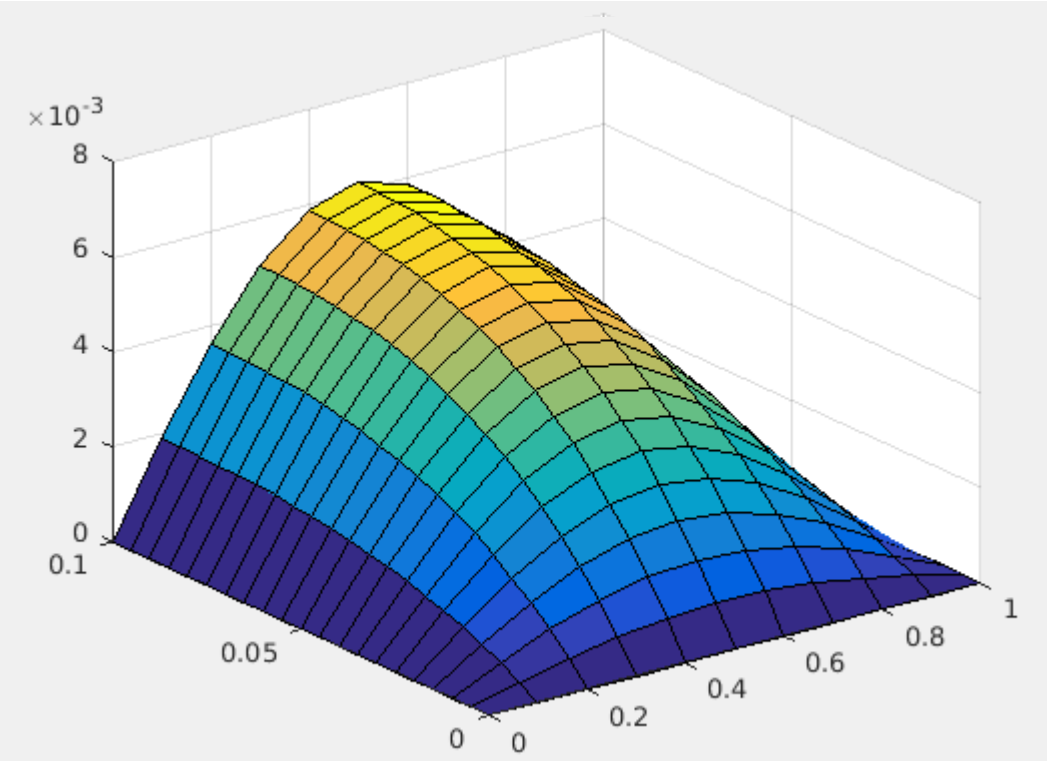
Code

clc;

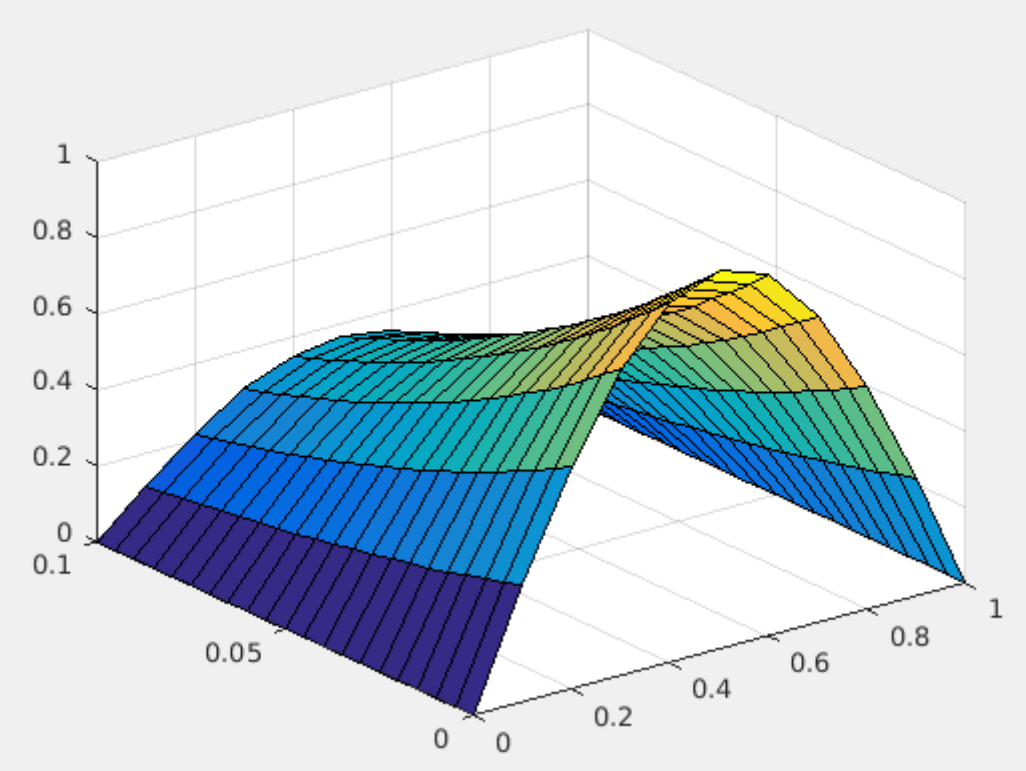
```
clear;
h = 0.1;
%h = 0.05;
k = 0.005;
Nx = 1/h;
Ny = 0.1/k;
u = zeros(Ny+1, Nx+1);
err = zeros(Ny+1, Nx+1);
r = k/(h^2);


% boundary conditions
for j = 1:Ny+1
    u(j,1) = 0;
    u(j, Nx+1) = 0;
end

% initial condition
for i = 1:Nx+1
    xi = 0+(i-1)*h;
    u(1, i) = sin(pi*xi);
end

% u(i, j) for all valid i, j
for j = 1:Ny
    for i = 2:Nx
        u(j+1, i) = r*u(j, i-1) + (1-2*r)*u(j,i) + r*u(j, i+1);
    end
end
for j = 1:Ny+1
    for i = 1:Nx+1
        err(j, i) = abs(act(j,i,h,k)-u(j,i));
    end
end

x = 0:h:1;
t = 0:k:0.1;
[xm ,tm] = meshgrid(x,t);
% surf(xm, tm, u);
surf(xm, tm, err);
xlabel('x');
ylabel('t');
title('Error as function of (t,x)');

% Actual function plotting
% [xc,yc] = meshgrid(x,t);
% zc = exp(-(pi^2).*yc).*sin(pi.*xc);
% surf(xc,yc,zc);

function val = act(j,i,h,k)
    t = (j-1)*k;
    x = (i-1)*h;
    val = exp(-(pi^2)*t)*sin(pi*x);
end
```

Output

Error function



By classical explicit scheme



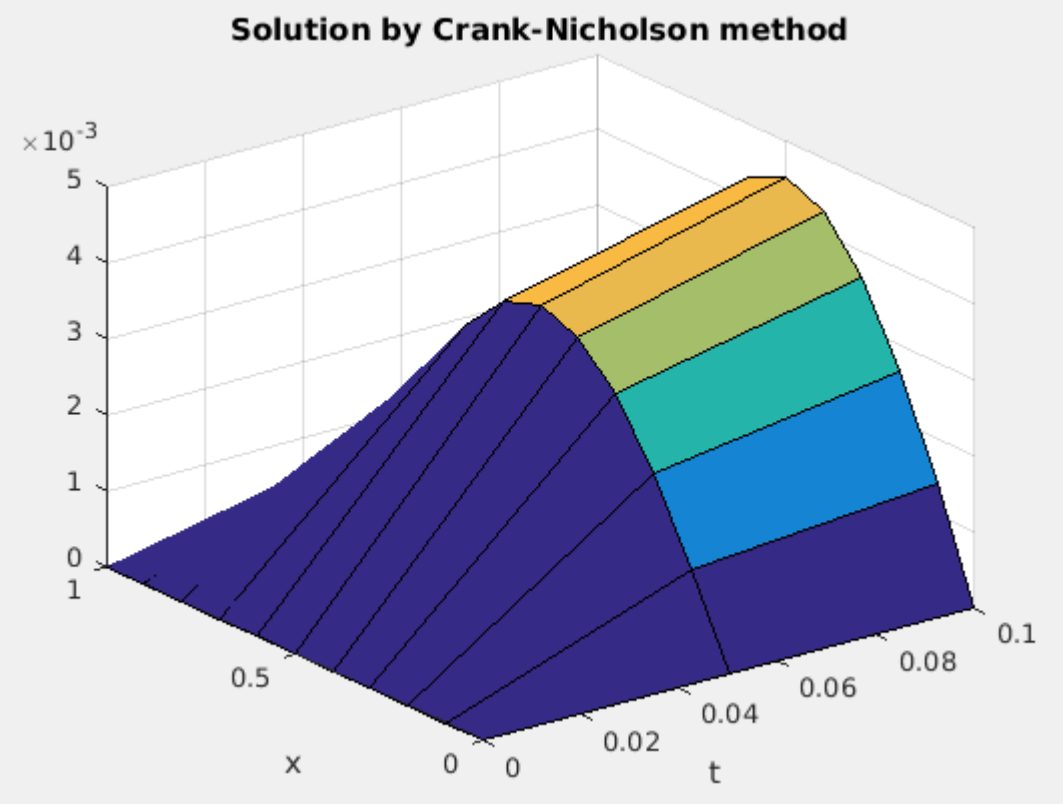
Question 2
Code

clc;

```
clear;

L = 1;
t = 0.1;
h = 0.1;
k = 0.05;
Nt = t/k;
Nx = L/h;
r = k/(h^2);
x = zeros(1,Nx+1);
t = zeros(1,Nt+1);
err = zeros(Nx+1, Nt+1);
for n = 1:Nx+1
    x(n) = (n-1)*h;
    u(n,1) = sin(pi*x(n));
end

for j = 1:Nt+1
    u(1,j) = 0;
    u(Nx+1,j) = 0;
    t(j) = (j-1)*k;
end

aal(1:Nx-2) = -r;
bbl(1:Nx-1) = 2.+2.*r;
ccl(1:Nx-2) = -r;
MMl = diag(bbl,0) + diag(aal,-1) + diag(ccl,1);

aar(1:Nx-2) = r;
bbr(1:Nx-1) = 2.-2.*r;
ccr(1:Nx-2) = r;
MMr = diag(bbr, 0) + diag(aar, -1) + diag(ccr, 1);

for j = 1:Nt
    u(2:Nx,j+1) = MMl\MMr*u(2:Nx,j);
end

for j = 1:Nt+1
    for i = 1:Nx+1
        err(i, j) = abs(act(i,j,h,k)-u(i,j));
    end
end

surf(t,x,err)
title('Solution by Crank-Nicholson method');
xlabel('t');
ylabel('x');

function val = act(i,j,h,k)
    t = (j-1)*k;
    x = (i-1)*h;
    val = exp(-(pi^2)*t)*sin(pi*x);
end
```

output

Error by crank nicholson



Question 3
Code

clc;

```
clear;

L = 1;
t = 0.1;
h = 0.1;
k = 0.01;
Nt = t/k;
Nx = L/h;
r = k/(h^2);
x = zeros(1,Nx+1);
t = zeros(1,Nt+1);
for n = 1:Nx+1
    x(n) = (n-1)*h;
    if x(n) <= 0.5
        u(n,1) = 2*x(n);
    else
        u(n,1) = 2*(1-x(n));
    end
end

for j = 1:Nt+1
    u(1,j) = 0;
    u(Nx+1,j) = 0;
    t(j) = (j-1)*k;
end

aal(1:Nx-2) = -r;
```

```
bbl(1:Nx-1) = 2.+2.*r;
ccl(1:Nx-2) = -r;
MMl = diag(bbl,0) + diag(aal,-1) + diag(ccl,1);
aar(1:Nx-2)=r;
bbr(1:Nx-1) = 2.-2.*r;
ccr(1:Nx-2) = r;
MMr = diag(bbr, 0) + diag(aar, -1) + diag(ccr, 1);

for j = 1:Nt
    u(2:Nx,j+1) = MMl\MMr*u(2:Nx,j);
end

surf(t,x,u)
title('Solution by Crank-Nicholson method');
xlabel('x');
ylabel('t');
```

Output