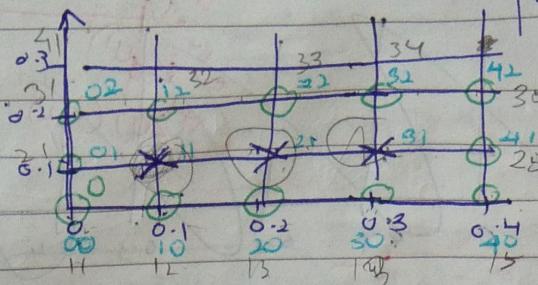


$n = 3$ $\rightarrow u, v$, row, FDM. $m=1$ $n=3$

$\rightarrow y, \text{row}, FDM.$

$m=2$

$\rightarrow y, \text{row}$



$$U_{nn} + U_{yy} = 0$$

$$0 < u < 0.4$$

$$0 < y < 0.2$$

$$h = 0.1$$

$$k = 0.1$$

$$n = 3$$

$$m = 1$$

$(U_{mm}) \rightarrow \text{update } i$

$$\frac{U_{i+1,j} - 2U_{i,j} + U_{i-1,j}}{h^2} +$$

$(U_{yy}) \rightarrow \text{update } j$

$$\frac{U_{i,j+1} - 2U_{i,j} + U_{i,j-1}}{k^2}$$

$= 0. \text{ Laplace}$

$$i=1, j=1$$

$$h^2 = 0.01$$

$$\frac{U_{21} - 2U_{11} + U_{01}}{h^2} + \frac{U_{12} - 2U_{11} + U_{02}}{k^2} = 0$$

$$\frac{U_{21}}{(0.1)^2} - \frac{-2U_{11}}{(0.1)^2} + \frac{-2U_{11}}{(0.1)^2} = -\frac{U_{01}}{(0.1)^2} - \frac{U_{01}}{(0.1)^2} - \frac{U_{12}}{(0.1)^2}$$

$$100 U_{21} - 200 U_{11} - 200 U_{11} = -100 U_{10} - 100 U_{01} - 100 U_{12}$$

$$-400 U_{11} + 100 U_{21} = -100 U_{10} - 100 U_{01} - 100 U_{12}$$

$$i=2, j=1$$

$$\frac{U_{31} - 2U_{21} + U_{11}}{h^2} + \frac{U_{22} - 2U_{21} + U_{32}}{k^2} = 0$$

$$\frac{U_{31}}{(0.1)^2} - \frac{-2U_{21}}{(0.1)^2} + \frac{U_{11}}{(0.1)^2} - \frac{-2U_{21}}{(0.1)^2} = -\frac{U_{20}}{(0.1)^2} - \frac{U_{22}}{(0.1)^2}$$

$$100 U_{31} - 400 U_{21} + 100 U_{31} = -100 U_{20} - 100 U_{22}$$

$$i=3, j=1$$

$$\frac{U_{41} - 2U_{31} + U_{21}}{(0.1)^2} + \frac{U_{32} - 2U_{31} + U_{42}}{(0.1)^2} = 0$$

$$100 U_{41} - 200 U_{31} - 200 U_{31} = -100 U_{30} - 100 U_{32} - 100 U_{41}$$

$$100 U_{21} - 400 U_{31} = -100 U_{30} - 100 U_{32} - 100 U_{41}$$

A

$$\begin{bmatrix} -400 & 100 & 0 \\ 100 & -400 & 100 \\ 100 & 100 & -400 \end{bmatrix}$$

B

$$\begin{bmatrix} U_{11} \\ U_{21} \\ U_{31} \end{bmatrix} = \begin{bmatrix} -100 U_{10} - 100 U_{30} - 100 U_{41} \\ -100 U_{20} - 100 U_{32} \\ -100 U_{30} - 100 U_{32} - 100 U_{41} \end{bmatrix}$$

$$\begin{bmatrix} 00 & 10 & 20 & 30 \\ 01 & 11 & 21 & 31 \end{bmatrix}$$

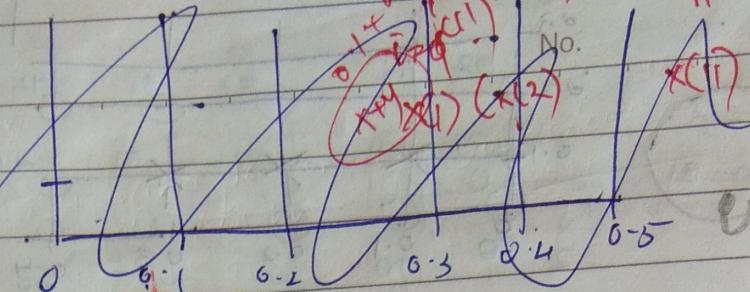
midnight

$$x = 0.4$$

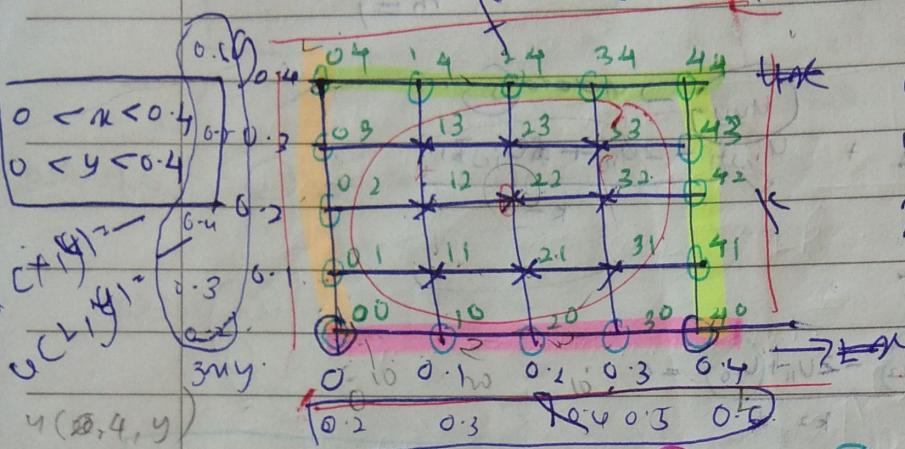
$$h_2 \frac{1}{n+1} \approx h+1$$

Laplace

Poisson



Date



$$u(x=0)$$

$$u(x=1)$$

$$f(x,y) = x^2 + y^2$$

$$h(x,y) =$$

$$K u(x,y) =$$

$$h^3 u(x,y) = h^2 q$$

$$\boxed{i=1, j=1} \quad u_{21} - 2u_{11} + u_{01} + u_{12} - 2u_{11} + u_{10} = 0$$

$$-400u_{11} + 100u_{21} + 100u_{12} = -100u_{01} - 100u_{10} \rightarrow b$$

$$u(0,0) = 0 \quad \rightarrow \quad u_{00} = 0$$

$$u(0,1) = -1 \quad \rightarrow \quad u_{01} = -1$$

$$\boxed{i=2, j=1} \quad u_{31} - 2u_{21} + u_{11} + u_{22} - 2u_{21} + u_{20} = 0$$

$$100u_{11} - 400u_{21} + 100u_{31} + 100u_{22} = -100u_{20} \rightarrow b$$

$$\boxed{i=3, j=1} \quad u_{41} - 2u_{31} + u_{21} + u_{32} - 2u_{31} + u_{30} = 0$$

$$100u_{21} - 400u_{31} + 100u_{32} = -100u_{30} - 100u_{41} \rightarrow b$$

$$\boxed{i=1, j=2} \quad u_{22} - 2u_{12} + u_{02} + u_{13} - 2u_{12} + u_{11} = 0$$

$$-400u_{12} + 100u_{22} + 100u_{13} + 100u_{11} = -100u_{02} \rightarrow b$$

$$\boxed{i=2, j=2} \quad u_{32} - 2u_{22} + u_{12} + u_{23} - 2u_{22} + u_{21} = 0$$

$$100u_{12} - 400u_{22} + 100u_{32} + 100u_{23} + 100u_{21} = 0 \rightarrow b$$

$$\frac{\partial M}{\partial x} = 0$$

$$U_{i+1} - U_{i-1} = 0$$

$$Ax = b \rightarrow Ax = A\sqrt{b}$$

M_x

$i=3, j=2$

$$U_{42} = \frac{-100U_{5L}}{(0.1)^2} + U_{22} + U_{33} - 10U_{22} + U_{31} = 0$$

$$100U_{22} - 400U_{32} + 100U_{33} + 100U_{31} = -100U_{4L} \rightarrow b$$

$i=1, j=3$

$$U_{23} - 2U_{13} + U_{03} + U_{14} - 2U_{13} + U_{12} = 0$$

$$-400U_{13} + 100U_{23} + 100U_{14} = -100U_{03} - 100U_{14} \rightarrow b$$

$i=2, j=3$

$$U_{33} - 2U_{23} + U_{13} + U_{24} - 2U_{23} + U_{12} = 0$$

$$100U_{13} - 400U_{23} + 100U_{33} + 100U_{22} = -100U_{24} \rightarrow b$$

$i=3, j=3$

$$U_{43} - 2U_{33} + U_{23} + U_{34} - 2U_{33} + U_{32} = 0$$

$$\begin{matrix} h^2 & k^2 \\ 1 & 2 \end{matrix} \quad 100U_{23} - 400U_{33} + 100U_{32} = -100U_{42} - 100U_{34}$$

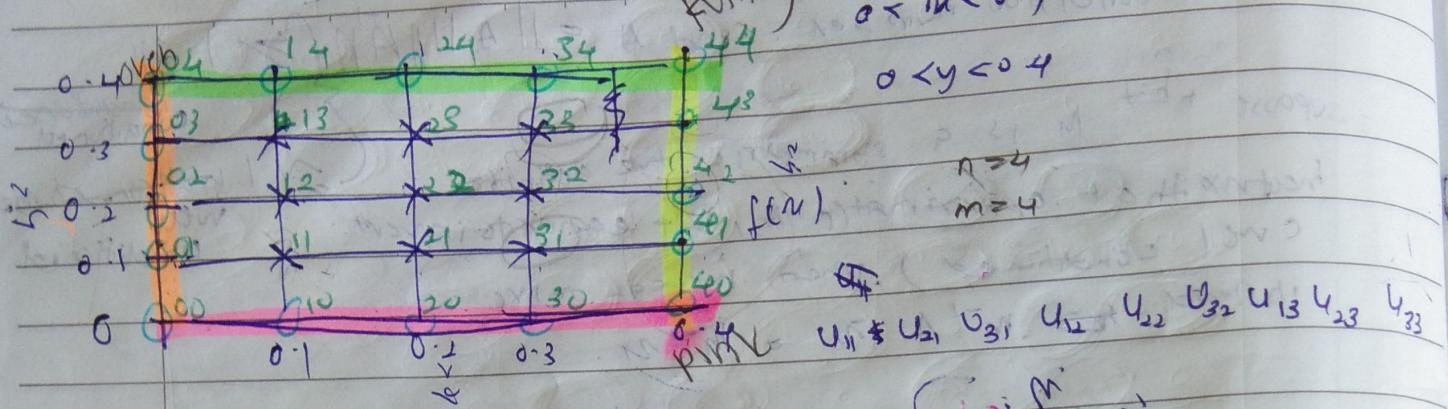
U_{11}	U_{11}	U_{31}	U_{12}	U_{22}	U_{32}	U_{13}	U_{23}	U_{33}
-400	100	0	100	0	0	0	0	0
100	-400	300	0	100	0	0	0	0
0	100	-400	0	0	100	0	0	0
100	0	0	-400	100	0	100	0	0

$$A \xrightarrow{M} b$$

U_{11}	U_{21}	U_{31}	U_{12}	U_{22}	U_{32}	U_{13}	U_{23}	U_{33}
-400	100	0	100	0	0	0	0	0
100	-400	0	0	100	0	0	0	0
0	100	0	0	0	100	0	0	0
0	0	100	0	0	0	100	0	0
0	0	0	100	0	0	0	-400	0
0	0	0	0	100	0	0	100	-400
0	0	0	0	0	100	0	0	100
0	0	0	0	0	0	100	0	-400

Crank-Nicholson

$$U_{xx} + U_{yy} = 0$$



$$0 < \alpha < 0.4$$

$$0 < \gamma < 0.4$$

$$n=4$$

$$m=4$$

$$U_{11} + U_{21} + U_{31} + U_{41} + U_{12} + U_{22} + U_{32} + U_{42} + U_{13} + U_{23} + U_{33} + U_{43}$$

$$w_{i+1,j} - 2w_{i,j} + w_{i-1,j} + U$$

\leftrightarrow

$$0.00$$

$$h^2 k^2$$

$$U_{xx} \left[\frac{U_{i+1,j} - 2U_{i,j} + U_{i-1,j}}{h^2} + \frac{U_{i+1,j+1} - 2U_{i,j+1} + U_{i-1,j+1}}{k^2} \right]$$

$$+ U_{yy} \left[\frac{U_{i,j+1} - 2U_{i,j} + U_{i,j-1}}{k^2} + \frac{U_{i+1,j+1} - 2U_{i+1,j} + U_{i+1,j-1}}{k^2} \right] = 0.$$

$$\boxed{i=1, j=1} \left(\frac{U_{11} - 2U_{11} + U_{01}}{(0.1)^2} + \frac{U_{21} - 2U_{12} + U_{02}}{(0.1)^2} \right) + \left(\frac{U_{12} - 2U_{11} + U_{01}}{(0.1)^2} + \frac{U_{22} - 2U_{21} + U_{11}}{(0.1)^2} \right) = 100U_{01} + 100U_{02} \\ - 400U_{11} - 100U_{21} + \dots + -100U_{11} + 200U_{22} = 100U_{10} + 100U_{20}$$

$$\boxed{i=2, j<1} \left(\frac{U_{31} - 2U_{21} + U_{11}}{(0.1)^2} + \frac{U_{32} - 2U_{22} + U_{12}}{(0.1)^2} \right) + \left(\frac{U_{22} - 2U_{21} + U_{11}}{(0.1)^2} + \frac{U_{32} - 2U_{31} + U_{21}}{(0.1)^2} \right) = 100U_{10} + 100U_{20} \\ - 100U_{21} - 400U_{31} + 100U_{11} + 100U_{12} - 100U_{22} - 100U_{32} = 100U_{10} + 100U_{20}$$

$$\boxed{i=3, j=1} \left(\frac{U_{41} - 2U_{31} + U_{21}}{(0.1)^2} + \frac{U_{42} - 2U_{32} + U_{22}}{(0.1)^2} \right) + \left(\frac{U_{32} - 2U_{31} + U_{21}}{(0.1)^2} + \frac{U_{42} - 2U_{41} + U_{31}}{(0.1)^2} \right) = 0 \\ - 100U_{21} - 400U_{31} + 100U_{22} - 100U_{32} = 100U_{40} - 100U_{41} - 200U_{42} + 100U_{43} + 100U_{30}$$

$$h = \sqrt{h^2 + k^2}$$

a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}	a_{17}	a_{18}
a_{21}	a_{22}	a_{23}	a_{24}	a_{25}	a_{26}	a_{27}	a_{28}
a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	a_{36}	a_{37}	a_{38}
a_{41}	a_{42}	a_{43}	a_{44}	a_{45}	a_{46}	a_{47}	a_{48}
a_{51}	a_{52}	a_{53}	a_{54}	a_{55}	a_{56}	a_{57}	a_{58}

i=1, j=2
 $\Rightarrow \left(\frac{U_{22} - 2U_{12} + U_{02}}{(0.1)^2} + \frac{U_{23} - 2U_{13} + U_{03}}{(0.1)^2} \right) + \left(\frac{U_{13} - 2U_{22} + U_{11} + U_{23} - 2U_{22} + U_{21}}{(0.1)^2} \right)$
 $= 100U_{11} + 100U_{21} - 400U_{12} - 100U_{22} - 100U_{13} + 200U_{23} = -100U_{12} - 100U_{23}$

i=2, j=2
 $\Rightarrow \left(\frac{U_{32} - 2U_{22} + U_{12}}{(0.1)^2} + \frac{U_{33} - 2U_{23} + U_{13}}{(0.1)^2} \right) + \left(\frac{U_{13} - 2U_{22} + U_{21} + U_{33} - 2U_{32} + U_{31}}{(0.1)^2} \right)$
 $= 100U_{21} + 100U_{31} + 160U_{12} - 100U_{22} - 100U_{32} + 100U_{13} - 100U_{23} + 120U_{33} = 0$

i=3, j=2
 $\Rightarrow \left(\frac{U_{42} - 2U_{32} + U_{22}}{(0.1)^2} + \frac{U_{43} - 2U_{33} + U_{23}}{(0.1)^2} \right) + \left(\frac{U_{33} - 2U_{32} + U_{31} + U_{43} - 2U_{42} + U_{41}}{(0.1)^2} \right)$
 $= 100U_{31} + 100U_{22} - 400U_{32} + 100U_{23} - 100U_{33} =$

i=1, j=3
 $\Rightarrow \left(\frac{U_{23} - 2U_{13} + U_{03}}{(0.1)^2} + \frac{U_{24} - 2U_{14} + U_{04}}{(0.1)^2} \right) + \left(\frac{U_{14} - 2U_{13} + U_{12} + U_{24} - 2U_{23} + U_{22}}{(0.1)^2} \right) = 0$
 $= 100U_{12} + 100U_{22} - 400U_{13} - 100U_{23} =$

i=2, j=3
 $\Rightarrow \left(\frac{U_{33} - 2U_{23} + U_{13}}{(0.1)^2} + \frac{U_{34} - 2U_{24} + U_{14}}{(0.1)^2} \right) + \left(\frac{U_{24} - 2U_{23} + U_{22} + U_{34} - 2U_{33} + U_{32}}{(0.1)^2} \right)$
 $= 100U_{22} + 100U_{32} + 100U_{13} - 400U_{23} - 100U_{33} =$

i=3, j=3
 $\Rightarrow \left(\frac{U_{43} - 2U_{33} + U_{23}}{(0.1)^2} + \frac{U_{44} - 2U_{34} + U_{24}}{(0.1)^2} \right) + \left(\frac{U_{34} - 2U_{33} + U_{32} + U_{44} - 2U_{43} + U_{42}}{(0.1)^2} \right)$
 $= 100U_{32} + 100U_{23} - 400U_{33} =$

a₃₁ + a₄₁
 a₃₅ + a₄₅
 KUTINS - h² k
 HFJAN - h² k
 GUNN - h
 PINE - h

a₄₁ + a₅₁ + a₅₂ + a₅₃
 a₅₁ + a₅₃ + a₅₄ + a₅₅
 a₅₃ + a₅₄ + a₅₅
 a₄₅ + a₅₅ + a₅₄ + a₅₃ + a₃₅

crant.

1 2 3

4 5 6

7 8 9

(x)

B

LUI

D

Date

U_{11}

U_{12}

U_{13}

U_{21}

U_{22}

U_{23}

U_{31}

U_{32}

U_{33}

1	-400	-100	0	-100	200	0	0	0	0
2	100	-400	-100	100	-100	200	0	0	0
3	0	100	-400	0	100	-100	-100	200	0
4	100	100	-100	-400	-100	0	100	-100	200
5	0	100	100	100	-100	-100	0	100	-100
6	0	0	100	0	100	-400	-400	-100	0
7	0	0	0	100	100	0	100	-400	-400
8	0	0	0	0	100	0	100	-400	-100
9	0	0	0	0	0	100	0	100	-400

LUR

$$A \bar{x} = b \text{ highlight } \frac{1}{a_{11}} \text{ break}$$

for $i=1:n-1$ and

for $j=1:m$

$$A(i + (j-1)*n, i + (j-1)*n + 1) = \frac{1}{a_{11}}$$

$$(A(i + (j-1)*n, i + (j-1)*n + 1, i + (j-1)*n + 1) = \frac{1}{a_{11}})$$

$$A(i + (j-1)*n, i + (j-1)*n + 1) = -1 \cdot A(1, 1)$$

block

A(1, 1)

A(1, 2)

A(1, 3)

A(2, 1)

A(2, 2)

A(2, 3)

A(3, 1)

A(3, 2)

A(3, 3)

for $i=1:n-1$

for $j=1:m-1$

A(1, 2)

A(2, 1)

A(2, 3)

A(3, 2)

for $i=1:m$

for $j=1:m-1$

A(1 + (j-1)*n, i + n) = $\frac{-1}{a_{11}}$

A(1 + (j-1)*n, i + n + 1) = $\frac{1}{a_{11}}$

A(1 + (j-1)*n, i + n + 2) = $\frac{1}{a_{11}}$

Upper part: $n=2, m=3$

Lower part: $n=2, m=3$

$A(1, 1) = A(1, 2) = A(2, 1)$

$A(2, 2) = A(2, 3) = A(3, 2)$

$$f_{\theta_1}(\vec{x}) = k \cdot f(\vec{r}) + \text{del } x$$

	0.5	0.6	1.6	2.0	$x^2 + y$	4.6	5.6	6.6	No.	Date
1.0-5	55	15	25	35	45	55	65	75	001	11/12/22
2.0-4	10	14	17	34	44	54	55	74	004	(11)
3.0-2	03	13	23	33	43	53	403	6	007	(11)
4.0-2	02	02	22	32	42	52	762	6	001	11/11/22
5.0-1	01	11	21	31	41	51	261	6	001	11/11/22
6.0	60	70	20	30	40	50	60	70	001	11/11/22
7.0	0.1	0.2	0.3	0.4	0.5	0.6	1.1	2.2	3.3	4.4

 $i=1, j=1$
 $b(1,1)$
 $b = \begin{pmatrix} 1 & 2 \\ 0 & 1 \end{pmatrix}$
 $b(j+1, 1)$
 $b(n, 1)$
 $b(k \times n + 1)$
 $b(k \times n + n + 1)$
 $b(1, 1)$
 $b(2, 1)$
 $b(3, 1)$
 $b(4, 1)$
 $b(5, 1)$
 $b(6, 1)$
 $b(7, 1)$
 $b(8, 1)$
 $b(9, 1)$
 $b(10, 1)$
 $b(11, 1)$
 $b(12, 1)$
 $b(13, 1)$
 $b(14, 1)$
 $b(15, 1)$
 $b(16, 1)$
 $b(17, 1)$
 $b(18, 1)$
 $b(19, 1)$
 $b(20, 1)$
 $b(21, 1)$
 $b(22, 1)$
 $b(23, 1)$
 $b(24, 1)$
 $b(25, 1)$
 $b(m \times n + 1)$
 $b(m \times n, 1)$
 $b(m \times n + 1)$
 $b(m \times n, 1)$
 $b(25 \times 1)$
 $b(5 \times 5 \times 1)$
 m
 n
 $j = 1$
 $j = 2$
 $j = 3$
 $j = 4$
 $j = 5$
 $j = 6$
 $j = 7$
 $j = 8$
 $j = 9$
 $j = 10$
 $j = 11$
 $j = 12$
 $j = 13$
 $j = 14$
 $j = 15$
 $j = 16$
 $j = 17$
 $j = 18$
 $j = 19$
 $j = 20$
 $j = 21$
 $j = 22$
 $j = 23$
 $j = 24$
 $j = 25$
 $\psi(m \times n + 1)$
 $G1 = 72$
 $G2 = 21$
 $G3 = 39$
 $G4 = 85$
 $G5 = 67$
 $G6 = 56$
 $G7 = 45$
 $G8 = 34$
 $G9 = 23$
 $G10 = 12$
 $G11 = 31$
 $G12 = 16$
 $G13 = 27$
 $G14 = 15$
 $G15 = 10$
 $G16 = 11$
 $G17 = 13$
 $G18 = 14$
 $G19 = 1$
 $G20 = 2$
 $G21 = 3$
 $G22 = 4$
 $G23 = 5$
 $G24 = 6$
 $G25 = 7$

$j = >$ 41 $2n + 1$ h printing $=$ for $i = n * m$
 0 0 n n^2 i $i = n * m$