Module 4

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Register number: 20242019

ODE PART

Question 1 to 4.

```
PS E:\computational_physics> cd "e:\computational_physics\Module_4\" ; if ($?) { gfortran question_1_4.f
90 -o question_1_4 } ; if ($?) { .\question_1_4 }

For Euler Method (dx =    1.0000000000000000E-003 ), Y_A - Y_E =   7.2476397872130178

For Modified Euler Method (dx =    1.0000000000000000E-003 ), Y_A - Y_ME =   7.7054613989943732E-002

For Improved Euler Method (dx =    1.0000000000000000E-003 ), Y_A - Y_IE =   5.1282205996884045E-002

For Runge Kutta 4 (dx =    1.0000000000000000E-002 ), Y_A - Y_RK4 =   2.7854113572288952E-002
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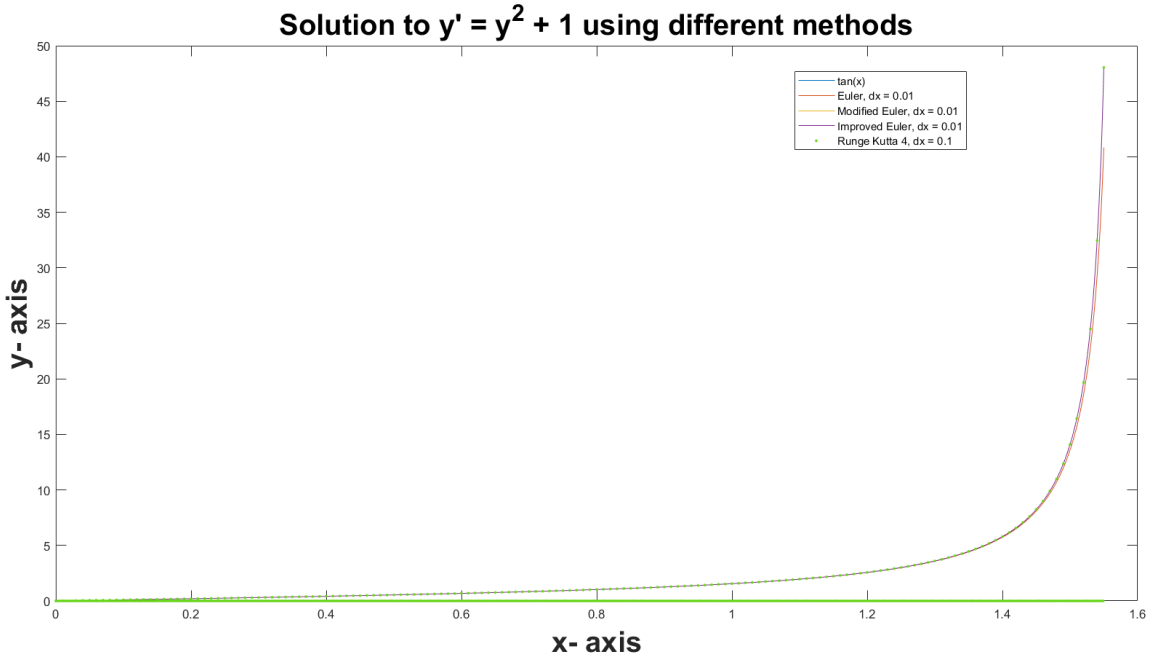
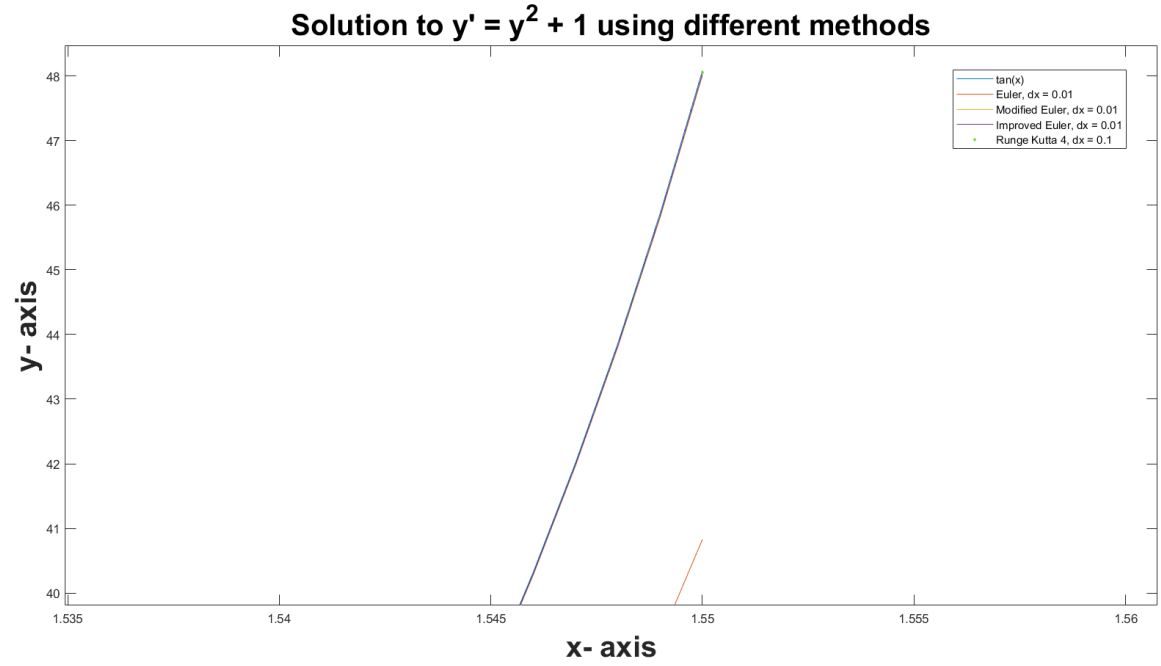
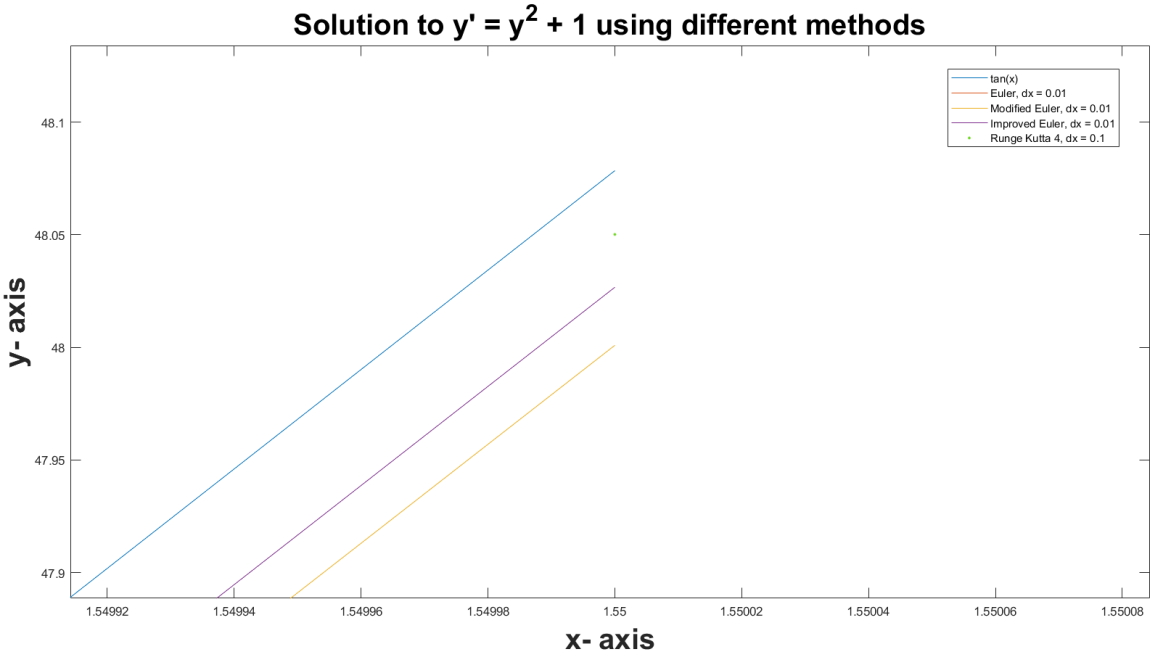



Solution to y' = y^2 + 1 using different methods
tan(x)
Euler, dx = 0.01
Modified Euler, dx = 0.01
Improved Euler, dx = 0.01
Runge Kutta 4, dx = 0.1
y- axis
x- axis
48
47
46
45
44
43
42
41
40
1.535
1.54
1.545
1.55
1.555
1.56


Solution to y' = y^2 + 1 using different methods
tan(x)
Euler, dx = 0.01
Modified Euler, dx = 0.01
Improved Euler, dx = 0.01
Runge Kutta 4, dx = 0.1
y- axis
x- axis
48.1
48.05
48
47.95
47.9
1.54992
1.54994
1.54996
1.54998
1.55
1.55002
1.55004
1.55006
1.55008

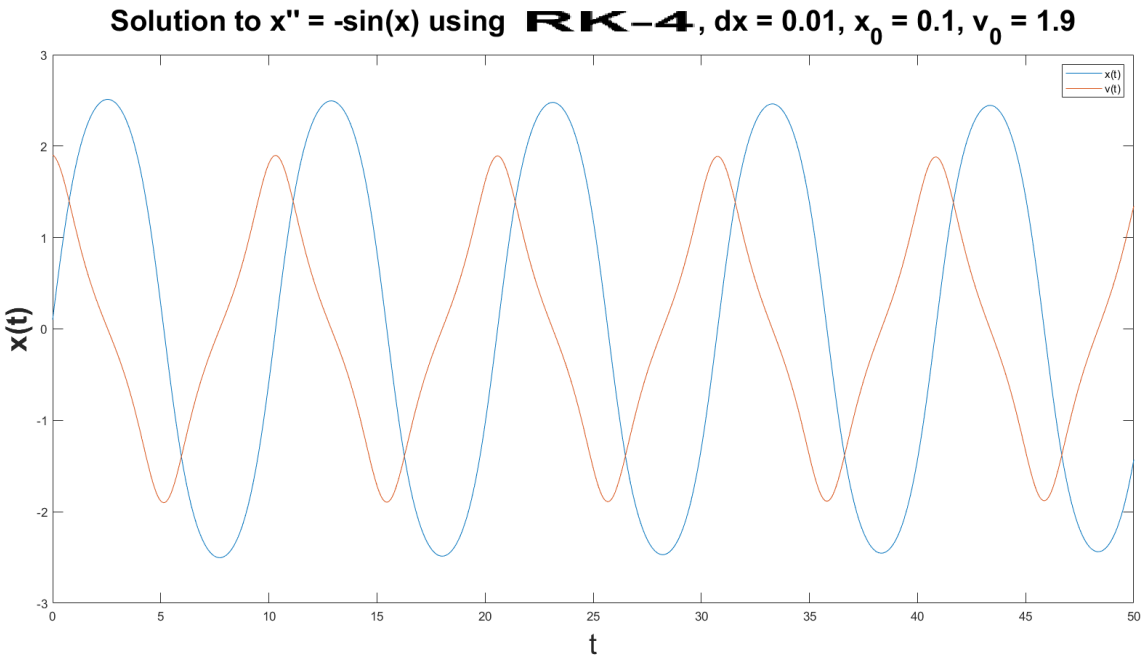
Question 5.

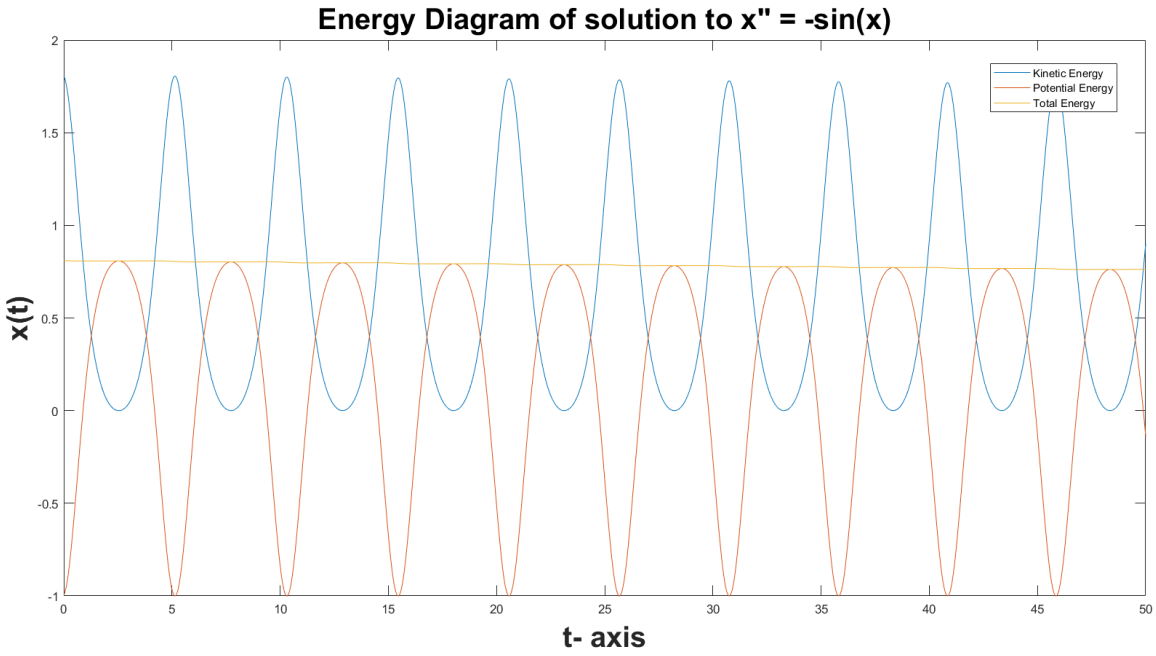
```
PS E:\computational_physics\Module_4> cd "e:\computational_physics\Module_4\" ; if ($?) { gfortran
question_5_7.f90 -o question_5_7 } ; if ($?) { .\question_5_7 }
 The value of x after 5000 iterations is =  -1.4308465704154238
 x_0, v_0 and dt are  0.10000000000000001        1.8999999999999999        1.0000000000000000E-002

 The value of x after 5000 iterations is =   2.8762724441638219
 x_0, v_0 and dt are   0.0000000000000000        1.9990000000000001        1.0000000000000000E-002

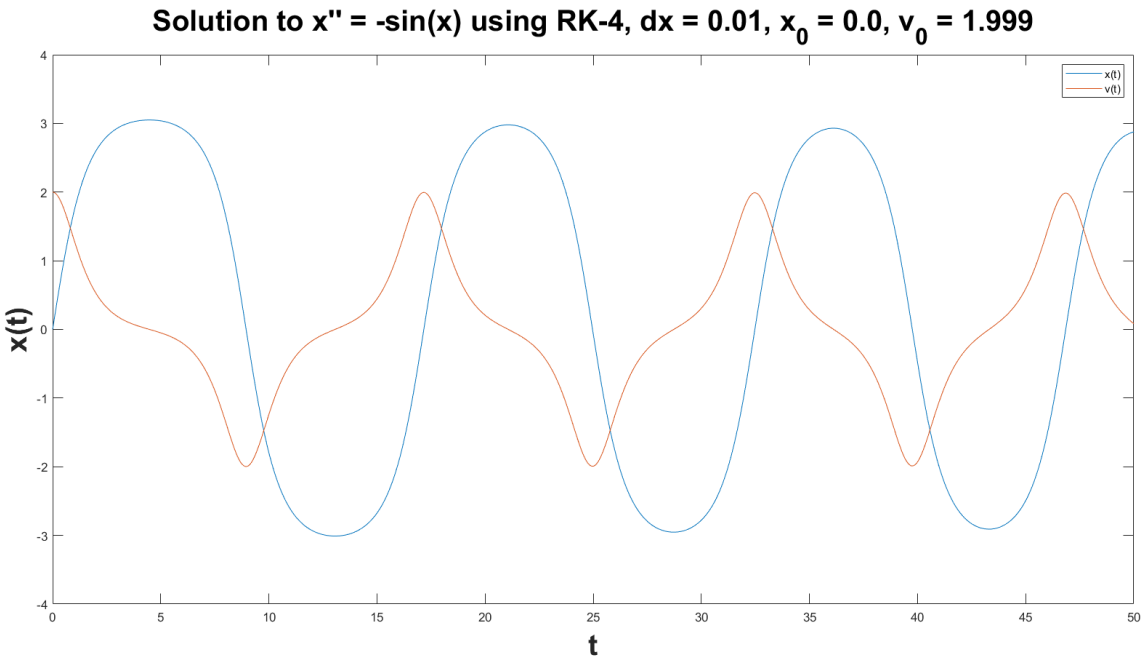
 The value of x after 5000 iterations is =  -3.0196973541066394
 x_0, v_0 and dt are   0.0000000000000000        1.9990000000000001        1.0000000000000000E-003

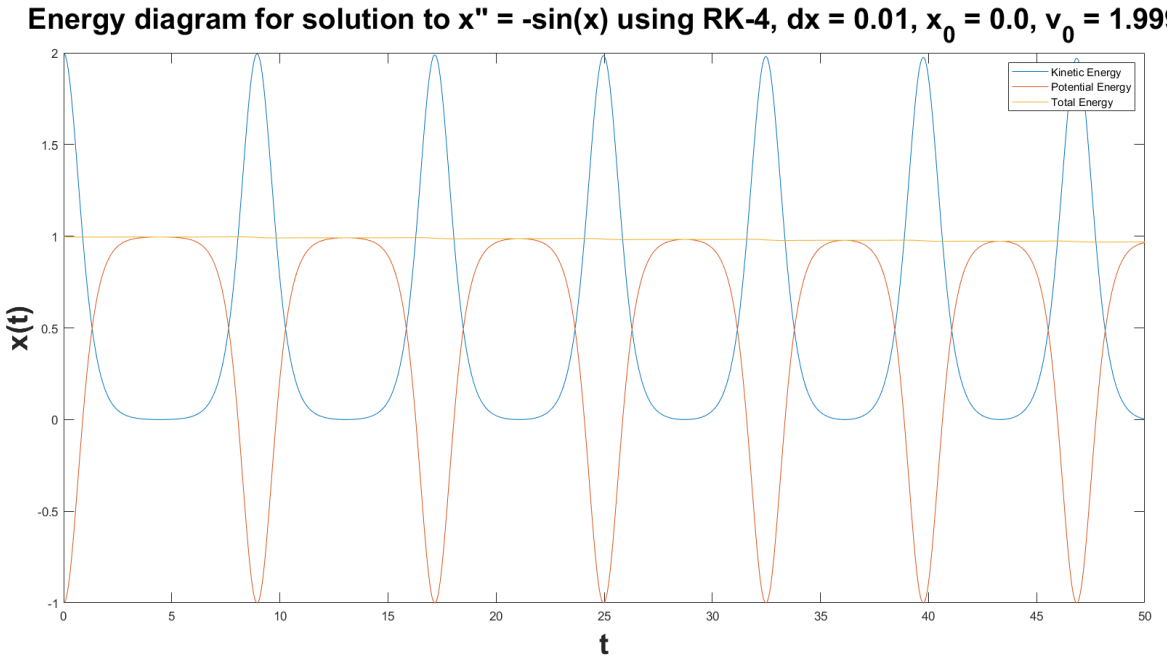
 The value of x after 5000 iterations is =   82.917683063967161
 x_0, v_0 and dt are   0.0000000000000000        2.2999999999999998        1.0000000000000000E-002
```





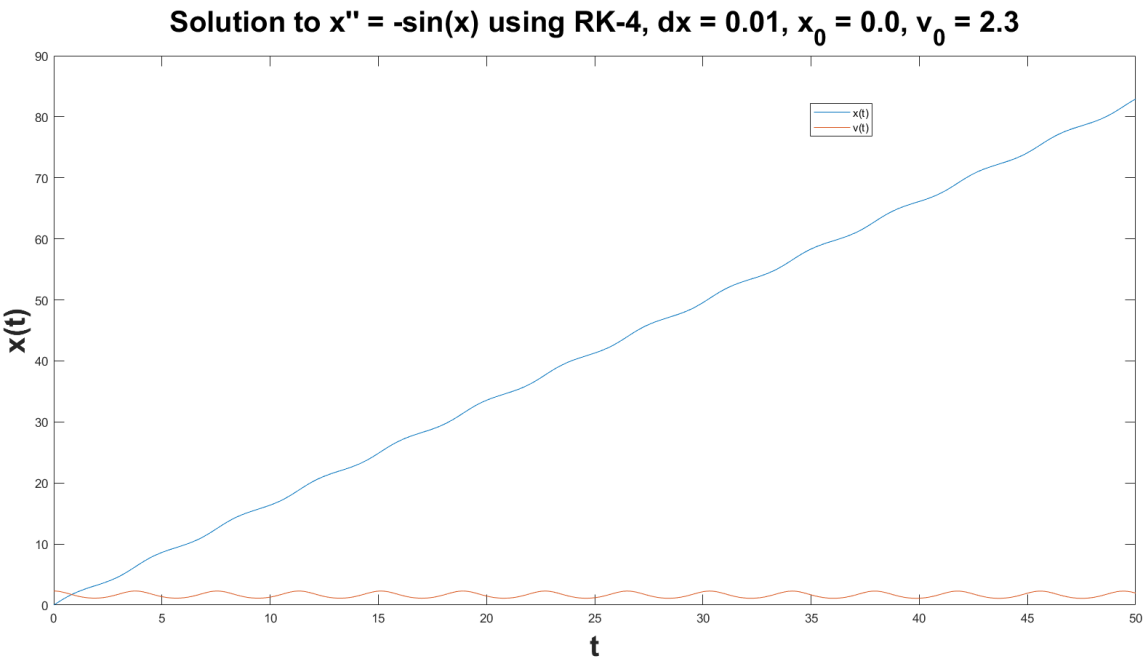
Question 6.

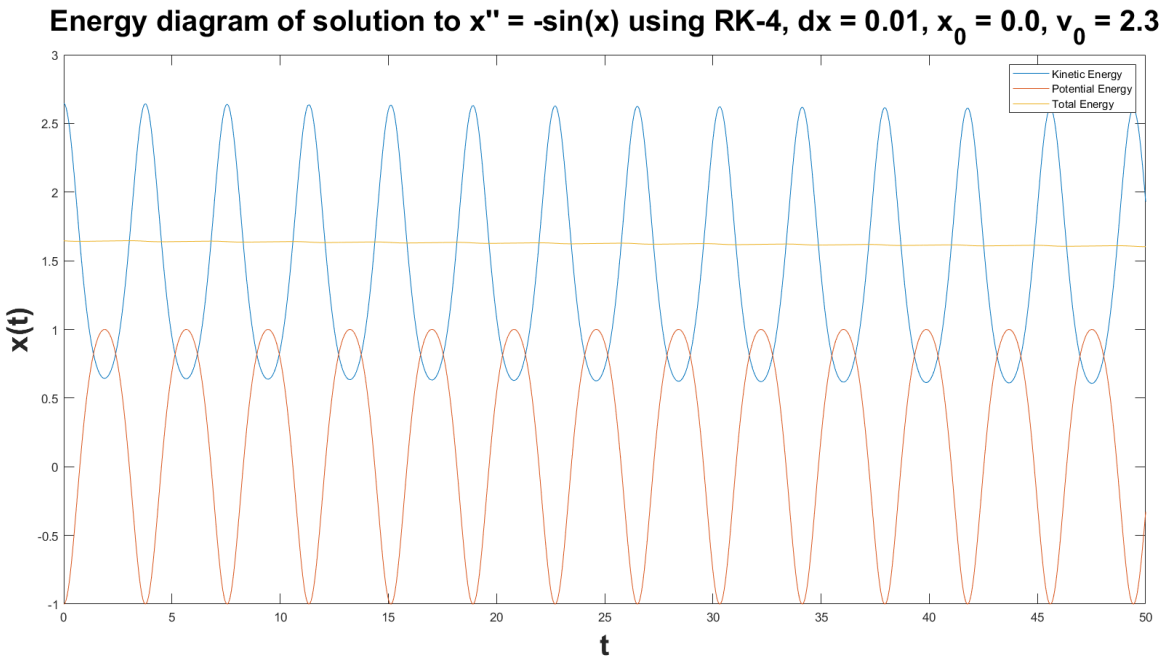

Solution to x'' = -sin(x) using RK-4, dx = 0.01, x0 = 0.0, v0 = 1.999
x(t)
v(t)
x(t)
t


Energy diagram for solution to x'' = -sin(x) using RK-4, dx = 0.01, x0 = 0.0, v0 = 1.999
Kinetic Energy
Potential Energy
Total Energy
x(t)
t

Question 7.

The solution looks very different because the initial velocity is more than the critical velocity, thus the bob of the pendulum goes past the extremum point.



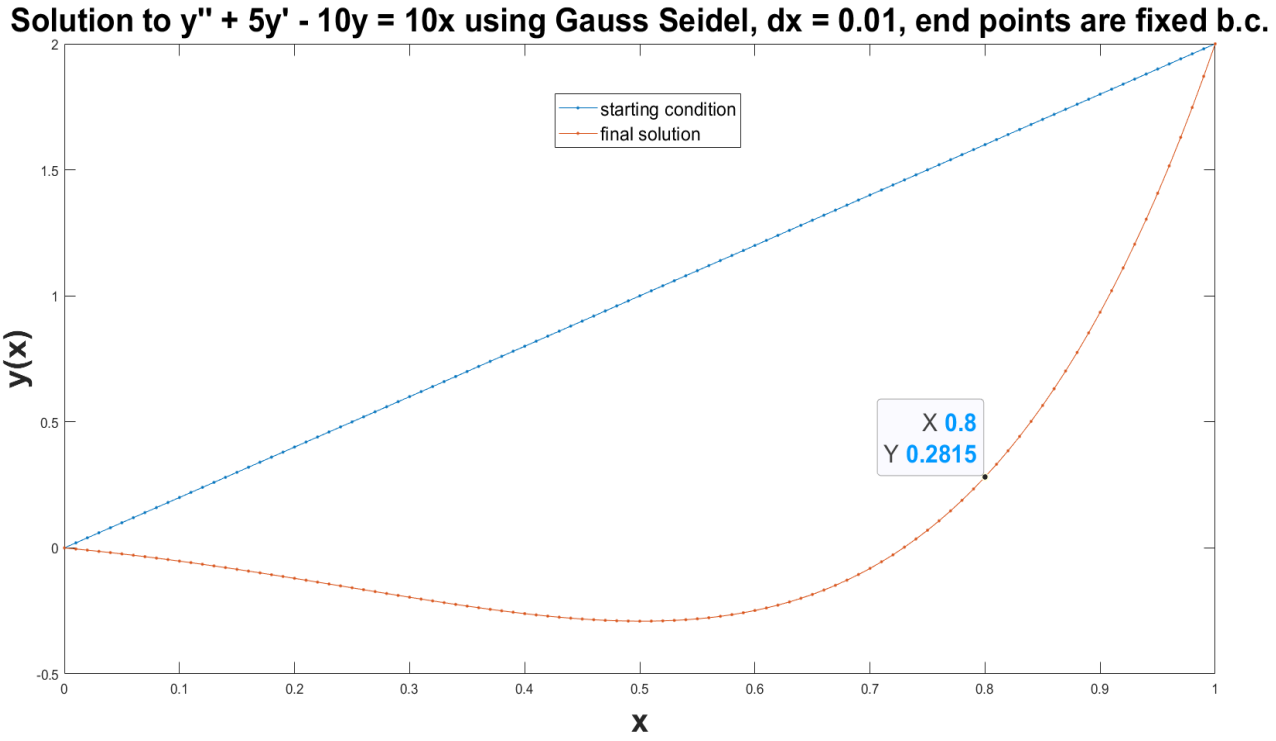


Question 8.

```
PS E:\computational_physics\Module_4> cd "e:\computational_physics\Mo
dule_4\" ; if ($?) { gfortran question_8.f90 -o question_8 } ; if ($?
) { .\question_8 }
 Number of iterations required =        2001
 Position of particle 1 at the end of t=40 is -0.12529609342239922
```

Question 9.

```
PS E:\computational_physics\Module_4> cd "e:\computational_physics\Mo
dule_4\" ; if ($?) { gfortran question_9.f90 -o question_9 } ; if ($?
) { .\question_9 }
 Number of iterations required =        4051
 y(0.8) =  0.28147010284959123
```



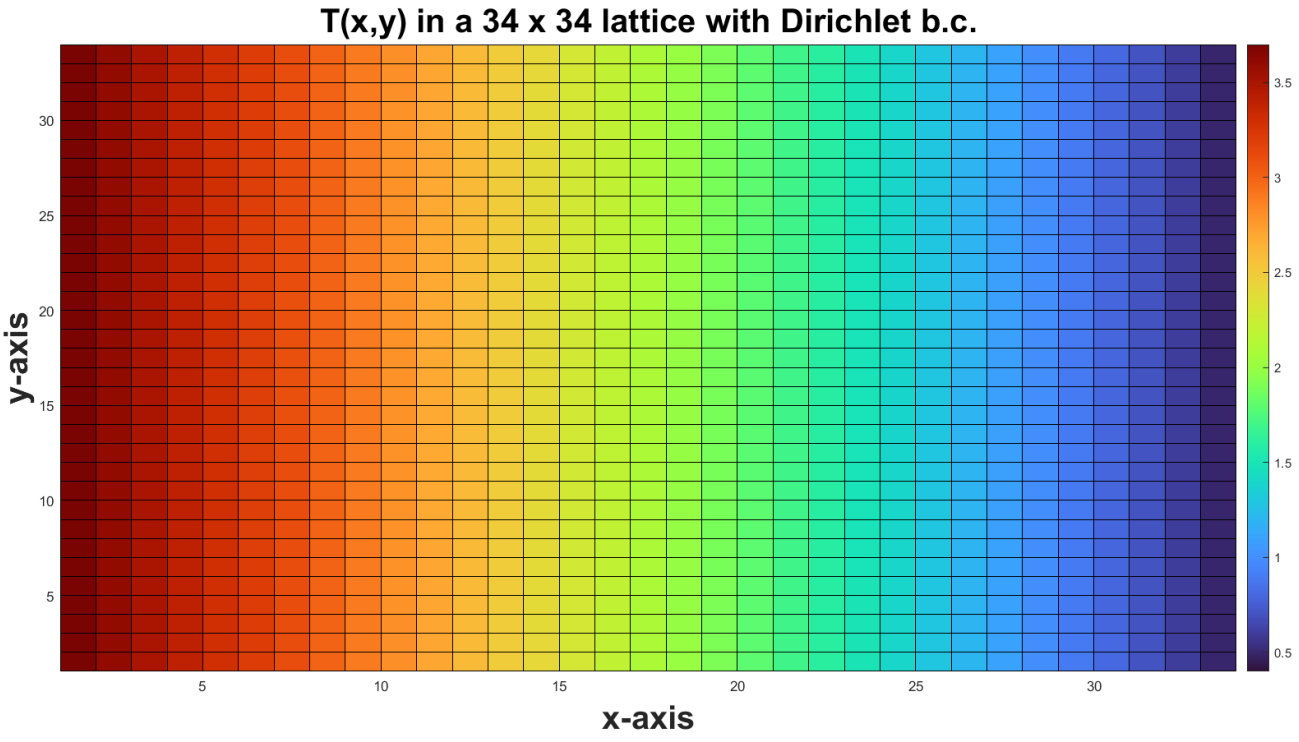
PDE PART

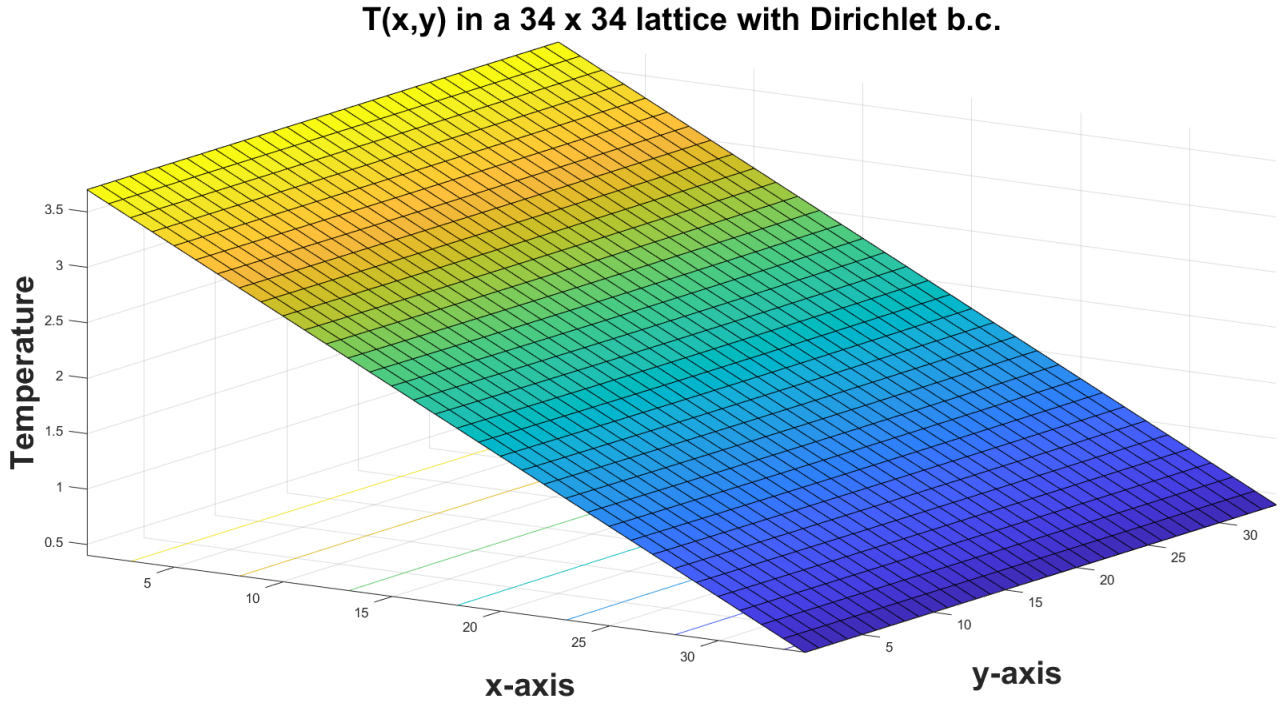
Question 3.

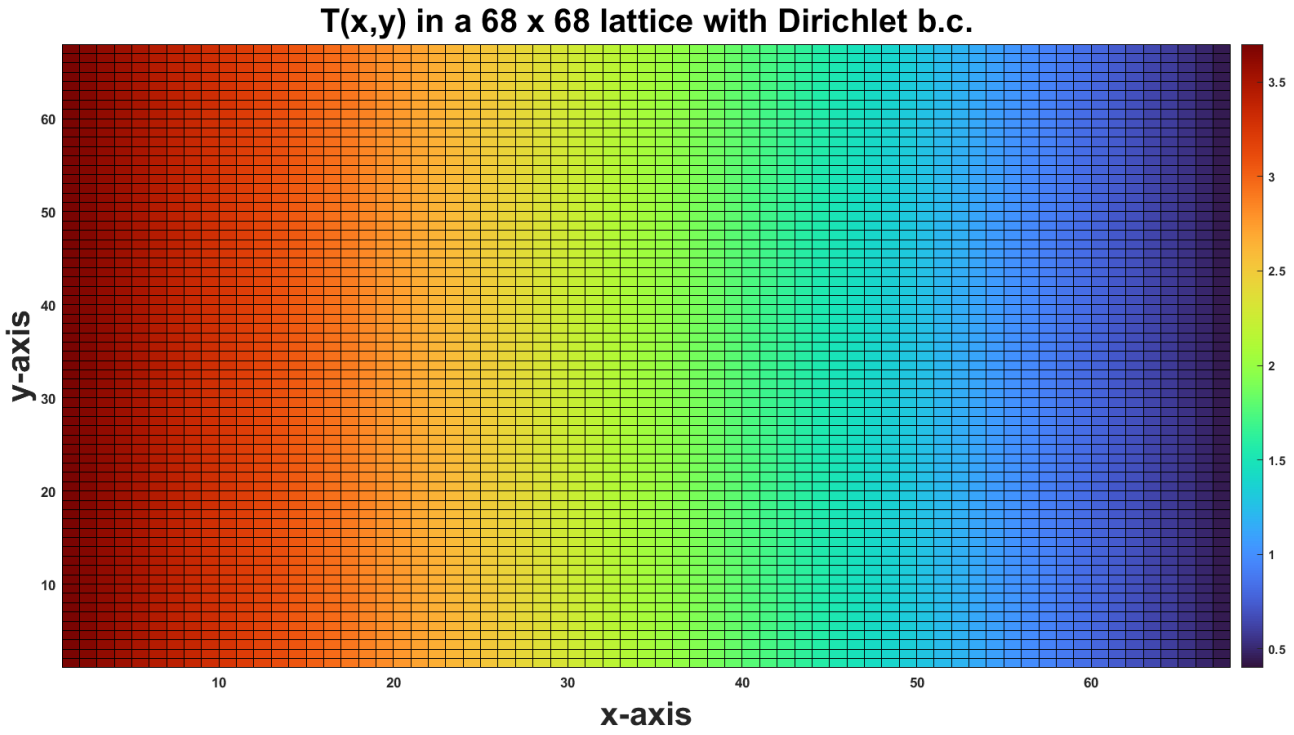
```
PS E:\computational_physics\Module_4> cd "e:\computational_physics\Mo
dule_4\" ; if ($?) { gfortran pde_question_3_extra.f90 -o pde_questio
n_3_extra } ; if ($?) { .\pde_question_3_extra }
 Number of iterations required (68 X 68 lattice) =        1944

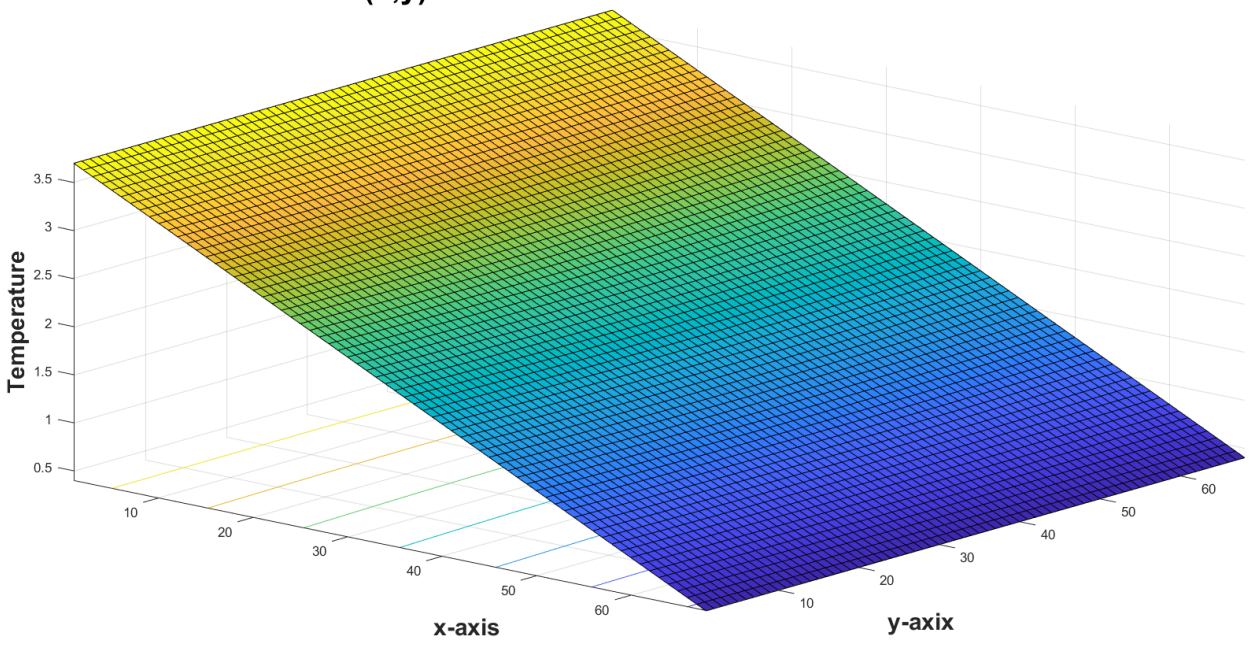
Temperature(40,40) =    1.7372231464403809
PS E:\computational_physics\Module_4> cd "e:\computational_physics\Mo
dule_4\" ; if ($?) { gfortran pde_question_3.f90 -o pde_question_3 }
; if ($?) { .\pde_question_3 }
 Number of iterations required (34 X 34 lattice)=         626

Temperature(20,20) =    1.7899564249866708
```




T(x,y) in a 34 x 34 lattice with Dirichlet b.c.
Temperature
3.5
3
2.5
2
1.5
1
0.5
5
10
15
20
25
30
x-axis
y-axis


T(x,y) in a 68 x 68 lattice with Dirichlet b.c.
y-axis
60
50
40
30
20
10
10
20
30
40
50
60
x-axis
3.5
3
2.5
2
1.5
1
0.5

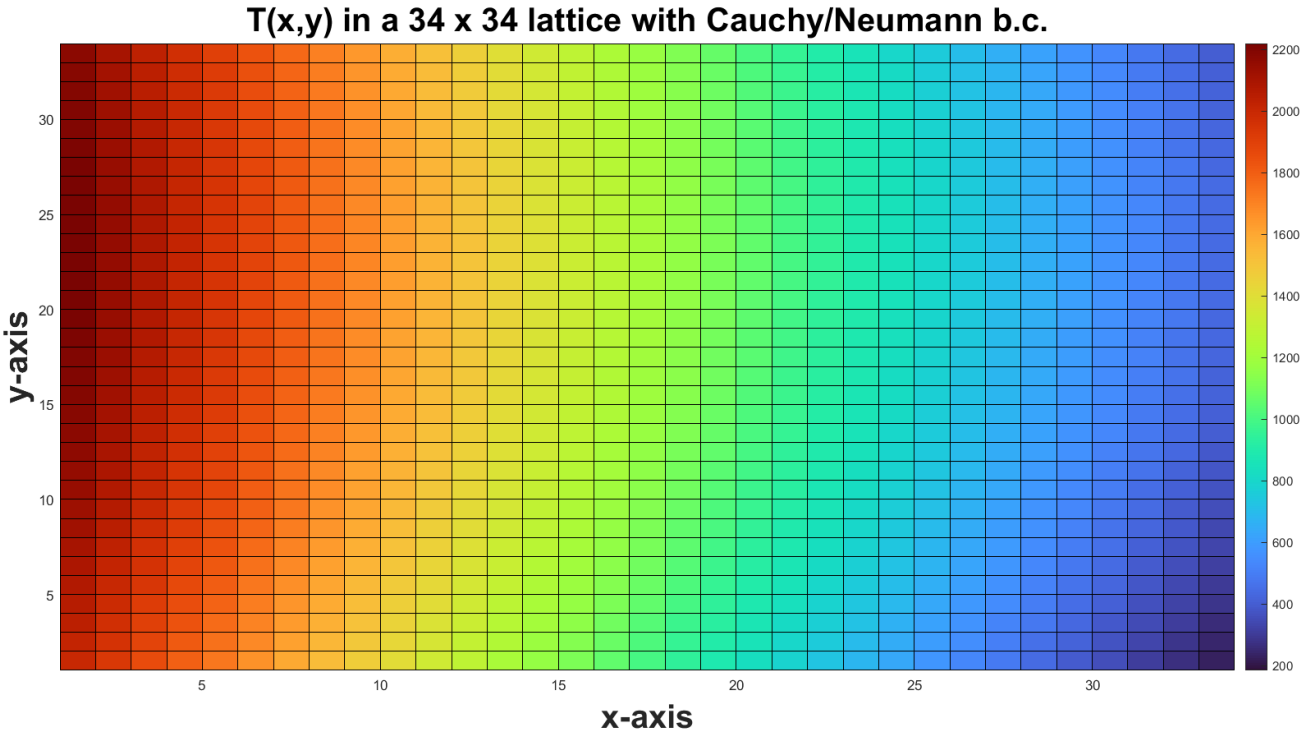

T(x,y) in a 68 x 68 lattice with Dirichlet b.c.
Temperature
3.5
3
2.5
2
1.5
1
0.5
10
20
30
40
50
60
x-axis
10
20
30
40
50
60
y-axix

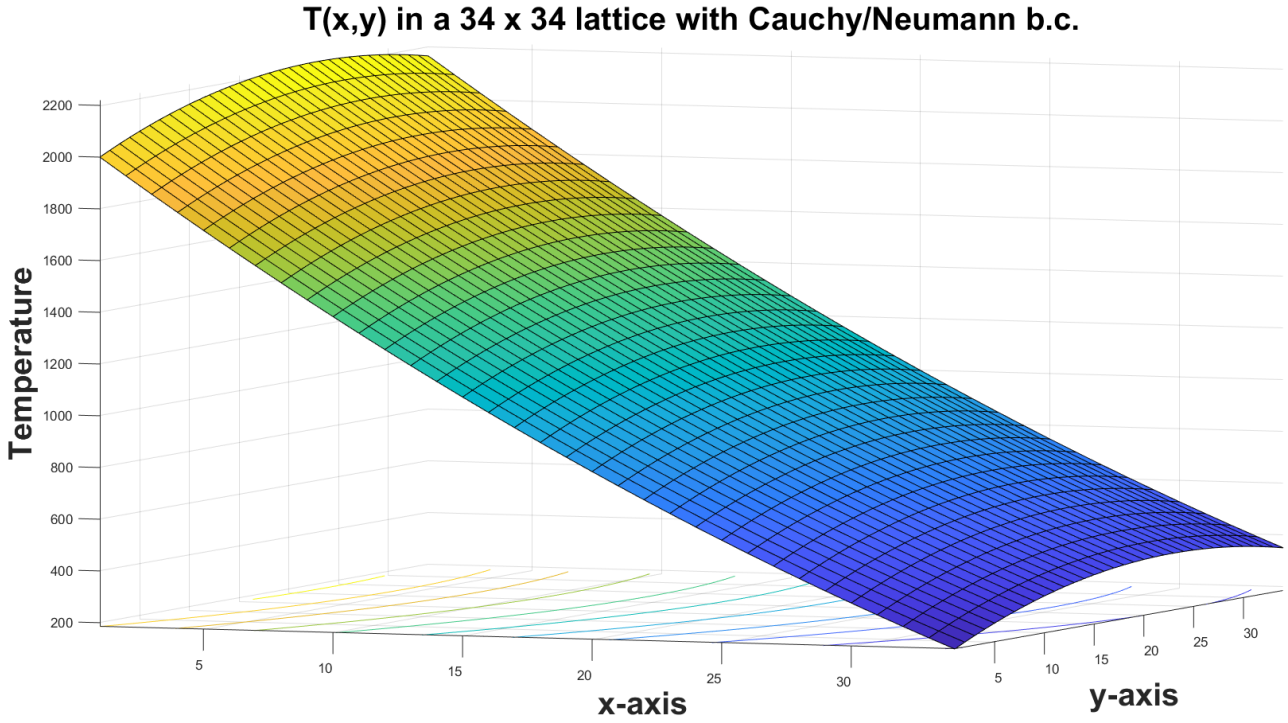
Question 4.

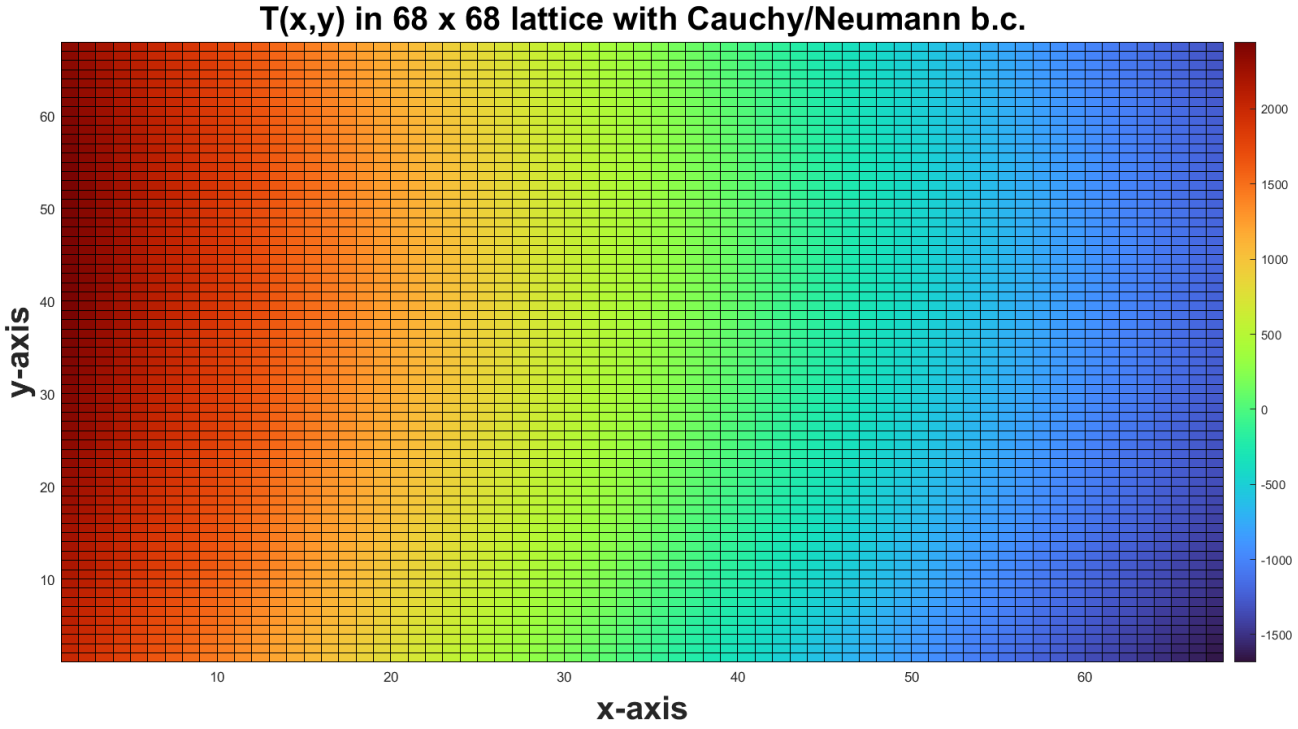
```
PS E:\computational_physics\Module_4> cd "e:\computational_physics\Mo
dule_4\" ; if ($?) { gfortran pde_question_4.f90 -o pde_question_4 }
; if ($?) { .\pde_question_4 }
 Number of iterations required (34 X 34 lattice) =        2368

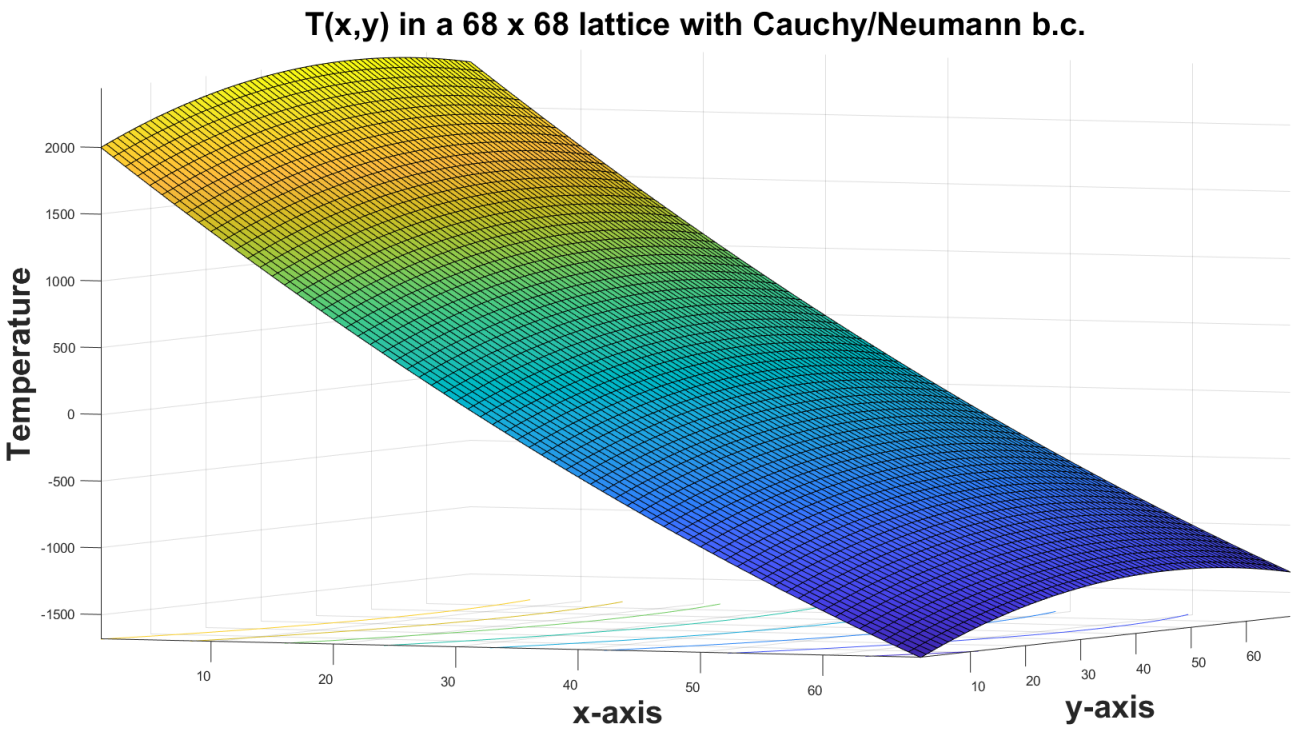
Temperature(10,10) =    1550.0072081540266
PS E:\computational_physics\Module_4> cd "e:\computational_physics\Mo
dule_4\" ; if ($?) { gfortran pde_question_4_extra.f90 -o pde_questio
n_4_extra } ; if ($?) { .\pde_question_4_extra }
 Number of iterations required (68 X 68 lattice) =        9005

Temperature(20,20) =    1050.0299314744286
```




T(x,y) in a 34 x 34 lattice with Cauchy/Neumann b.c.
Temperature
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
5
10
15
20
25
30
x-axis
5
10
15
20
25
30
y-axis


T(x,y) in 68 x 68 lattice with Cauchy/Neumann b.c.
y-axis
60
50
40
30
20
10
10
20
30
40
50
60
x-axis
2000
1500
1000
500
0
-500
-1000
-1500


T(x,y) in a 68 x 68 lattice with Cauchy/Neumann b.c.
Temperature
2000
1500
1000
500
0
-500
-1000
-1500
10
20
30
40
50
60
x-axis
10
20
30
40
50
60
y-axis