Computational Physics

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Fall term 2020
Project 3, due October 21, 2020 at 11:55 pm
to be uploaded to https://moodle.jacobs-university.de

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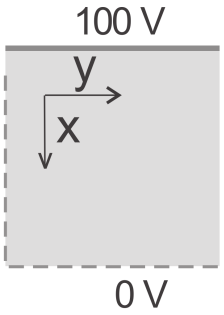
3. Laplace Problem on a square [100 points]



Find the electric potential for all points inside the charge-free square shown in the above figure. The bottom and sides of the square are grounded, while the wire at the top is kept at 100 V.
Write a Python code which can solve the problem using i) the Jacobi, ii) the Gauss-Jacobi and iii) the SOR approach.
a) Choose an appropriate value of the grid spacing and create a surface (or 3D) plots of the potential $V(x,y)$ using all three approaches. For simplicity set the side length of the square to 1.
b) Modify the code so that it quits iterating at iteration n once the sum $\sum_{ij} |V_{i,j}^{n+1} - V_{i,j}^{n}|$ over all grid points converges to some measure of precision such as 10^{-4} .
c) Investigate the effect of varying the step size h. Draw conclusions regarding the stability and accuracy of the solution for various h's.
d) Investigate the effect of using Gauss-Seidel versus Jacobi relaxation versus SOR. Which converges faster? Do the answers agree?

General remarks for all Projects

You will have to (i) analyze the problem, (ii) select an algorithm (if not specified), (iii) write a Python program, (iv) run the program, (v) visualize the data numerical data, and (vi) extract an answer to the physics question from the data.
Which checks did you perform to validate the code? State the results you got for these tests.
For each project you will submit a short report describing the physics problem, your way of attacking it, and the results you obtained. Provide the documented Python code in such a form that we can run the code. A Jupyter Notebook including the code and report is fine but not necessary.