PHYS639, Spring16, Problem 5

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The potential of the electric field satisfies Poisson's equation

$$\triangle V = \rho,$$

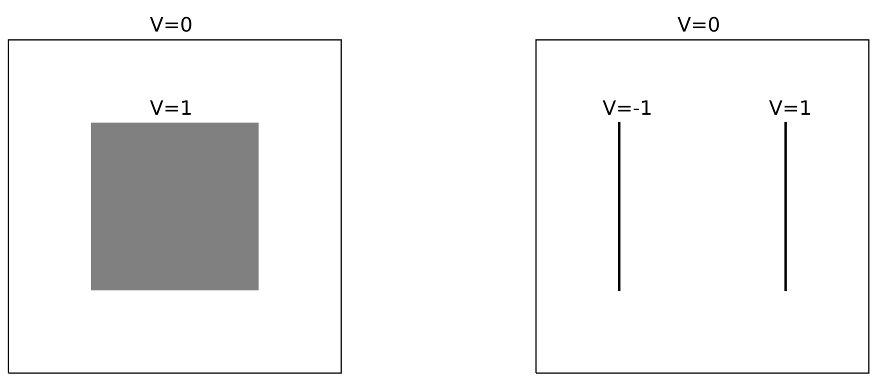
where V is the potential and ρ is the charge density. To have a stable solution, this equation must be supplemented by appropriate boundary conditions, e.g. by giving the value of V everywhere on a close surface. Using either *Jacobi*, *Gauss-Siedel*, or *simultaneous over-relaxation* mehtods, find electric potential for the following boundary conditions:

1. A hollow metallic prism held at $V = 0$ with a solid metallic inner conductor held at $V = 1$ (left panel of the figure below). No charges. Solve in two dimensions.

2. Two capacitors held at $V = 1$ and $V = -1$ inside a conducting square held at $V = 0$ (right panel on the figure below). No charges. Solve in two dimensions.

3. A conducting cube held at $V = 0$ with a charge located somewhere inside the cube. Solve in three dimensions.

4. A charge in empty space. Solve in three dimensions. (Hint: Your boundary conditions are $V = 0$ at infinity).



Deliverables

For all four cases above, plot the following:

1. If the problem is in 2D, a contour plot (or a surface plot) of the potential. If a problem is in 3D, contour plots (or surface plots) for slices along z-axis.

2. Similar plots for the electric field strength $\mathbf{E} = \nabla V$. $\mathbf{E}$ is a vector so your plot will be a field of small arrows.

3. For the last problem, plot V along one of the axises and compare your results to the analytic expectation of $V \sim 1/r$.