Warm-Up for March 2nd, 2022

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1 Memory Bank

1. 2D charge density: $\sigma = Q/A$, where Q and A are the total charge and area, respectively
2. Laplace's Equation in 3D: $\nabla^2 V(\mathbf{r}) = 0$
3. Laplace's Equation in 1D:

$$\frac{d^2V}{dx^2} = 0 \tag{1}$$

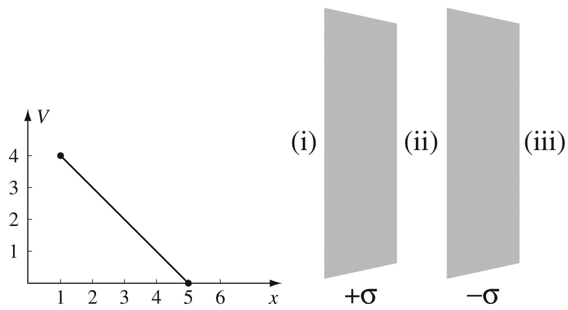

Figure 1: (Left) A solution to *Laplace's Equation* in 1D. (Right) a 1D capacitor.

2 Electric Field in a Parallel-Plate Capacitor

Recall that the field near a flat plane of charge oriented in the yz-plane (see Fig. 1, right) is

$$\mathbf{E} = \frac{\sigma}{2\epsilon_0}\hat{x} \tag{2}$$

- Show that for oppositely charged flat planes, the field is $\mathbf{E} = (\sigma/\epsilon_0)\hat{x}$

- Note that $\mathbf{E}$ is a constant. Suppose the negative side of the capacitor is grounded ($V = 0$), and the negative side is located at $x = 5$ mm. Suppose the positive side is located at $x = 1$ mm, and has a potential of 4 Volts. (a) Show that Fig. 1 (left) is the solution for $V(x)$ by solving Laplace's Equation. (b) In terms of given variables, what is the slope? (c) Show that $V(x)$ in the middle is the average of $V(x)$ at the endpoints.