Electric Force Between Charged Plates I [pln71]

Parallel plates in vacuum:

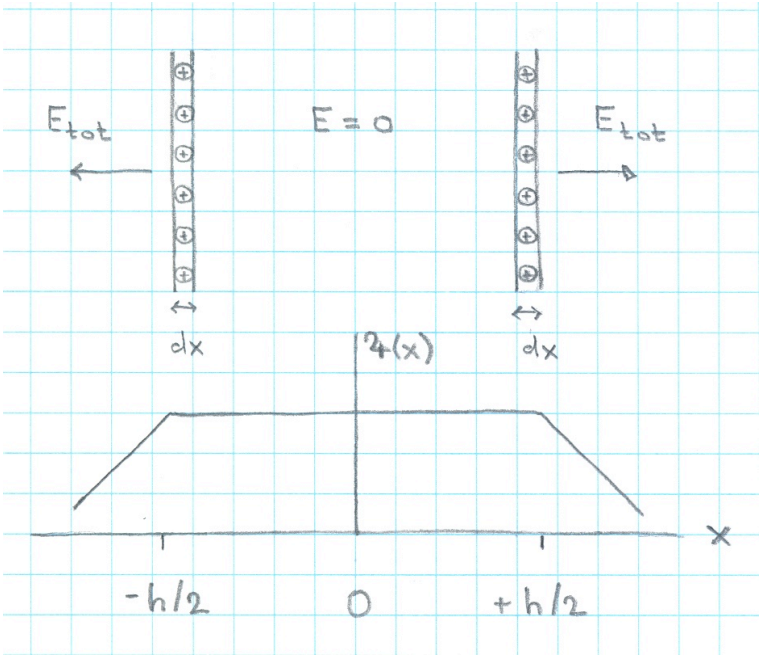
Consider two parallel plates of infinitesimal thickness dx and equal (positive) charge per unit area $\sigma = \rho dx$ on them. The plates are positioned at a distance h from each other as shown.

Each plate generates a uniform electric field $E_\mathrm{p} = \sigma/2\epsilon_0$ pointing away from it. This ignores perimeter effects. The total field then vanishes between the plates. On the outside, the field is uniform with magnitude $E_\mathrm{tot} = \sigma/\epsilon_0$ and pointing away.

The electric potential $\psi(x)$ is constant between the plates and descends from that values on the outside at the rate $|d\psi/dx| = |E_\mathrm{tot}| = \sigma/\epsilon_0$.

The force between the plates is repulsive and independent of distance. Its magnitude per area is determined as follows:

$$f \doteq \frac{F}{A} = \sigma E_\mathrm{p} = \frac{\sigma^2}{2\epsilon_0} = -\frac{\epsilon_0}{2}\left(\frac{d\psi}{dx}\right)_{-h/2}\left(\frac{d\psi}{dx}\right)_{+h/2}.$$



[adapted from Doi 2013]