\[ \nabla \cdot E = \frac{\rho}{\varepsilon_0} \]
\[ \nabla \cdot B = 0 \]
\[ \nabla \times E = -\frac{\partial B}{\partial t} \]
\[ \nabla \times B = \mu_0 \varepsilon_0 \frac{\partial E}{\partial t} + \mu_0 J \]

**Electricity and Magnetism I: 3811**

Professor Jasper Halekas
Van Allen 301
MWF 9:30-10:20 Lecture
Announcements

- Final Exam scheduled for 12:30-2:30pm Wednesday 12/18 in Van 301 (this room)
First midterm exam is next Wednesday (Oct. 2) during normal class hours

- Exam covers Griffiths Ch. 1-2 & lectures through Friday 9/27

- Equation sheet posted on course website
  - You are responsible for printing this, annotating it if you desire, and bringing it to the test

- Two sample midterms posted on course website
  - Format of this year’s exam will be very similar
  - Problems will include spherical, cylindrical, and Cartesian geometry
Induced Charge
Conductor w/ Cavity

E induced

Total Field
How much charge on walls?

Gaussian surface
\[ \oint E \cdot d\mathbf{a} = 0 \]
since \( E = 0 \)

\[ \Rightarrow Q_{\text{enc}} = 0 \]

\[ \Rightarrow -q \text{ on inner wall} \]

If conductor net neutral
\[ \Rightarrow +q \text{ on outer wall} \]
Conductor w/ Cavity
Conductor with Irregular Cavity

- Charge on inner wall cancels field everywhere in conductor

- Regardless of shape and location of cavity
Conductor w/ Cavity
Non-spherical Conductor

Weaker $\vec{E}$

Stronger $\vec{E}$

Equipotentials

- Transition from tangent to surface to roughly spherical
Charge on Conductor

(b)

(c)
**Force on Conductor**

\[ \Delta E = \frac{\sigma}{\varepsilon_0} \hat{n} \]

\[ \Rightarrow \mathbf{E}_{\text{out}} = \frac{\sigma}{\varepsilon_0} \hat{n} \text{ outside of conductor} \]

\[ \Rightarrow \sigma = \varepsilon_0 \mathbf{E}_{\text{out}} \]

**Force on charge**

**Force/area**

\[ \mathbf{F} = \mathbf{F} / A \]

\[ = Q \mathbf{E} / A \]

\[ = \sigma \mathbf{E} \]

\[ \text{w/} \quad \mathbf{E} = \mathbf{E}_{\text{ave}} = \frac{\mathbf{E}_{\text{out}} + \mathbf{E}_{\text{in}}}{2} \]

\[ = \frac{E_{\text{out}}}{2} \]

\[ = \frac{\sigma}{2\varepsilon_0} \hat{n} \]

\[ \mathbf{F} = \sigma \mathbf{E}_{\text{ave}} = \frac{\sigma^2}{2\varepsilon_0} \hat{n} \]

outward electrostatic pressure!

\[ P = |\mathbf{F}| = \frac{\sigma^2}{2\varepsilon_0} = \left(\frac{\sigma}{\varepsilon_0}\right)^2 \cdot \frac{1}{2} \cdot \frac{1}{2} \]

\[ = \frac{1}{2} \varepsilon_0 \mathbf{E}_{\text{above}} \]

pressure \leftrightarrow energy density
Capacitors

\[ V_+ \quad +Q \quad V_- \quad -Q \]

\[ \Delta V = V_+ - V_- \]
(sometimes sloppily written as \( V \))

\[ = - S^+ E \cdot dl \]

\[ C = \frac{Q}{\Delta V} \]

- Since \( E \) and \( V \) linear and thus proportional to \( Q \)

\[ \Rightarrow C = \text{constant} \]

depends only on geometry
Parallel-Plate Capacitor

For $A \gg d^2$

$$\vec{E}_+ = \frac{\sigma_+}{\varepsilon \varepsilon_0} \hat{n}_+ = \frac{Q}{2 \varepsilon_0 A} \hat{n}_+$$

$$\vec{E}_- = \frac{-\sigma_-}{\varepsilon \varepsilon_0} \hat{n}_- = -\frac{Q}{2 \varepsilon_0 A} \hat{n}_-$$

$$\begin{align*}
\vec{E}_+ & \uparrow & \downarrow \vec{E}_- \\
\vec{E}_+ & \downarrow & \downarrow \vec{E}_- \\
\vec{E}_+ & \downarrow & \uparrow \vec{E}_- \\
\end{align*} \Rightarrow \begin{align*}
E &= 0 \\
E &= \frac{Q}{\varepsilon_0 A} \\
E &= 0
\end{align*}$$

$$\Delta V = -S \vec{E} \cdot \delta \vec{l} = E \cdot d = \frac{Q d}{\varepsilon \varepsilon_0}$$

$$C = \frac{Q}{\Delta V} = \varepsilon_0 \frac{A}{d}$$