\n\nElectricity and Magnetism I: 3811

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

- Final Exam scheduled for 3:00-5:00pm Tuesday 12/11 in Van 456

- First midterm exam is next Wednesday (9/26) during normal class hours
  - Equation sheet is posted on the course website
    - You are responsible for printing this, annotating it if you desire, and bringing it to the test
  - Practice midterm posted on the course website
Charge Near Conductor
Conductor w/ Cavity
Conductor w/ Cavity
Conductor in cavity

- shape and location do not matter!

\[ \vec{E} = 0 \]

- charge on inner wall cancels field of enclosed charge everywhere!
Faraday Ice Pail
Charge on Conductor
Non-spherical conductor

\[ \vec{E} = \frac{\sigma}{\varepsilon_0} \hat{n} \]
always perpendicular to surface

- To accomplish this, charge concentrated near sharp corners
Non-spherical Conductor

- Local contours tangent to surface
- Far away contours roughly spherical
  \[ \Rightarrow \] close spacing near tips
  \[ \Rightarrow \] strong \( \vec{E} \)
**Force on Conductor**

\[ \Delta \vec{E} = \sigma \hat{n} \]

\[ \Rightarrow \vec{E}_{\text{outside}} = \frac{\sigma}{\epsilon_0} \hat{n} = -\frac{\sigma}{\epsilon_0} \hat{n} \]

\[ \Rightarrow \sigma = \frac{\epsilon_0}{\text{In}} \]

\[ = \frac{1}{2} \vec{E} \]

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*In presence of external \( \vec{E}_{\text{other}} \), charge feels a force*

**Force/area**

\[ \vec{F} = \sigma \vec{E}_{\text{average}} \]

\[ = \frac{1}{2} \sigma (\vec{E}_{\text{above}} + \vec{E}_{\text{below}}) \]

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Consider "patch" of charge

Consider a region of charge \( \sigma \) with an external field \( \vec{E}_{\text{other}} \).

\[ \vec{E} = \vec{E}_{\text{patch}} + \vec{E}_{\text{other}} \]

\[ \vec{E}_{\text{above}} = \vec{E}_{\text{other}} + \frac{\sigma}{2 \epsilon_0} \hat{n} \]

\[ \vec{E}_{\text{below}} = \vec{E}_{\text{other}} - \frac{\sigma}{2 \epsilon_0} \hat{n} \]

\[ \Rightarrow \vec{E}_{\text{other}} = \frac{1}{2} (\vec{E}_{\text{above}} + \vec{E}_{\text{below}}) = \vec{E}_{\text{average}} \]
Conductor

\[ \vec{E}_{\text{above}} = \sigma / \varepsilon_0 \hat{n} \]
\[ \vec{E}_{\text{below}} = 0 \]

\[ \vec{E}_{\text{average}} = \sigma / 2 \varepsilon_0 \hat{n} \]

\[ \vec{F} = \sigma \vec{E}_{\text{average}} \]
\[ = \sigma \varepsilon_0 \frac{\varepsilon_0}{2} \hat{n} \]

- outward electrostatic pressure

\[ P = |\vec{F}| = \sigma \varepsilon_0 \frac{\varepsilon_0}{2} = \left( \frac{\sigma}{\varepsilon_0} \right)^2 \frac{\varepsilon_0}{2} \]
\[ = \frac{1}{2} \varepsilon_0 \vec{E}_{\text{above}}^2 \]

pressure \leftrightarrow energy density