\[ \nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0} \]

\[ \nabla \cdot \mathbf{B} = 0 \]

\[ \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \]

\[ \nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \mathbf{J} \]

**Electricity and Magnetism I: 3811**

Professor Jasper Halekas
Van Allen 301
MWF 9:30-10:20 Lecture
# Electricity and Magnetism on One Slide

## Formulation in SI units

<table>
<thead>
<tr>
<th>Name</th>
<th>Integral equations</th>
<th>Differential equations</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gauss’s law</strong></td>
<td>$\iiint_{\partial \Omega} \mathbf{E} \cdot d\mathbf{S} = \frac{1}{\varepsilon_0} \iiint_{\Omega} \rho , dV$</td>
<td>$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$</td>
<td>The electric field leaving a volume is proportional to the charge inside.</td>
</tr>
<tr>
<td><strong>Gauss’s law for magnetism</strong></td>
<td>$\iiint_{\partial \Omega} \mathbf{B} \cdot d\mathbf{S} = 0$</td>
<td>$\nabla \cdot \mathbf{B} = 0$</td>
<td>There are no magnetic monopoles; the total magnetic flux piercing a closed surface is zero</td>
</tr>
<tr>
<td><strong>Maxwell–Faraday equation (Faraday’s law of induction)</strong></td>
<td>$\oint_{\partial \Sigma} \mathbf{E} \cdot d\ell = -\frac{d}{dt} \iiint_{\Sigma} \mathbf{B} \cdot d\mathbf{S}$</td>
<td>$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$</td>
<td>The voltage accumulated around a closed circuit is proportional to the time rate of change of the magnetic flux it encloses.</td>
</tr>
<tr>
<td><strong>Ampère’s circuit law (with Maxwell’s addition)</strong></td>
<td>$\oint_{\partial \Sigma} \mathbf{B} \cdot d\ell = \mu_0 \iiint_{\Sigma} \mathbf{J} \cdot d\mathbf{S} + \mu_0 \varepsilon_0 \frac{d}{dt} \iiint_{\Sigma} \mathbf{E} \cdot d\mathbf{S}$</td>
<td>$\nabla \times \mathbf{B} = \mu_0 \left( \mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right)$</td>
<td>Electric currents and changes in electric fields are proportional to the magnetic field circulating about the area they pierce.</td>
</tr>
</tbody>
</table>
E&M on One Coffee Cup

What part of

$\mathbf{E} \cdot d\mathbf{A} = \frac{q}{\varepsilon_0}$

$\mathbf{B} \cdot d\mathbf{A} = 0$

$\mathbf{E} \cdot d\mathbf{S} = -\frac{d\Phi_B}{dt}$

$\mathbf{B} \cdot d\mathbf{S} = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$

don't you understand?
Vector Analysis

\( \nabla (fg) = f \nabla g + g \nabla f \)
\( \nabla (\vec{u} \cdot \vec{v}) = \vec{u} \times (\nabla \times \vec{v}) + \vec{v} \times (\nabla \times \vec{u}) + (\vec{u} \cdot \nabla) \vec{v} + (\vec{v} \cdot \nabla) \vec{u} \)
\( \nabla \cdot (f \vec{v}) = f (\nabla \cdot \vec{v}) + \vec{v} \cdot (\nabla f) \)
\( \nabla \cdot (\vec{u} \times \vec{v}) = \vec{v} \cdot (\nabla \times \vec{u}) - \vec{u} \cdot (\nabla \times \vec{v}) \)
\( \nabla \times (f \vec{v}) = (\nabla f) \times \vec{v} + f (\nabla \times \vec{v}) \)
\( \nabla \times (\vec{u} \times \vec{v}) = \vec{u} (\nabla \cdot \vec{v}) - \vec{v} (\nabla \cdot \vec{u}) + (\vec{v} \cdot \nabla) \vec{u} - (\vec{u} \cdot \nabla) \vec{v} \)
Electrostatics
Potentials

Electric Field Lines

Equipotential Surface
Electric Fields in Matter
Magnetostatics
Magnetic Fields in Matter
Contacts/Office Hours

- **Instructor:** Jasper S Halekas
- **Office:** 414 Van Allen Hall
- **Phone:** (319) 335-1929
- **E-mail:** jasper-halekas@uiowa.edu
- **Office Hours:**
  - Monday 10:30-11:30 am,
  - Wednesday 2:00-3:00 pm,
  - Thursday 3:00-4:00 pm
  - *Or by Appointment*
Resources: Web Pages

- Web Pages:
  - Main Web Page
      - Hosts syllabus, schedule, class notes, assignments, etc.
  - ICON:
    - [https://uiowa.instructure.com/courses/88515](https://uiowa.instructure.com/courses/88515)
      - Links to main site, syllabus, schedule, etc.
        - All grades will be posted here
Notes from each class (both slides and blackboard material) will be merged and placed online in PDF form within one day after the class.

- Can be found on the main class web page, on the “Notes” tab.
The textbook can be purchased anywhere. Make sure you get the Fourth Edition.

We will use the same textbook next semester as well.
Reading

- Reading should be completed before lecture

- There are no graded quizzes
  - There will be some ungraded quizzes

- Reading ahead is highly recommended, and will make lecture and discussions more productive
  - It will also make you better prepared for exams
Weekly homework assignments will be hand-written and hand-graded. Assignments are due in class on Fridays (or before). If you do your homework in electronic form please print it out.

You are allowed to work with other students on the homework, but each student must write out a full set of solutions.

Solutions must clearly show all work. Full credit will not be given for incomplete work. Partial credit may be assigned for correct logic on intermediate steps even if you don’t get the final answer.

The lowest scoring of the 11 homework assignments will be dropped – i.e. you get a “freebie”
Exams

- Midterm exams will be held during regular class hours. The final exam will be two hours, scheduled during finals week at a time to be announced.

- Exams will be closed book, long-form, hand-graded
  - You will be provided with an equation sheet, which you can annotate as you see fit
  - Questions will require symbolic or text answers – no calculators needed

- No make-up exams other than in legitimate extenuating circumstances with prior approval!
  - If you do not contact me in advance you will not earn full credit for the exam
Exam Schedule:  Two Midterm Exams:
- Wednesday, Sep. 26  Ch. 1-2
- Wednesday, Nov. 7  Ch. 3-5.2
- Final Exam, TBD Date  Ch. 1-6

Grading:
- Homework  25%
- Two Midterms  20% Each
- Final Exam  35%
- Quizzes  Ungraded
Student A has the following scores:

<table>
<thead>
<tr>
<th>Category</th>
<th>Score</th>
<th>Percentage</th>
<th>Weight</th>
<th>Class Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>90/100</td>
<td>.900</td>
<td>25</td>
<td>22.5</td>
</tr>
<tr>
<td>Midterm 1</td>
<td>65/100</td>
<td>.65</td>
<td>20</td>
<td>13.0</td>
</tr>
<tr>
<td>Midterm 2</td>
<td>72/100</td>
<td>.72</td>
<td>20</td>
<td>14.4</td>
</tr>
<tr>
<td>Final</td>
<td>68/100</td>
<td>.68</td>
<td>35</td>
<td>23.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>68/100</strong></td>
<td><strong>.68</strong></td>
<td><strong>35</strong></td>
<td><strong>73.7/100</strong></td>
</tr>
</tbody>
</table>

Student A has 73.7 class points. These will determine his/her class rank, which will be used to determine his/her grade.
CLAS recommends the following grade distribution for advanced courses:

- A 22%, B 38%, C 36%, D 3%, F 1%.
- A similar curve will be used in assigning final grades – this curve may be adjusted slightly depending on the overall performance of the class.

For example:

- If 73.7 translated to a class rank of 9/18 = 50th percentile, Student A would get a B by this curve.
Cheating

- Don’t!

- Cheating is a major disservice to you and your classmates

- If you are caught, it will affect your grade, and you could face disciplinary action

- Copying homework solutions from anywhere is not fair play
  - If you don’t work out your homework yourself, it will very likely hurt your performance on exams
Please let me know if you have questions, comments, complaints, or are struggling with particular concepts. This class is for you, and I am here to help.

- Students may communicate with me by phone, e-mail, or in person
- Students with issues or questions should if possible raise them in person by attending office hours or by scheduling an appointment
- If you prefer to give me anonymous feedback there is a comments envelope on my door
Ask Questions!

- If you have a question, others likely have the same question
- Don’t be afraid to speak up!
What I Care About (And Don’t Care About) as an Instructor

- I care about:
  - Developing a strong conceptual understanding
  - Learning how to approach problems of different types and apply appropriate problem-solving techniques

- I don’t care about:
  - Rote memorization of facts or equations

- As you progress in physics, you will never be able to remember every equation
  - You don’t need to – that’s what reference material is for!
  - If you remember concepts and remember how to approach problems of different types, you will be a good physicist
<table>
<thead>
<tr>
<th>Dates</th>
<th>Week</th>
<th>Reading (Due Monday unless noted)</th>
<th>HW Due Friday</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 20-24</td>
<td>Week 1</td>
<td>Ch. 1.1-1.2</td>
<td>No HW</td>
<td></td>
</tr>
<tr>
<td>Aug. 27-31</td>
<td>Week 2</td>
<td>Ch. 1.3-1.5</td>
<td>HW 1</td>
<td></td>
</tr>
<tr>
<td>Sep. 3-7</td>
<td>Week 3</td>
<td>Ch. 1.6-2.1 (Wed)</td>
<td>HW 2</td>
<td><em>Labor Day Holiday 9/3</em></td>
</tr>
<tr>
<td>Sep. 10-14</td>
<td>Week 4</td>
<td>Ch. 2.2-2.3</td>
<td>HW 3</td>
<td></td>
</tr>
<tr>
<td>Sep. 17-21</td>
<td>Week 5</td>
<td>Ch. 2.4-2.5</td>
<td>HW 4</td>
<td></td>
</tr>
<tr>
<td>Sep. 24-28</td>
<td>Week 6</td>
<td>No Reading</td>
<td>No HW</td>
<td>Midterm #1 Wed 9/26 Chapters 1-2</td>
</tr>
<tr>
<td>Oct. 1-5</td>
<td>Week 7</td>
<td>Ch. 3.1-3.2</td>
<td>HW 5</td>
<td></td>
</tr>
<tr>
<td>Oct. 8-12</td>
<td>Week 8</td>
<td>Ch. 3.3-3.4</td>
<td>HW 6</td>
<td></td>
</tr>
<tr>
<td>Oct. 15-19</td>
<td>Week 9</td>
<td>Ch. 4.1-4.2</td>
<td>HW 7</td>
<td></td>
</tr>
<tr>
<td>Oct. 22-26</td>
<td>Week 10</td>
<td>Ch. 4.3-4.4</td>
<td>HW 8</td>
<td></td>
</tr>
<tr>
<td>Oct. 29-Nov. 2</td>
<td>Week 11</td>
<td>Ch. 5.1-5.2</td>
<td>HW 9</td>
<td></td>
</tr>
<tr>
<td>Nov. 5-9</td>
<td>Week 12</td>
<td>No Reading</td>
<td>No HW</td>
<td>Midterm #2 Wed 11/7 Chapters 3-5.2</td>
</tr>
<tr>
<td>Nov. 12-16</td>
<td>Week 13</td>
<td>Ch. 5.3-5.4</td>
<td>HW 10</td>
<td></td>
</tr>
<tr>
<td>Nov. 19-23</td>
<td>Thanksgiving Recess</td>
<td>No Reading</td>
<td>No HW</td>
<td><em>Turkey Week!</em></td>
</tr>
<tr>
<td>Nov. 26-30</td>
<td>Week 14</td>
<td>Ch. 6.1-6.4</td>
<td>HW 11</td>
<td></td>
</tr>
<tr>
<td>Dec. 3-7</td>
<td>Week 15</td>
<td>No Reading</td>
<td>No HW</td>
<td></td>
</tr>
<tr>
<td>Dec. 10-14</td>
<td>Finals Week</td>
<td>No Reading</td>
<td>No HW</td>
<td>Final Exam TBA on Ch. 1-6</td>
</tr>
</tbody>
</table>
Vectors

\[ \overrightarrow{A} = \begin{bmatrix} A_x, A_y, A_z \end{bmatrix} \] (bold face \( \overrightarrow{A} \) in text)

\[ |\overrightarrow{A}| = A = \sqrt{A_x^2 + A_y^2 + A_z^2} \]

Addition

\[ \overrightarrow{A} + \overrightarrow{B} = \begin{bmatrix} A_x + B_x, A_y + B_y, A_z + B_z \end{bmatrix} \]

\[ \overrightarrow{A} - \overrightarrow{B} = \overrightarrow{A} + (\overrightarrow{B}) \]

Multiplication

\[ a \overrightarrow{A} = \begin{bmatrix} aA_x, aA_y, aA_z \end{bmatrix} \]

Dot product

\[ \overrightarrow{A} \cdot \overrightarrow{B} = A_xB_x + A_yB_y + A_zB_z \]

\[ = |\overrightarrow{A}| |\overrightarrow{B}| \cos \theta_{AB} = AB \cos \theta_{AB} \]
The dot product involves projection:

\[ \vec{A} \cdot \vec{A} = A_x A_x + A_y A_y + A_z A_z = |\vec{A}|^2 = A^2 \]

\[ (\vec{A} - \vec{B}) \cdot (\vec{A} - \vec{B}) = A^2 + B^2 - 2AB \cos \theta_{AB} \]

"Law of cosines"

Cross product:

\[ |\vec{A} \times \vec{B}| = AB \sin \theta \]

Direction by right-hand rule

Area of parallelogram:

\[ A_B \sin \theta = \text{Area of parallelogram} \]