

# Introduction to Electromagnetism

## Overview

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# Electromagnetism

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### electromagnetism

Pronunciation: /ɪˌlektroʊˈmæɡnɪtɪz(ə)m/ Line-break:  On  Off

**5** *Physics* the region in which a particular condition prevails, especially one in which a force or influence is effective regardless of the presence or absence of a material medium.

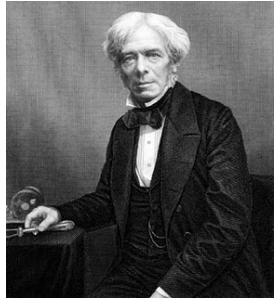
- the force exerted or potentially exerted in a field.

*noun*  
[mass noun]

the phenomenon of the interaction of electric currents or fields and magnetic fields.

- the branch of physics concerned with electromagnetism.

# Maxwell's Equations



Michael Faraday  
(1791–1867)

$$\nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = 0$$

Faraday's law

$$\nabla \times \mathbf{H} - \frac{\partial \mathbf{D}}{\partial t} = \mathbf{J}$$

*"Displacement current"*

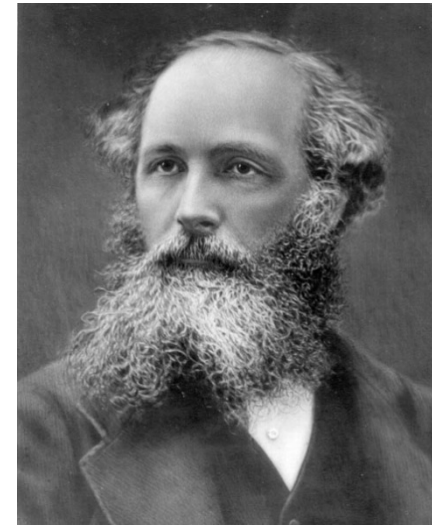
Ampère's law

$$\nabla \cdot \mathbf{D} = \rho$$

Gauss's law

$$\nabla \cdot \mathbf{B} = 0$$

No free magnetic monopole (?)



James Clerk Maxwell  
(1831–1879)

$$\mathbf{D} = \epsilon \mathbf{E} = \epsilon_0 \mathbf{E} + \mathbf{P}$$

Constitutive relations

$$\mathbf{H} = \frac{1}{\mu} \mathbf{B} = \frac{1}{\mu_0} \mathbf{B} - \mathbf{M}$$

*Findings of 19<sup>th</sup> century!!*

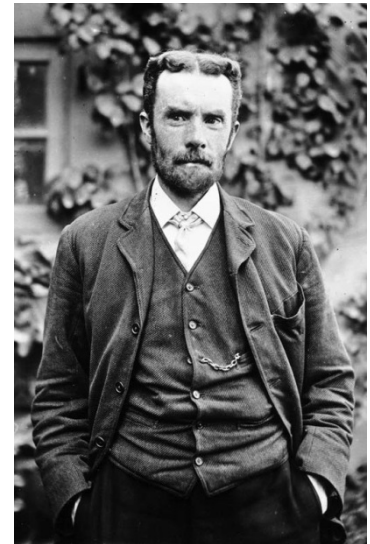
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Andre Marie Ampere  
(1775 - 1835)



Carl Friedrich Gauss  
(1777 - 1855)



Oliver Heaviside  
(1850–1925)

# James Clerk Maxwell



# Syllabus

- **Course book:**

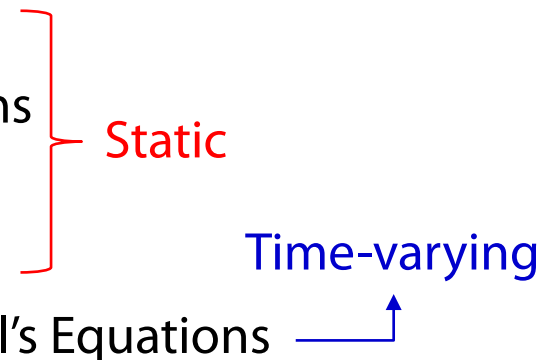
- Field and Wave Electromagnetics by D. K. Cheng, 2nd ed., Addison-Wesley, 1989.

- **What you have learnt (I presume):**

- Engineering mathematics I & II, Circuit theory I

- **What you will be learning:**

- Chap. 1. The Electromagnetic Model
- Chap. 2. Vector Analysis
- Chap. 3. Static Electric Fields
- Chap. 4. Solution of Electrostatic Problems
- Chap. 5. Steady Electric Currents
- Chap. 6. Static Magnetic Fields
- Chap. 7. Time-Varying Fields and Maxwell's Equations



- **Assessment:**

- Participation/quiz (10%), assignment (25%), practice (25%) exam 1 (15%), exam 2 (8%), exam 3 (17%)

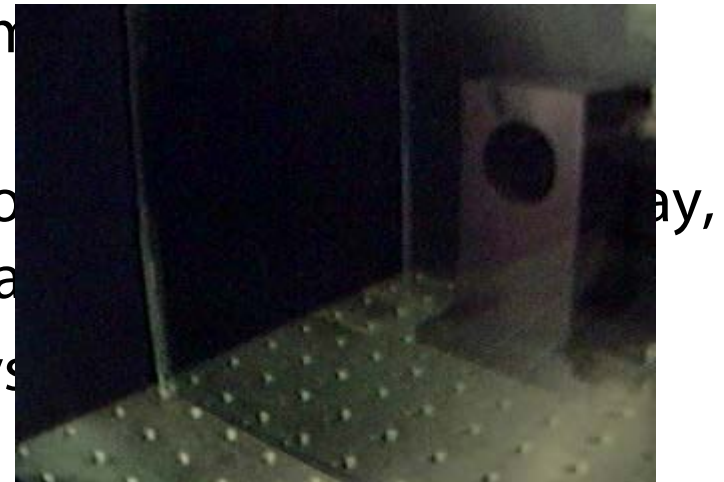
# Lightening: A Good Example!



[http://en.wikipedia.org/wiki/File:Lightning\\_over\\_Oradea\\_Romania\\_3.jpg](http://en.wikipedia.org/wiki/File:Lightning_over_Oradea_Romania_3.jpg)

# Conclusions

- “Introduction to Electromagnetism”: easy or difficult?
  - Only 4 independent equations!
  - *Even easier for static fields!*
- A lot of exciting things ahead if you’ve made it through!
  - Electronics (Wired/Wireless communication, high-speed circuits, etc.)
  - Photonics (Optical communication, bio-medicine, energy, nano/meta)
  - High-energy physics, atomic physics, etc.)



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