Electricity and Magnetism PHYS-350:

2013

(1005-1125 Tuesday, Thursday, Rutherford 115)

http://www.physics.mcgill.ca/~gang/PHYS350/PHYS350.home.htm

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Math background: **Prerequisites**: Math 222A,B (Calculus III= multivariate calculus), 223A,B (Linear algebra), **Corequisites**: **314A** (Advanced Calculus = vector calculus), 315A (Ordinary differential equations)

Primary Course Book: "Introduction to Electrodynamics" by D. J. Griffiths, Prentice-Hall, (2013, fourth edition).

Similar books:

-"Electromagnetism", G. L. Pollack, D. R. Stump, Addison and Wesley, 2002.

-"Electromagnetic fields" by R. K. Wangsness, 1979, John Wiley and Sons,

-"Classical Electromagnetism" by R. H. Good, 1999, Harcourt Brace College publishers.

-"Electromagnetic fields and waves" by P. L. Lorrain, D. P. Corson, F. Lorrain, 1988 (3rd edition) W. H. Freeman and co., New York.

Reference: "Classical Electrodynamics", J.D. Jackson, 1998 Wiley.

Outline:

1. Vector Analysis:
   Algebra, differential and integral calculus, curvilinear coordinates, Dirac δ function, potentials.
2. Electrostatics:
   Definitions, basic notions, laws, divergence and curl of the electric potential, work and energy.
3. Special techniques:
   Laplace's equation, images, seperation of variables, multipole expansion.
4. Electrostatic fields in matter:
   Polarization, electric displacement, dielectrics.
5. Magnetostatics:
   Lorenz force law, Biot-Savart law, divergence and curl of $\underline{B}$, vector potentials.
6. Magnetostatic fields in matter:
   Magnetization, field of a magnetic object, the auxiliary field $\underline{H}$, magnetic permeability, ferromagnetism.
7. Electrodynamics:
   Electromotive force, Faraday's law, Maxwell's equations.

PHYS 350 Assessment:

Homework **(20%)**:	Midterm **(30%)**:	Final **(50%)**:
There will be 5 assignment sheets each with about 10 problems from the course textbook. All students will be required to hand in the homework which will be marked by the TA. Deadlines will be typically 2 weeks later; the suggested total worth of all the submitted problems is 20%. The rationale for the low percentage is that you'll need to do the problems simply in order to understand the material and do the exams; the 20% is simply a small *extra* incentive.	The main purpose of the midterm is to assess where you are with respect to where you should be and for me to assess the class progress. The midterm will be in class (90 minutes) and will consist of three problems, you will be able to use one two sided crib sheet. I suggest 30% overall grade weight (however, see below). The date will be roughly the same day as the second marked assignment is returned, i.e. roughly 1/3 of the way into the semester.	The final will consist of 5 problems (3 hours) 4 of which will be on material covered since the midterm; you will be able to use one two sided crib sheet. The final will be worth 50% or 80% (midterm=0%), whichever formula gives a higher result. This means that even if the midterm is poor, you have a chance to redeem yourselves.

Outcomes

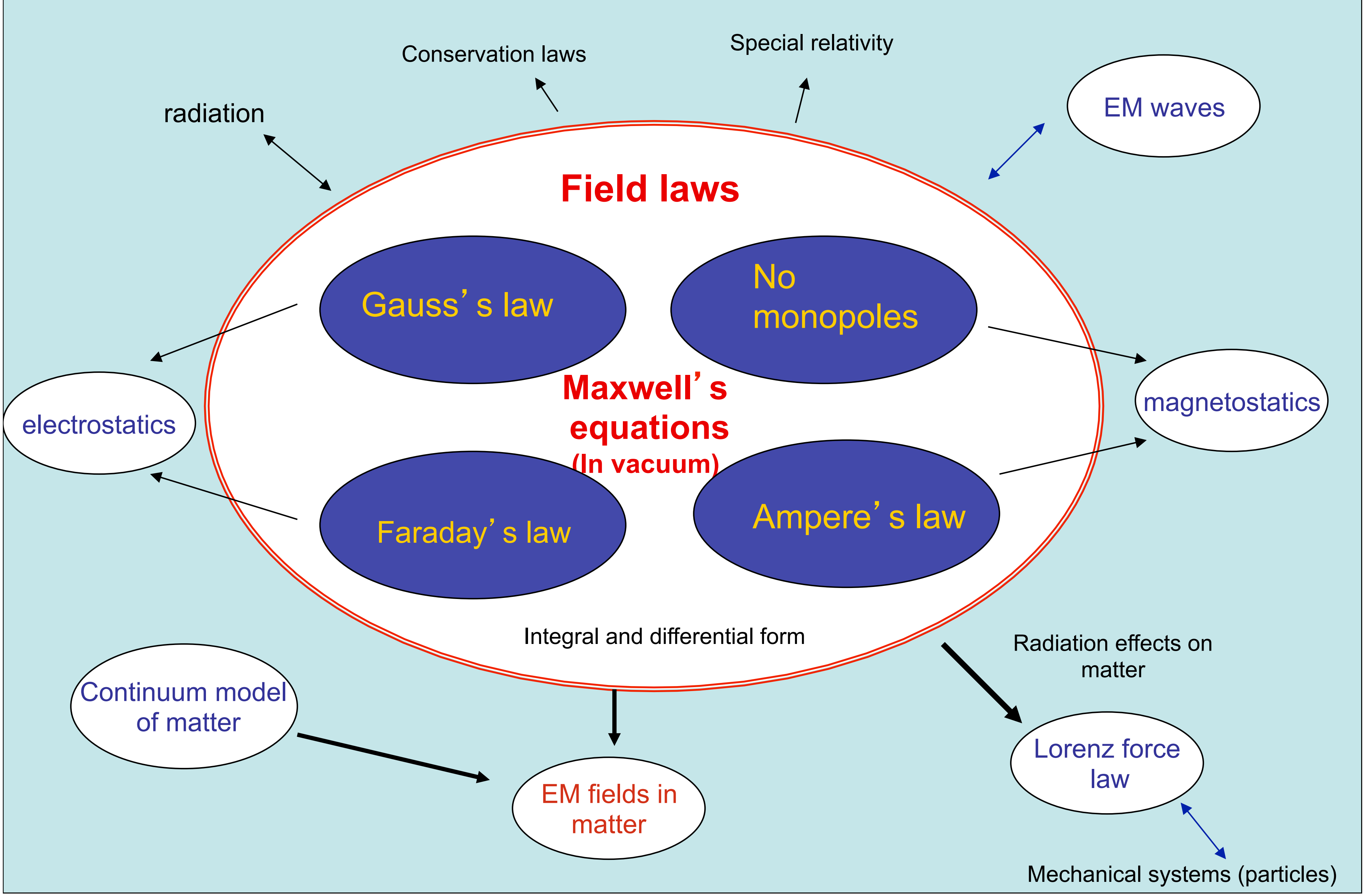
Concept	Outcomes	Rough time on topic (roughly the percentage of problems on a given topic)
Electrostatics	Solve problems involving static electric fields from charge distributions. Able to use scalar potentials, solve problems involving conductors, multipoles, image charges, the Laplace equation.	40%
Magnetostatics	Solve problems involving static current distributions. Able to use vector potentials, solve problems involving magnetic dipoles, Lorenz force law.	25%
EM Fields in matter	Be able to solve (static) problems involving polarization, magnetization, electric displacement and *H* fields	20%
Electrodynamics	Solve problems involving time varying E and B fields: electromotive force, electromagnetic induction.	15%

PHYS 350: Course Calender 2013

Homework #1 due Sept. 24
Homework #2 due Oct. 10
Midterm Oct. 22
Homework #3 due Oct. 29
Homework #4 due Nov. 12
Homework #5 due Nov. 29 (last class)

Note that these deadlines may be subject to some change, check the course web site.

EM concept map



Brief Chronology of the early development of Electricity Magnetism and optics (1)

≈300BC: The Greeks discover that amber displays electrical properties:

16thC: William Gilbert extends this to glass, sealing wax, sulphur, precious stones. He also showed that magnetism and electricity were different; the former could orient (e.g. iron filings) while the latter could not.

1621: Willebrod Snell discovered the correct law for the diffraction of light.

1637: Descartes proposed that light is particulate and derived Snell's law from that assumption.

1665: Francsco Grimaldi discovered that the edges of shadows were coloured and the shadows a little too big, phenomena he ascribed to waves in the "light fluid". He also suggested that different frequencies corresponded to different colours.

1672-76: Olaus Rohmer proposed that light travels with a finite velocity which he estimated from transit times of Jupiter's moons.

1678-1690: Christian Huygens proposed that light was longitudinal vibrations in the "luminiferous ether".

1680-1704: Newton proposed that light was corpuscular, and showed that white light was a mixture of colours.

1745: The Leiden jar and electric shock are discovered.

Chronology (2)

1750: John Mitchell, showed that $F \approx 1/r^2$ for magnetic repulsion.

1752: B. Franklin shows lightning is an electric phenomenon. He also proposed that an electrical fluid pervaded all space and material bodies. An excess of electrical fluid renders the body positively charged.... many problems (since excess charge found to "stick to surfaces").

1767: Priestly showed that no force is exerted on a charge within a hollow charged sphere, hence concludes (following Newton in gravity) that $F \approx 1/r^2$.

1785-1789: Coulomb showed that $F \approx 1/r^2$ for both E+M.

1799: Voltaic cell discovered (Volta), giving continuous current (unlike Leiden jar).

1801: Young resuscitated Huygen's wave theory of light and showed the existence of diffraction patterns.

1817: Fresnel derived the known laws of optics by assuming that light was a transverse wave.

1820: Oersted shows the magnetic effects of such currents. In particular, an electric current would rotate about a magnetic pole... first example of non-central force. This is the principle of the electric motor.

1820: Ampere deduces that magnetism = result of circular electric currents.

1831: Faraday discovers electromagnetic induction linking mechanical motion and magnetism to the production of current. This is the principle of the dynamo.

1834: Wheatstone showed that current electricity travels at speeds one and a half times (!) the speed of light.

1837: Electric condensers and dielectrics (Faraday).

Chronology (3)

1845: Analogous behaviour of magnetic materials (Faraday).
1846: Faraday suggests that light = "vibrations" of EM force lines (not quite right, but close).
1850: Fizeau showed that the speed of current ranges from 1/3 to 2/3 c depending on composition of wire.
1850-1862: Foucault accurately measured the speed of light using rotating mirrors.
1857: Kirchoff showed that static and current electricity were related by a constant of the order of the speed of light.
1862: Maxwell adds the last effect: that a changing electric field generates a magnetic field, thus discovering the last of "Maxwell's equations". He then proposed that light is an EM wave. He imagined that E+M fields were manifestations of disturbances in rotating tubes of ether with tiny particles acting as ball-bearings.
1883: Fitzgerald pointed out the possibility of generating EM waves from oscillating current.
1886: Hertz proved this experimentally by building a “detector” (antenna).