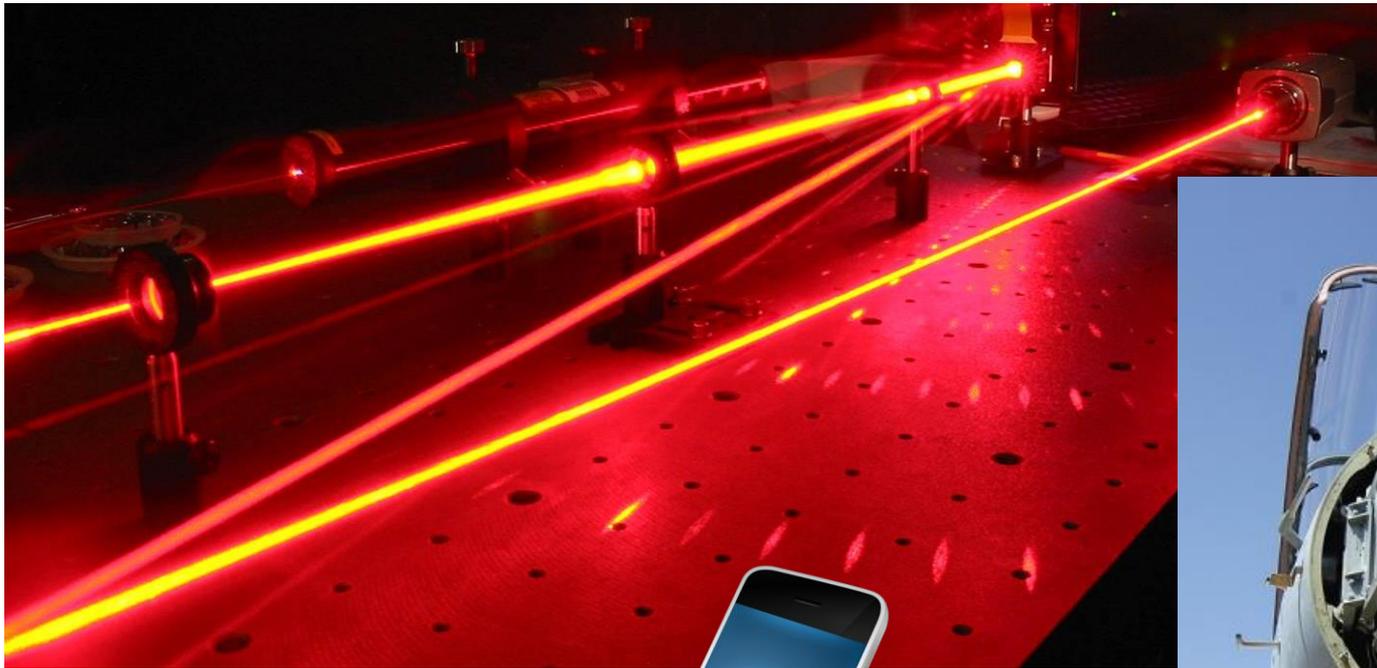
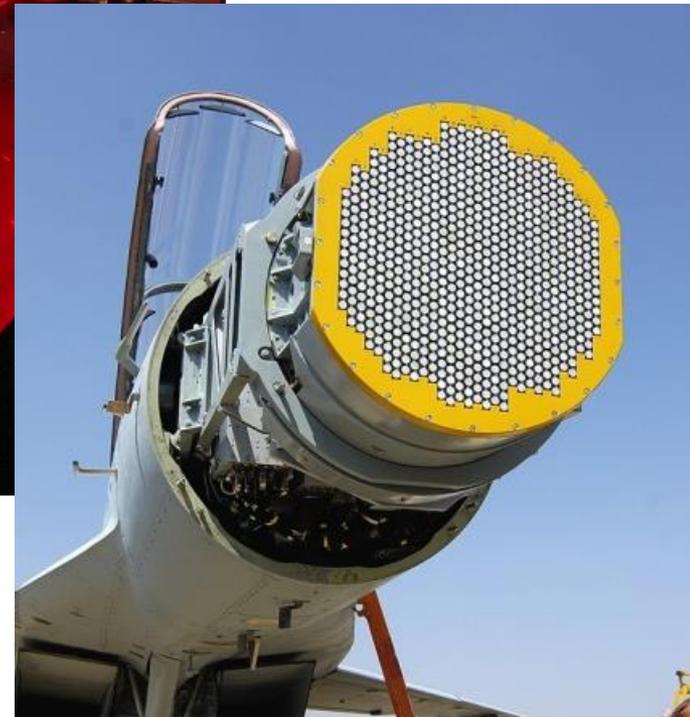


Physics 402: Electricity & Magnetism II

(i.e. time-dependent electromagnetism)



[image from www.apdconsumo.pt]



[image from weapons.technology.youngster.com]

Instructors

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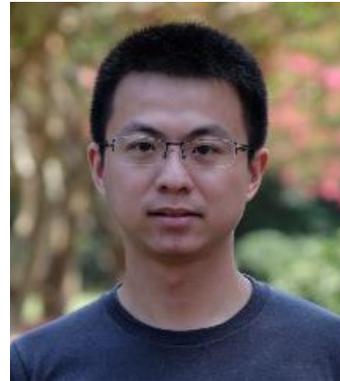
web: <http://www.physics.wm.edu/~saubin/index.html>



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Office hours:

Aubin: Wednesday 4-5pm

Chen: Tuesday 3-4pm

Course Objectives

Introduce the basic *physics* and *applications* of **time-dependent electromagnetic fields**.

The course will cover the following topics:

- Electromotive force, Faraday's law
- Ohm's law, inductance
- Maxwell's equations, Maxwell stress tensor
- EM field momentum, energy, and Poynting vector
- EM waves in vacuum and matter
- EM potentials, gauges, retarded potentials
- Waveguides and transmission lines
- Optics and diffraction theory
- Dipole radiation, radiation reaction
- EM simulation software
- Relativistic electrodynamics, $F_{\mu\nu}$, covariance

Statics vs. Dynamics: Applications

Time-independent E&M (PHYS 401):

- understand magnets.
- calculate electrical circuits.
(... at low frequencies)
- understand static electricity on a balloon ... free charges are rare !!!
- low energy ion beams.

Statics vs. Dynamics: Applications

Time-independent E&M (PHYS 401):

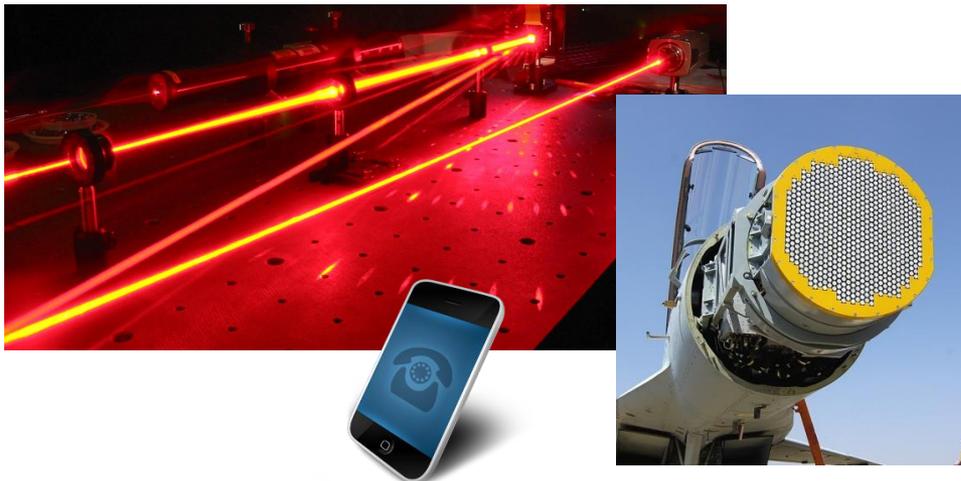
- understand magnets.
- calculate electrical circuits.
(... at low frequencies)
- understand static electricity on a balloon ... free charges are rare !!!
- low energy ion beams.

Time-dependent E&M (PHYS 402):

- antennas, radio, radar ...
... wireless, microwave ovens ...
- all of optics.
- relativity, speed of light.
- first unification of forces/fields.

$$\vec{E} \leftrightarrow \vec{B}$$

- modern particle accelerators.



... a few more things about E&M

- E&M is the most mathematically sophisticated theory in Physics.
... except for quantum field theory ... general relativity.
- Standard E&M theory can solve very hard/complex problems.
- E&M is generally the hardest part of graduate qualifying exams.
- Electrodynamics is an important part of the GRE.

Course Work

- **Problem sets:** weekly.
- **Participation:** class attendance, classroom discussion, occasional quiz.
- **Midterm** (after fall break).
- **Final** covers all course material with emphasis on 2nd half of course.

Weighting:

Problem sets:	45%
Participation:	10%
Midterm:	15%
Final Exam:	30%
<hr/>	
Total =	100%

References

Text: Almost all of the course materials and problem sets will be taken from the following required text for the course:

Introduction to Electrodynamics by D. Griffiths
[Prentice-Hall (3rd/4th ed., 2013)]

EM simulation software: FEKO in the Electronics Lab.

The rest of the course materials will be taken from the following texts:

Classical Electrodynamics, by J. D. Jackson.

Modern Electrodynamics, by A. Zangwill.

The Feynman Lectures on Physics, by R. Feynman, R. Leighton, M. Sands.

Schedule (I)

Week 0: 8/25

Review of Electrostatics & Magnetostatics

Brief review of time independent electric & magnetic fields in vacuum and matter.

Week 1: 8/30-9/1

Introduction to Electrodynamics

Faraday's law, Lenz's law, electromotive force, inductance.

Week 2: 9/6-8

Maxwell's Equations

The unification of electricity & magnetism, displacement currents.

Week 3: 9/13-15

Electromagnetic Momentum

Momentum of EM fields, Maxwell's stress tensor, Poynting vector.

Week 4: 9/20-22

Electromagnetic Waves in Vacuum

Wave solutions to Maxwell's equations, light, and polarization.

Week 5: 9/27-29

Introduction to Optics: EM waves in matter

Reflection and refraction at a dielectric interface.

Week 6: 10/4-6

Optics continued

Brewster's angle, total internal reflection, EM waves in conductors.

----- *Fall Break* -----

Week 7: 10/13

Midterm

Schedule (II)

Week 8: 10/18-20 **Transmission Lines and EM Resonators**

TEM transmission lines, coaxial cables, and Fabry-Perot cavities.

Week 9: 10/25-27 **Potentials, Gauges, and Fields**

Coulomb and Lorentz gauges, retarded potentials, Liénard-Wiechert potentials.

Week 10: 11/1-3 **Radiation Fields**

Radiation from accelerating charges, synchrotron radiation.

Week 11: 11/8-10 **Dipole Radiation**

Dipole radiation, basic antenna theory, radiation reaction, synchrotron radiation.

Week 12: 11/15-17 **Diffraction Theory & EM Simulation**

Fraunhofer & Fresnel diffraction. EM simulation.

Week 13: 11/22 **Lorentz Transformations**

EM simulation (cont.), Lorentz invariance, relativistic mechanics, 4-vectors

----- Thanksgiving Break -----

Week 14: 11/29-12/1 **Relativistic Electrodynamics**

$F_{\mu\nu}$, Lorentz invariance, covariant formulation of Electromagnetism.

Dec 7, 2016, 9am-noon **Final Exam**