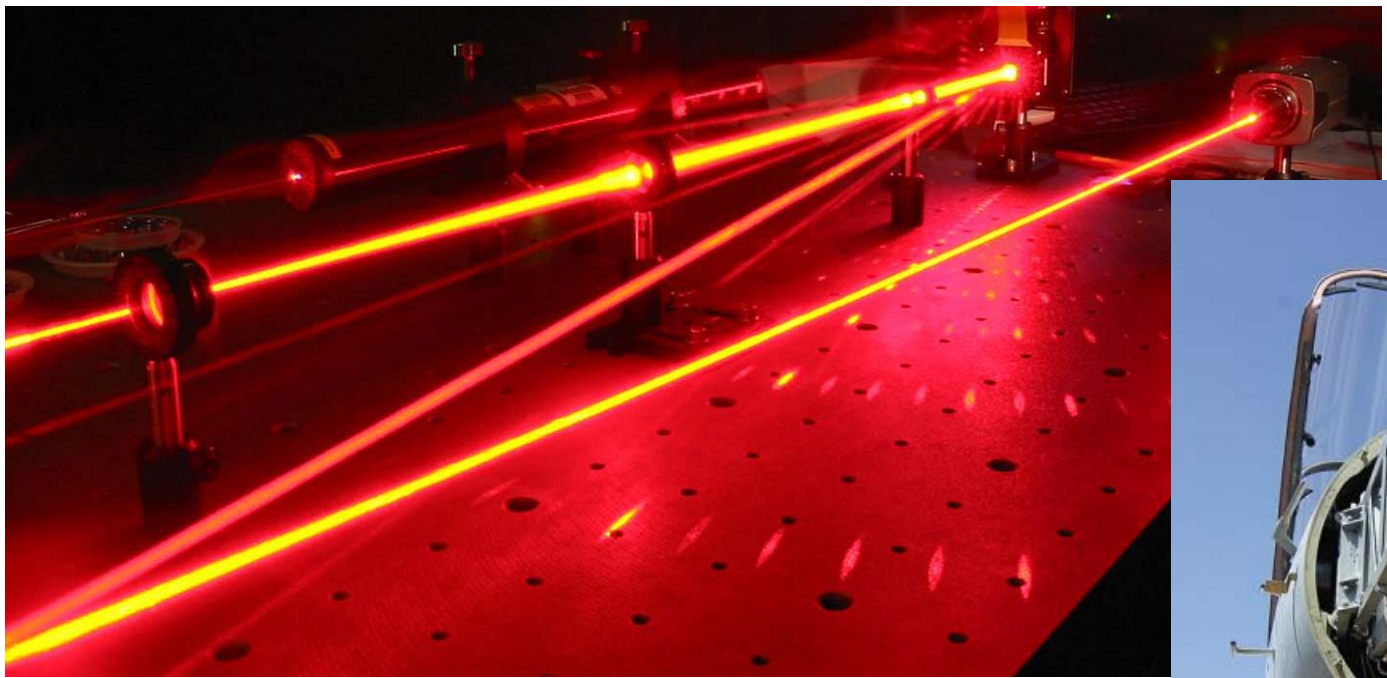
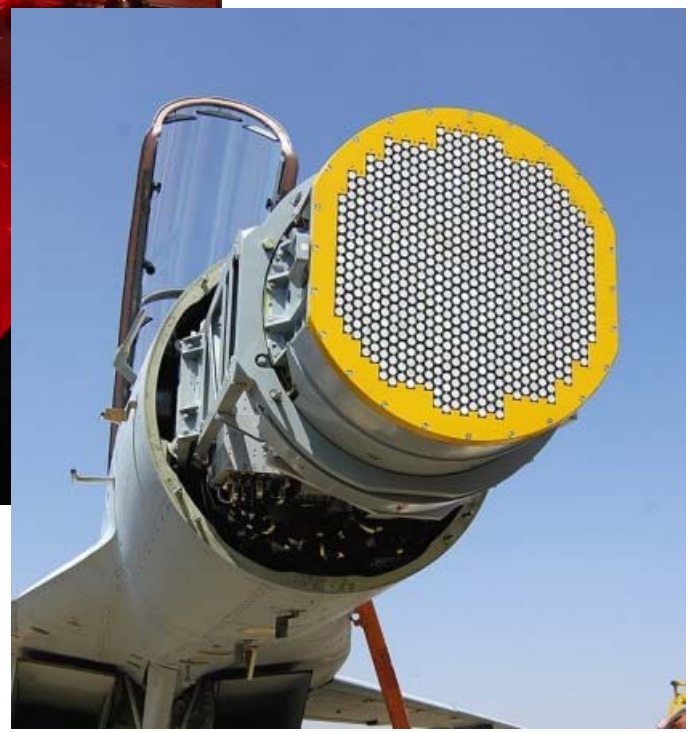
Physics 402: Electricity & Magnetism II

(i.e. time-dependent electromagnetism)





[image from weapons.technology.youngester.com]

Instructors

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Wednesday: 4:30-5:30 pm (Aubin)
(Fancher/Pyle: TBA)

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
- Electromagnetic field momentum, energy, and Poynting vector
- Electromagnetic waves in vacuum and matter
- Electromagnetic potentials, gauges, retarded potentials
- Waveguides and transmission lines
- Optics and diffraction theory
- Dipole radiation, radiation reaction
- 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 !!!

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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.

- 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%
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 ed., 1999)]

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

Classical Electrodynamics, by J. D. Jackson.

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 **Wave Optics: Diffraction Theory**
Fraunhoffer and Fresnel diffraction. Diffraction integrals.

Week 13: 11/22 **Lorentz Transformation**
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 14, 2011, 9am-noon **Final Exam**