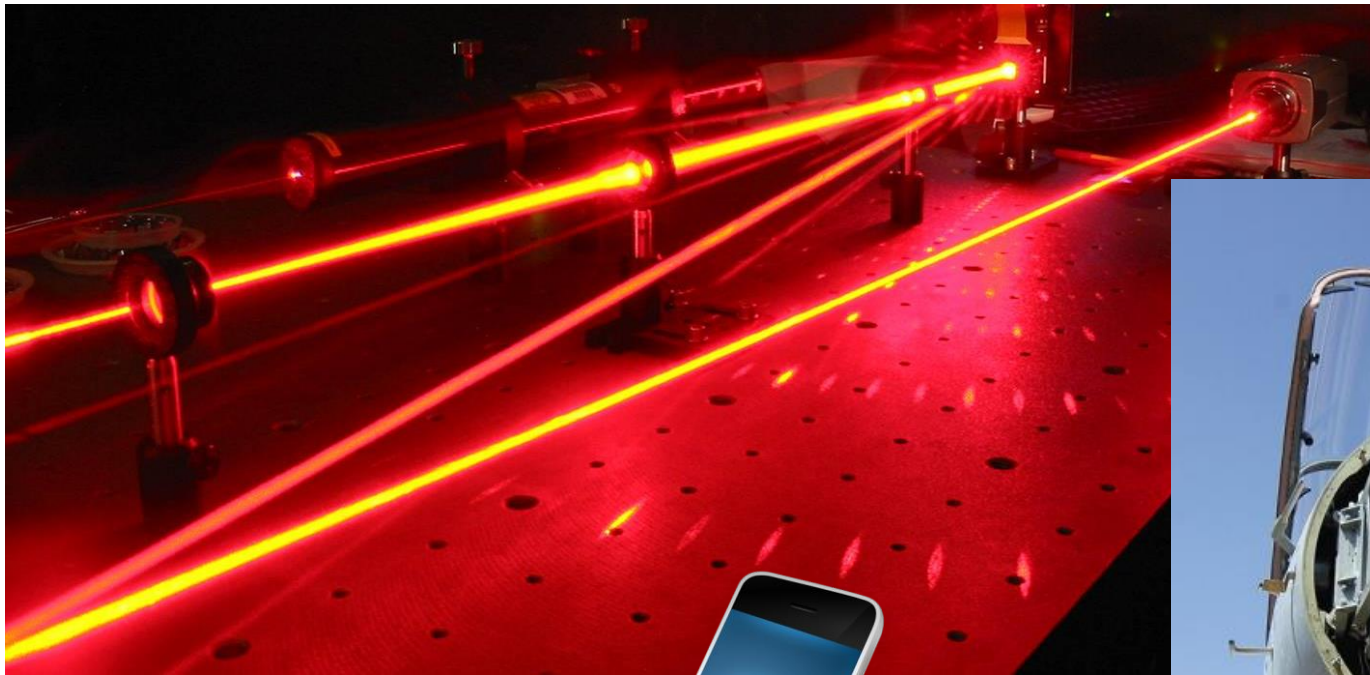


# Physics 402: Electricity & Magnetism II

(i.e. time-dependent electromagnetism)



[image from [www.apdconsumo.pt](http://www.apdconsumo.pt)]



[image from [weapons.technology.youngster.com](http://weapons.technology.youngster.com)]

# Instructors

## Prof. Seth Aubin

Office: room 255, Small Hall, tel: 1-3545

Lab: room 069, Small Hall (new wing), tel: 1-3532

e-mail: [saubi@wm.edu](mailto:saubi@wm.edu)

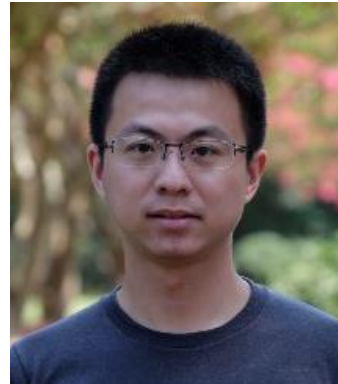
web: <http://www.physics.wm.edu/~saubin/index.html>



## Junhao Chen

Office: room 220A, Small Hall

e-mail: [jchen11@email.wm.edu](mailto:jchen11@email.wm.edu)



## 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):

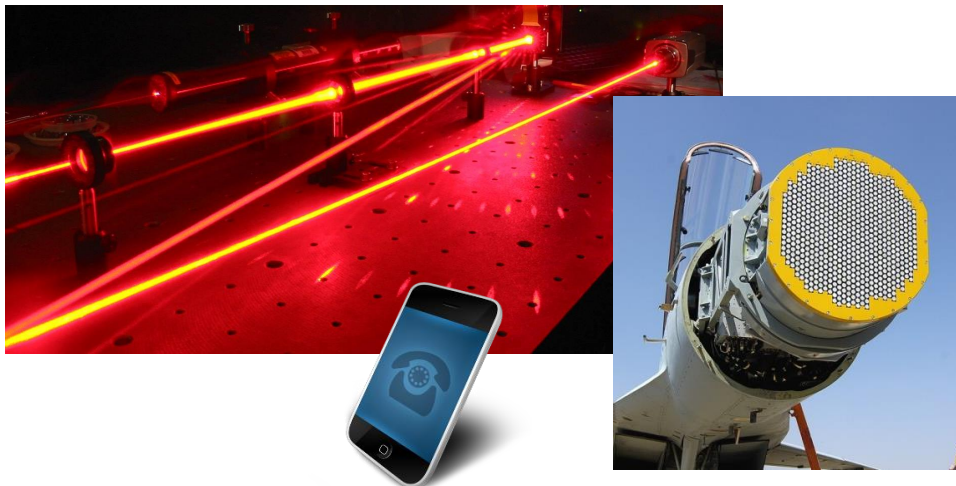
- understand magnets.
- calculate electrical circuits.  
(... at low frequencies)
- understand static electricity on a balloon ... free charges are rare !!!
- low energy ion beams.

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 2<sup>nd</sup> 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 (3<sup>rd</sup>/4<sup>th</sup> 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**