

# **Applied Electromagnetism: Magnet and RF-Cavity Design**

Jeremiah Holzbauer - FNAL

Mauricio Lopes - FNAL

# Objectives

This course will focus on the theory and design of the two main components of accelerators: magnets and RF cavities. The class will be structured to give a good understanding of the underlying electromagnetics as well as the practical demands of component design.

While this class is not intended to be a software tutorial, modeling software will be used extensively to give students hands-on experience with the process of designing these accelerator components.

# Class Structure 1

- 20 Lectures (~1.5h each)
- ~ 12 hours of tutorials
- 12+ hours for the project development
- ~ 6 hours for the final project presentations

# Class Structure 2

- Homework (40%)
- Project (60 %)
  
- The project will be done in pairs.
- The teams should be decided by the end of this week!
- Drawing lots on Friday of this week
- Each team will develop two projects: a Magnet and a Cavity related project.
- Afternoons of the second week dedicated to the projects development.
- No HW during the second week.
- Final presentation will be on Thursday of the next week.

# Schedule

Magnet design tutorial  
 RF Cavity design tutorial  
 Final Project development  
 School ends at noon

Magnet design lecture  
 RF Cavity design lecture  
 Final Project Presentations  
 Summary

First week					
	Monday	Tuesday	Wednesday	Thursday	Friday
9:00-10:30	Introduction	Cavities and Figures of Merit	Stored Energy	Couplers and Cavity Testing	FEM
10:45-12:15	Introduction to RF	Perturbations	Design Examples	Magnetic Measurements	Tutorial (FEMM)
12:15-13:30	Lunch				
13:30-15:00	Conformal Map	RF Components	Tutorial	Tutorial (OPERA3D)	Simulation Procedure
15:15-16:45	Waveguides and Cavities	Magnet Excitation			Tutorial

Second week					
	Monday	Tuesday	Wednesday	Thursday	Friday
9:00-10:30	Practical Concerns	SC magnets	Advanced Simulations	Presentations	Summary
10:45-12:15	Magnet Fabrication	Advanced Design	Unusual designs		
12:15-13:30	Lunch				School end
13:30-15:00	Project	Project	Project	Presentations	
15:15-16:45					

# Course Material

- J. Tanabe – “Iron Dominated Electromagnets: Design, Fabrication, Assembly and Measurements” - World Scientific Pub Co Inc – 2005 – ISBN: 981256327X  
<http://www.slac.stanford.edu/cgi-wrap/getdoc/slac-r-754.pdf>
- Class notes

# General School Information

- USPAS Office is in the Tannehill Room (open 8:30 am to 5 pm)
- Classes start at 9 a.m.
- Dinner will be in the “Capitol D” ballroom from 6 pm to 7 pm
- Study will be held in the “Capitol D” ballroom immediately following dinner (open from 7 pm to midnight)
- This classroom will be open until midnight

# Instructors

## Jeremiah Holzbauer

- Undergraduate at the University of Wisconsin – Madison
  - Applied Mathematics, Nuclear Engineering, Physics
- Graduate Work at Michigan State University
  - Superconducting RF
  - Low-Beta cavity design for the Facility for Rare Isotope Beams (FRIB)
  - Multi-harmonic buncher/RFQ design for FRIB and ReA3
- Post-doctoral Work at Argonne National Laboratory
  - Advanced Photon Source – Upgrade, short pulse x-ray production
  - SRF deflecting-mode cavity research and development with heavily damped
  - Lower/Higher-Order Mode damper design
  - Cryomodule Design
- Associate Scientist at Fermi National Accelerator Laboratory
  - Dressed 1.3 GHz R&D for LCLS-II
  - Mechanical Tuner R&D for LCLS-II and PIP-II
  - Active Resonance Control for Microphonics Compensation

jholzbauer@fnal.gov

# Instructors

## Mauricio Lopes

- Undergraduate at the University of Sao Paulo – Brazil
  - Physics
- Graduate Work at University of Sao Paulo - Brazil
  - Transport Line Magnets Design
  - Main Microtron Design
- Physicist/Magnet Designer for the Spanish Light Source (ALBA), Barcelona, Spain
  - SR Magnets
  - Booster Magnets
  - Transfer Line Magnets
- Post-doctoral Work at Fermilab
  - IR Quadrupoles for ILC
  - Helical Solenoids for the Muon Collider
- Associate Scientist at Fermilab
  - Mu2e Transport Solenoids
  - Elliptical Combined Function Magnets for the Muon Collider SR
- Scientist I
  - Mu2e Transport Solenoid Leader

mllopes@fnal.gov