Introduction

EE 2FH3 Winter 2014 (Prof. Mohamed H. Bakr)

ELECTROMAGNETICS I

Room: ITB-A219 ext. 24079

E-mail: mbakr@mail.ece.mcmaster.ca

Main Topics

* Vector Calculus
* Electrostatics
* Magnetostatics
* Introduction to Electromagnetic Waves

Information about myself

B.Sc. in Electronics and Communication Engineering, Cairo University, Cairo, Egypt with Distinction (honors), 1992

M.Sc. in Engineering Mathematics (Optimization), Cairo University, 1996

Ph.D. in Computer Aided Design (CAD) of Microwave Circuits, McMaster University, 2000

P.Eng., Ontario, 2003

Author/coauthor of over 200 journal and conference papers, two book chapters, one book, and two patents

Information about myself (Cont'd)

Research Areas: Optimization methods, computer-aided design and modeling of microwave circuits and photonic structures, neural networks applications, computational electromagnetics, bioelectromagnetism, and nanophotonics

Awards/Scholarships:
TRIO Student Internship in OSA, inc. 1997
Ontario Graduate Scholarship (OGS) 1998-2000,
NSERC PostDoctoral Fellowship 2000-2001,
Premier's Research Excellence Award (PREA) 2003-2009,
McMaster Tenure 2007
NSERC DAS Award, 2011
Full Professor 2013

Information about myself (Cont'd)

Courses taught:

ECE 750 Advanced Engineering Electromagnetics

EE 2EI4 Electronic Devices and Circuits

EE 3TP4 Signals and Systems

ECE 757 Numerical Techniques in Electromagnetics

EE 2EI5 Electronic Devices and Circuits

EE 3FI4 Theory and Applications in Electromagnetics

EE 2FH3 Electromagnetics I

EE 2CI5 Introduction To Electrical Engineering

EE 3FK4 Electromagnetics II

ECE 733Nonlinear Optimization for Electrical Engineering

ECE4OI6 Engineering Design

Associate editor of two electromagnetics-related journals

Texts

Recommended text

1- Matthew N.O. Sadiku, *Elements of Electromagnetics*, 5th edition, Oxford University Press.

2. Course webpage

http://www.ece.mcmaster.ca/faculty/bakr/ee2FH3/EE2FH3_Main_2014.htm

3. M.H. Bakr, *Matlab Experiments Manual for EE2FH3*, McMaster University Courseware, 2007.

Grading

Final exam: 50 %

Midterm exams: 30 %

First Midterm February 25th, 6:30 pm-8:30 pm

Second Midterm March 24th, 6:30 pm-8:30 pm

5 Matlab Assignments: 10 %

Project: 10% (5% more bonus)

Failure on the final exam means failure of the course!

all grades final unless error in marking proven

Maxwell's Equations

Integral form	Differential form
$\oiint_S \boldsymbol{D}.d\boldsymbol{S} = \iiint_V q_{ev}\, dV = Q_{ev}$	$\nabla.\boldsymbol{D} = q_{ev}$
$\oiint_S \boldsymbol{B}.d\boldsymbol{S} = 0$	$\nabla.\boldsymbol{B} = 0$
$\oint_C \boldsymbol{E}.d\boldsymbol{l} = -\frac{\partial}{\partial t}\iint_S \boldsymbol{B}.d\boldsymbol{S}$	$(\nabla \times \boldsymbol{E}) = -\frac{\partial \boldsymbol{B}}{\partial t}$
$\oint_C \boldsymbol{H}.d\boldsymbol{l} = \iint_S \boldsymbol{J}.d\boldsymbol{S} + \frac{\partial}{\partial t}\iint_S \boldsymbol{D}.d\boldsymbol{S}$	$(\nabla \times \boldsymbol{H}) = \boldsymbol{J} + \frac{\partial \boldsymbol{D}}{\partial t}$

The Static Case

Integral form	Differential form
$\oiint_S \boldsymbol{D}.d\boldsymbol{S} = \iiint_V q_{ev}\, dV = Q_{ev}$	$\nabla.\boldsymbol{D} = q_{ev}$
$\oiint_S \boldsymbol{B}.d\boldsymbol{S} = 0$	$\nabla.\boldsymbol{B} = 0$
$\oint_C \boldsymbol{E}.d\boldsymbol{l} = 0$	$(\nabla \times \boldsymbol{E}) = \boldsymbol{0}$
$\oint_C \boldsymbol{H}.d\boldsymbol{l} = \iint_S \boldsymbol{J}.d\boldsymbol{S}$	$(\nabla \times \boldsymbol{H}) = \boldsymbol{J}$

Covered Topics

1. Mathematical basics: vector algebra, vector calculus, coordinate systems and transformations
2. Electrostatics in vacuum
3. Current and conductors
4. Dielectrics and capacitance
5. The Poisson and Laplace equations
6. The steady magnetic field
7. Magnetic force, torque and energy
8. Magnetic materials and inductance
9. Faraday's law
10. Wave propagation in lossless and lossy media

Detailed Lecture Tables

Date	Lecture	Description	Chapter
Jan 6th	0	Organizational Meeting	
Jan 8th	1	Vector Algebra: scalars and vectors, unit vectors, subtraction and addition, position and distance vectors, vectors multiplications	Chapter 1: pages 3-15
Jan 10th	2	Vector Algebra: scalar triple product, vector triple product, Cartesian coordinates, cylindrical coordinates	Chapter 1: pages 15-25, Chapter 2: pages 29-33
Jan 13th	3	Vector Algebra: spherical coordinates, constant value surfaces	Chapter 2: pages 33-49
Jan 15th	4	Vector Calculus: differential elements, line integrals	Chapter 3: pages 57-67
Jan 17th	5	Vector Calculus: Del operators, gradient of a scalar, Divergence operator, Divergence theorem	Chapter 3: pages 67-79
Jan 20th	6	Vector Calculus: Curl operator, Stokes theorem, Laplacian of a scalar, Classification of vectors	Chapter 3: pages 80-95
Jan 22nd	7	Electrostatic Fields: Coloumb’s law, definition of electric field	Chapter 4: pages 107-115

Detailed Lecture Tables (Cont'd)

Jan 24th	**8**	**Electrostatic Fields: superposition: line charges, surface charges, volume charges**	**Chapter 4: pages 115-126**
Jan 27th	9	Electrostatic Fields: Electric flux density, Gauss law, applications of Gauss law	Chapter 4: pages 126-137
Jan 29th	10	Electrostatic Fields: Electric potential, relations between E and V	Chapter 4: pages 137-146
Jan 31st	11	Electrostatic Fields: Electric dipole, Energy density	Chapter 4: pages 146-160
Feb 3rd	12	Fields in Different Materials: Convection and Conduction currents, Conductors	Chapter 5: pages 173-182
Feb 5th	13	Fields in Different Materials: Polarization in dielectrics, dielectric constant and strength, linear, isotropic, and homogenous medium	Chapter 5: pages 183-191
Feb 7th	14	Fields in Different Materials: continuity equations, boundary conditions,	Chapter 5: pages 192-206
Feb 10th	15	Electrostatic Boundary Value Problems: Poisson's and Laplace's equations, applications	Chapter 6: pages 215-239
Feb 12th	16	Electrostatic Boundary Value Problems: Resistance and capacitance, applications	Chapter 6: pages 239-256

Detailed Lecture Tables (Cont'd)

Feb 14th	**17**	**Electrostatic Boundary Value Problems: method of images, applications**	**Chapter 6: pages 256-267**
Feb 24th	18	Magnetostatic Fields: Biot-Savart's law, applications	Chapter 7: pages 281-292
February 25th, at 6:30 pm, First Midterm			
Feb 26th	19	Magnetostatic Fields: Ampere's law, applications	Chapter 7: pages 293-300
Feb 28th	20	Magnetostatic Fields: Magnetic flux density, magnetic Scalar and vector potential, applications	Chapter 7: pages 301-310, 312-316
March 3rd	21	Magnetostatic Forces, Materials, and devices: Forces due to magnetic Fields, forces due to two current elements	Chapter 8: pages 331-343
March 5th	22	Magnetostatic Forces, Materials, and devices: Magnetic torque, magnetic dipole, applications	Chapter 8: pages 343-350
March 7th	23	Magnetostatic Forces, Materials, and devices: Magnetization in materials, classification of matter, magnetic boundary conditions	Chapter 8: pages 350-362
March 10th	24	Magnetostatic Forces, Materials, and devices: Inductors and inductances, magnetic energy	Chapter 8: pages 362-373
March 12th	25	Magnetostatic Forces, Materials, and devices: Magnetic circuit, Force on magnetic materials, applications	Chapter 8: pages 374-383
March 14th	26	Maxwell's Equations: Faraday's law, applications	Chapter 9: pages 399-410

Detailed Lecture Tables (Cont'd)

March 17th	**27**	**Maxwell's Equations: Displacement current, final formulation of Maxwell's equations, time-varying potentials**	**Chapter 9: pages 411-419**
March 19th	28	Maxwell's Equations: Time harmonic waves, applications	Chapter 9: pages 419-432
March 21st	29	Maxwell's Equations: Wave equation, General definitions	Chapter 10: pages 445-452
March 24th, at 6:30 pm, Second Midterm			
March 24th	30	Maxwell's Equations: Waves in lossy media	Chapter 10: pages 452-458
March 26th	31	Maxwell's Equations: Plane waves, plane waves in good conductors	Chapter 10: pages 458-470
March 28th	32	Maxwell's Equations: Poynting vector and power	Chapter 10: pages 470-475

Surprise!

123rf.com

Flipped Classroom

You are part of an experiment in engineering education

I will not be teaching! You will be learning. My rule is to guide your learning experience (from the sage on stage to the guide on the side)

All lectures in video will be available on iTunesU, the night before your lecture

You will spend around 50 minutes listening to the lecture before coming to the classroom. You will read the corresponding part in the textbook and attempt to solve drill problems.

We will have discussions on more problems and practical applications in the classroom

Flipped Classroom (Cont’d)

Course lecture resources on iTunesU (download iTunes, go to iTunes Store, and then open iTunesU)

Groups of 6 to be seated together (to facilitate discussions)

I will pose a problem and ask groups to discuss possible solution during the class. Will help in discussions.

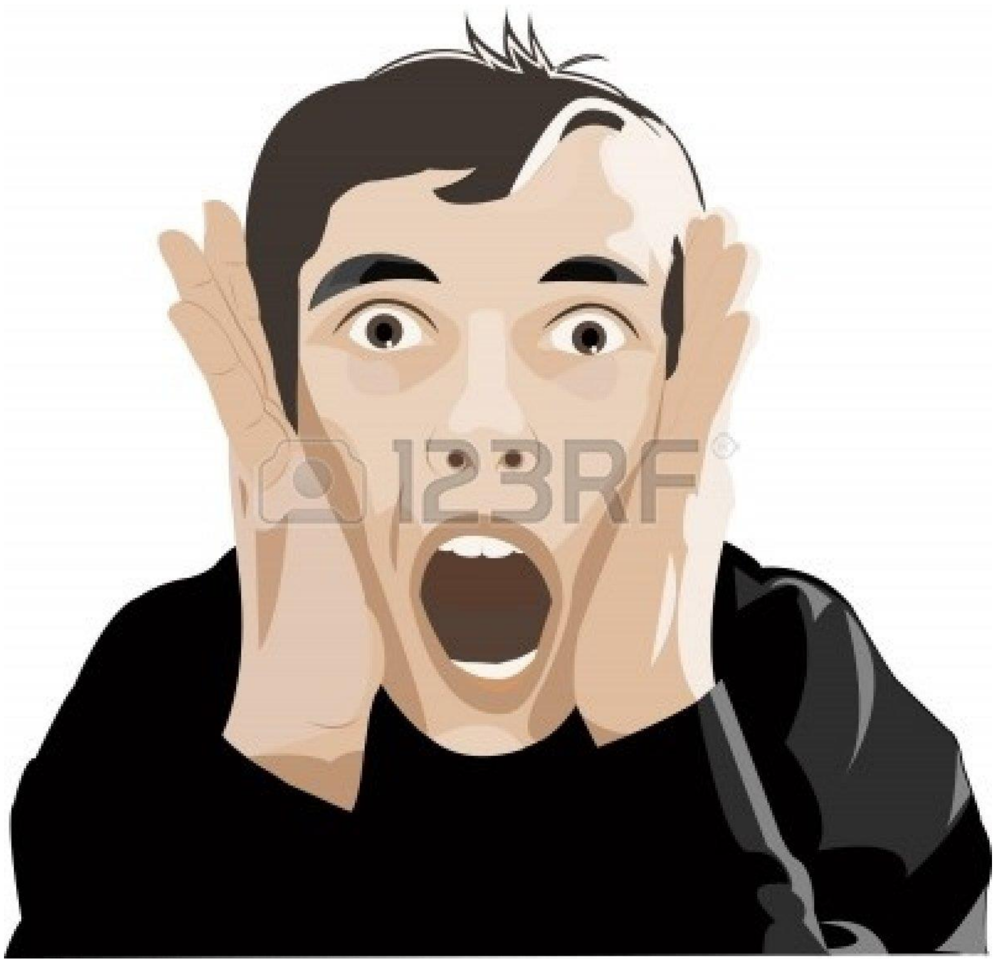
A group is then picked to present their solution and I will comment on this solution

I will present as possible practical applications

We will effectively have 4 tutorials per week

Exams will be mostly based on problems solved in the classrooms/tutorials

A second surprise!



Experiential Learning

the same approach used in EE4OI6 is adopted in your project (10%-15% of your total grade)

I will assume in this project that you are employees in EE2FH3 Inc.

you are asked to research, simulate, and design an electromagnetic structure (antenna, filter, etc.) that satisfies the design specifications

you will form groups of 6 (same groups of classrooms) to work together on this project

15-minutes biweekly meetings to assess your progress

presentation to the whole class at the end of the project

Experiential Learning (Cont'd)

we will use the free and open source MATLAB-based electromagnetic solver OpenEM

possible topics of your projects: wideband antennas, small antennas, dielectric resonator antennas, microwave filters, photonic filters, planar antennas, waveguide filters, terahertz antennas, nanophotonics, antenna arrays, metamaterials, through-the-wall radars, etc.

I will help those who come with interesting ideas to publish their projects (5% bonus for excellence in this project)

PIER website for paper downloads

Studying EM: Rules of Survival

Listen to lecture before classroom and read corresponding book material. Solve, if possible, as many drill problems as you can

Do your MATLAB assignments (one per week. Only 5 will be marked)

Do not miss classrooms or tutorials

Attend all project-related meetings

DO NOT TRY TO REMEMBER ALL FORMULAS – this is impossible. Remember only definitions and fundamental physical laws. Try to grasp the physics behind a formula or a solution. You will be allowed cheat sheets in midterm and final exam

Cogito, ergo sum

Exam Formats

Tests and mid-term exam are closed-book exams. HOWEVER:

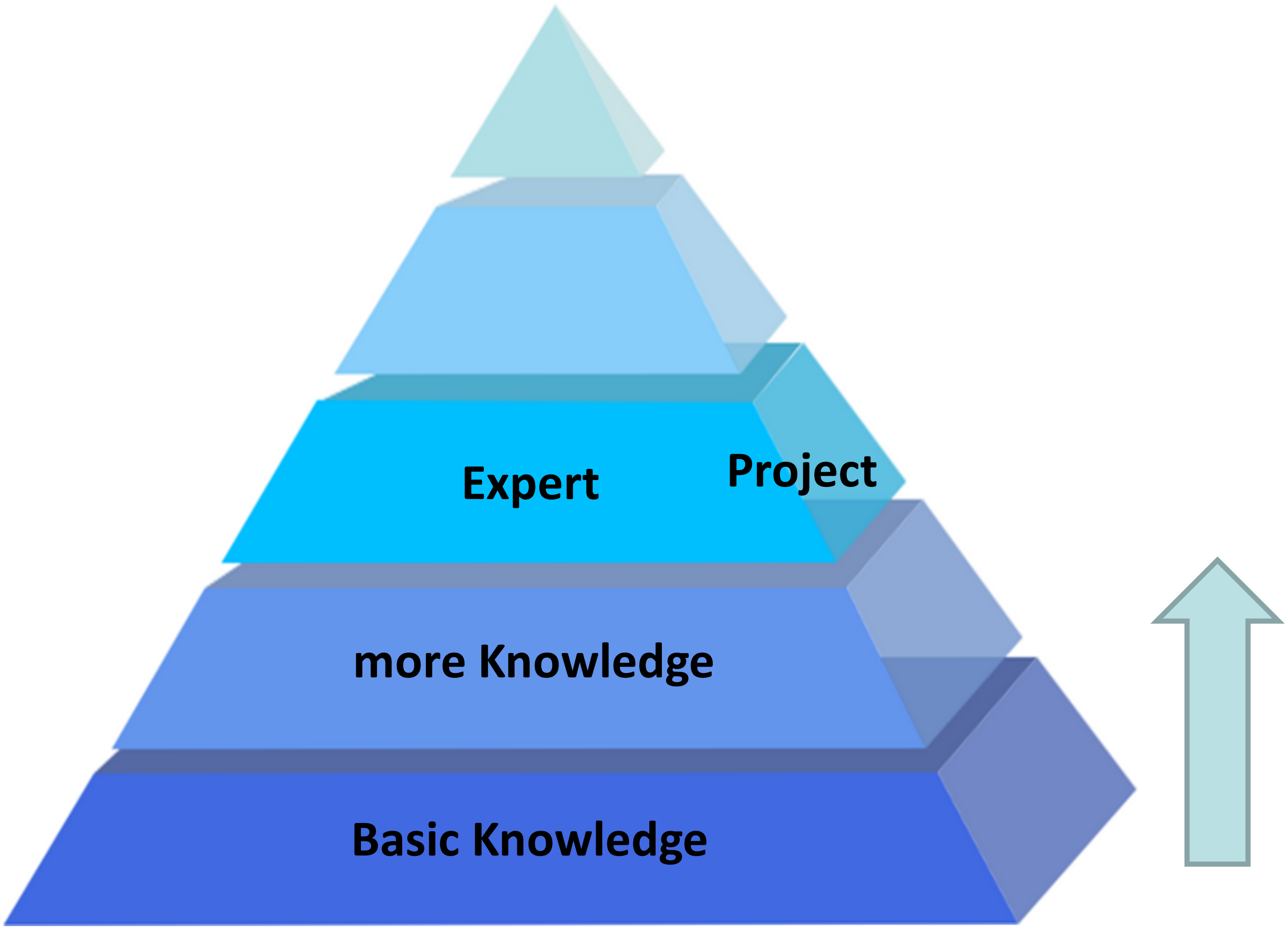
Midterm I allows 2 pages (1 sheet, Letter size) of your own writing

Midterm II allows 4 pages (2 sheets, Letter size) of your own writing

Final exam allows 8 pages (4 sheets, Letter size) of your own writing

Cheating results in 0 grade and academic dishonesty charges

Course Philosophy



remove course abstractness and connect it to real life