# Course Syllabus ELEC390
# Fundamentals of Electromagnetics
[version 1.1 1/24/2013]

**Instructor:** Alan Cheville
Dana 301
577-3640
alan.cheville@bucknell.edu

**Office Hours:** TBD based on instructor and student schedules

**Text:** Fundamentals of Applied Electromagnetics, 6th Edition
Fawwaz T. Ulaby, Eric Michielssen, Umberto Ravaioli
ISBN-10: 0132139316 • ISBN-13: 9780132139311
2010 • Prentice Hall

**Room:** BRKI 066

**Scheduled Meetings:** Class M, W, F @ 1100; Representation Session Th @ 1100

**Summary:**

This course will cover the fundamentals of electromagnetics, or the basic laws and rules that underlie much of the rest of electrical engineering. Much of what the course covers spans a fuzzy boundary between physics and electrical engineering and for this reason may be perceived as more mathematically intensive than many other engineering courses. However the ideas that underlie electromagnetics are relatively simple, and this course will try to explore the underlying ideas.

The reason electromagnetics is seen as a challenging course by many students is that the concepts we will be working with do not necessarily have analogs in our everyday experience as a human being. We cannot sense most electromagnetic fields and must try to understand them without sensing them. While this can be challenging, being able to understand things that don't behave like objects on the human scale, can only be measured through instruments, or calculated mathematically is a key skill for engineers. Although electromagnetics is often seen as challenging to understand, the power of prediction and accuracy of the equations you will learn extend from dimensions too small for man to measure with his most powerful instruments to distances inconceivable by cosmic standards.

The course is divided into four major themes:

1. **How do wires behave at high frequencies?** Why wires and electrical circuits don't behave the way we expect at higher frequencies. How engineers get signals from one place to another on wires and some of the issues to consider when you need to do so.
2. **What is Electricity and Magnetism?** This section explores the properties of electrical charges and tries to answer the question of where magnetism comes from. More stage setting through moving electric charges and the forces they exert.
3. **How does energy move through free space?** Understanding how signals (i.e. energy) can move through space and materials without wires to carry. How to make simple predictions about how signals propagate.
4. **How to we couple energy from circuits in to and from free space?** How we can build simple devices to couple electrical signals from wired circuits into free space and capture signals that are propagating through free space?

**Learning Objectives:**

The learning objectives for this course include three basic types of learning: knowledge of facts and concepts, the ability to do skills and procedures, and attitudes and your own knowledge of knowing (metacognition). There are specific learning outcomes for each of these categories that are given in three tables at the end of this syllabus.

**Course Organization:**
The course will use a format that is currently known as a “flipped classroom”. In brief instead of being told information in class and doing problems outside of class, we will try to create a learning environment that better aligns with the engineering work place. The general idea is that you work independently (i.e. outside of class) to learn what you need to know. When you come to class you will work in teams on a problem that helps you apply what you learned to a relevant engineering problem.

In a typical week of the course you will read the assignment the day before you come to class, test your understanding through an on-line quiz, then study the problem you will be solving in class and outline a solution. When you get to class the next day you will work with your team on a problem set that will be turned in at the end of the class; you may not take this problem to finish outside of class. At the end of each module your team will be given a review test

**Grading and Assignments:**
My goal as an instructor in this course is that every student will demonstrate sufficient competence in fundamental electromagnetics to earn an “A”. Grades are not curved or adjusted so you are not in competition. I expect you to cooperate with your peers to help each earn the highest grade they can.

| Course Element | Total Points | Weighting |
|---|---|---|
| On-line Quiz | 150 ± 30 | 15% ± 3% |
| Solution Outline | 100 ± 20 | 10% ± 2% |
| *In-Class Exercise (ICE)** | *250 ± 50* | *25% ± 5%* |
| *End of Module Test** | *4 @ 50 ± 10 each* | *4 @ 5% ± 1%* |
| Final Exam | 100 ± 20 | 10% ± 2% |
| Assessment and Reflection | 50 ± 10 | 5% ± 1% |
| Representation Challenges | 150 ± 30 | 15% ± 3% |
| **Total** | **450 team, 550 indiv.** | **100%** |

** represents a team rather than individual grade*

The course elements you are being graded on as indicated in the table above are:

- <u>On-line Quiz:</u> A Moodle quiz over the day’s reading assignment taken outside of class. You may make multiple times.
- <u>Solution Outline:</u> An outline of the problem(s) your team will work on in class that has critical information removed. You will be asked to submit a written flowchart, description, or pseudocode of the procedure that will be collected at the start of class. If you wish a copy for yourself, please bring it.
- <u>In-Class Exercise (ICE)*:</u> A problem, or set of problems your team will solve in class. Only one solution is turned in for the entire team, and the team shares the grade.
- <u>End of Module Test*:</u> Similar to an in-class exercise, but no solution outline is due and you won’t know what the problems are ahead of time. There will be a wider range of problem types as well that might include short answer or multiple choice. Your team submits one copy and the grade is shared.
- <u>Final Exam:</u> A summative final exam that will cover all the content in the course. Expect problems from past on-lines quizzes to be on the exam.
- <u>Assessment and Reflection:</u> Over the course of the semester you will be asked to write reflective statements on what you have learned as well as to take certain quizzes to assess your learning. The grades on these aren’t based what you score, but rather the effort and thought you put into your answer.
- <u>Representation Challenges:</u> For each of the four topics you will be asked to choose one idea, concept, theory, device, etc. and creatively illustrate it through multiple representations. Representations include descriptions, formulas, Matlab code, schematics, animations, sounds, etc.

The grading policy is simple. You can earn a total of 1000 points over the course from all the elements as outlined in the table above. The number of points determines your grade; grades will not be curved or otherwise adjusted at the end of the semester. There will not be any “extra credit” or boosting of grades to the next discrete letter grade for people who are “on the border”.

You may, however, adjust the weighting of any course element by ± 20% of its value as long as the total point weighting for the course adds up to 1000. For example although you did quite well on the on-line quizzes ( 135 out of 150 points) you do poorly on the final (60 out of 100 points). You may choose to decrease the weight of the final by from 10% to 8% (or from 60 to 48 points) and up the on-line quizzes from 15% to 17% of the final grade (from 135 to 153 points). This will allow you to choose what elements of the course best align with your particular learning style. Note that you must submit the requested changes yourself at the end of the course before grades are submitted. *This adjustment will not be done for you.*

The lowest three grades on the on-lines quizzes will automatically be dropped.

Course elements in the table above marked with a * are group grades. Any *group grade* will be modified by how your group members rate your contribution to the team effort as determined by a peer evaluation at the end of each topic (4× per semester). Here is a specific example: Axel, Bob, Charlotte, and Deb form a team. After the first topic is finished each team member is given 300 points to assign to the other members. (100 points per team member, not counting yourself). *You do not rate yourself.* Axel is given 80 points by Bob, 110 points by Charlotte, and 120 points by Deb since they each thought Axel contributed 80%, 110%, and 120% of the his share of the effort on the work during the topics respectively. Axel thus gets an average of 103.3% of the overall grade. As instructor I reserve the right to modify peer evaluation grades if I feel that the process does not reflect professional behavior standards.

**Professionalism and Academic Honesty:**
This course seeks to try to recreate the environment of engineering practice. For this reason professional behavior is expected from all those in the course at all times. You will need to sign and return the student-instructor contract attached later in the syllabus that outlines specific expectations regarding behavior. There are several expectations for professionalism in this course that may differ from other courses you are taking or have taken:

- In this class you are required to work in groups and to seek other student's help in solving problems.
- You are expected to share information or material help with any other student or team in a way that best supports their learning and professional development.
- Plagiarism of any type is not permitted. You must identify others who provided any ideas, work, help, or other substantial aid in work you submit. You are required to identify those who helped you both in all written work turned in for a grade as well as when answering questions from the instructor or TA's.
- Knowingly providing false or misleading information, incorrect code, or defective hardware to any other student, team, TA, or the instructor are considered violations of academic honesty.
- You may not reproduce or copy course material for a purpose that it was not expressly intended for without the permission of the instructor. An example would be copying of on-line quiz questions to use as a study guide. If in doubt, ask.

**Late Assignments:**
Generally no late work will be accepted, particularly in class exercises and solution outlines. If you think you might have to turn in an assignment late, please see me as far in advance as possible. No late tests to be given under *any* circumstances.

**Attendance Policy:**
Attendance does not directly impact your grade directly in any way. However failure to attend class may impact your peer evaluation score.

## Student-Instructor Contract for ELEC390

The purpose of this contract it to make you aware of what is expected from every person participating in this course but does not supersede Bucknell University regulations or policies. By signing it you acknowledge you have read and agree to abide by these guidelines.

(1) I accept that everything I may need to know will not be taught in class and I must actively seek to educate myself. I am responsible for learning material outside of the regular class meeting times and will endeavor to educate myself on anything I need to learn to accomplish the projects.

(2) The instructor is responsible for making learning resources available through print, verbal, and/or electronic means to the best of their ability.

(3) I promise to freely share my knowledge and any valuable learning resources I find with others in the class and the instructor so that the course can be improved in future iterations.

(4) I acknowledge that this class uses a team-based format and promise to treat my team members with professionalism, respect, and honesty. I acknowledge that everyone has different strengths and will help to teach any team members who need assistance as I expect they will also assist me.

(5) I promise to evaluate my team members fairly based on the work they performed and not let personal prejudices affect my evaluations.

(6) I understand the syllabus is a binding contract on how grades will be assigned, and have read and understand all the information it contains.

(7) Courses at Bucknell that receive one unit of academic credit have a *minimum* expectation of 12 hours per week of student academic engagement. Student academic engagement includes both the hours of direct faculty instruction (or its equivalent) and the hours spent on out of class student work. If I believe the workload for this course does not match these guidelines, I will bring the matter up with the instructor.

(8) I am *expected* to consult the instructor, TA's, and other students for help, but I will not take credit for any work I have not done or represent others' work as my own.

(9) The instructor guarantees that all assignments will be graded fairly using a written set of evaluation criteria (a rubric). I will have access to this rubric before the due date of any assignment.

(10) I am responsible for asking any questions on the material covered if I do not understand it, and the instructor is responsible for answering these questions to the best of our ability.

(11) The instructor is responsible for making the material as understandable, pertinent, and timely as possible, and I promise to provide constructive feedback if I am dissatisfied with the material or presentation.

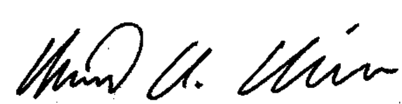
(12) Both the instructor and I are responsible for maintaining a scholarly environment based upon mutual trust and respect.

(13) As a student and citizen of the Bucknell University community:

- I will not lie, cheat, or steal in my academic endeavors.
- I will forthrightly oppose each and every instance of academic dishonesty.
- I will let my conscience guide my decision to communicate directly with any person or persons I believe to have been dishonest in academic work.
- I will let my conscience guide my decision on reporting breaches of academic integrity to the appropriate faculty or deans.

______________________________

**Student**



**Procedural or Skill** learning objectives represent how to do something, or using skills, algorithms, techniques, and methods including determining when to use appropriate procedures.

This course has the following learning outcomes for a basic understanding of electromagnetics that form a representative set of what students should be able to do by the end of the course. These may not all be covered, change during the course, or be modified depending on formative evaluation performed during the class.

| **Students will be able to** | **as evidenced by** | **ABET Outcome** |
|---|---|---|
| calculate the refection coefficient and standing wave ratio of a lossless transmission line… | receiving a score of > 70% on one or more of: multiple online quiz questions, an exam problem, or an in-class problem as a team. | A,E |
| calculate the power delivered to a load in a transmission line circuit… | receiving a score of > 70% on one or more of: multiple online quiz questions, an exam problem, or an in-class problem as a team. | A |
| design simple transmission line based devices including impedance matching and filters… | receiving a score of > 70% on one or more of: multiple online quiz questions, an exam problem, or an in-class problem as a team. | A.C |
| use appropriate vector and integral operations to calculate static electric and magnetic simple charge and current distributions respectively… | receiving a score of > 70% on one or more of: multiple online quiz questions, an exam problem, or an in-class problem as a team. | A,E |
| calculate the capacitance and/or inductance of simple structures… | receiving a score of > 70% on one or more of: multiple online quiz questions, an exam problem, or an in-class problem as a team. | A,E |
| calculate power in a uniform plane wave and power transmitted across a dielectric boundary… | receiving a score of > 70% on one or more of: multiple online quiz questions, an exam problem, or an in-class problem as a team. | A,E |
| calculate reflection and transmission of a plane wave impinging on a dielectric interface… | receiving a score of > 70% on one or more of: multiple online quiz questions, an exam problem, or an in-class problem as a team. | A,E |
| determine the electromagnetic field radiated by simple structures… | receiving a score of > 70% on one or more of: multiple online quiz questions, an exam problem, or an in-class problem as a team. | A,E |
| use multiple ways to represent and communicate engineering concepts (including graphical, mathematical, computational, schematic, and objects)… | a rubric scored analysis of individual presentations that shows they have successfully used all these representations. | A,G, K |
| use Matlab to numerically model and solve simple electromagnetic problems… | completing individual assignments that reflect this skill with a score of > 70% as judged by a rubric. | M |
| work effectively on a team of peers to solve assigned problems… | the scores received on peer evaluations. | D |

**Factual** learning outcomes include knowledge of terminology, units, and some fundamental physical constants used in electromagnetics.

**Conceptual** learning outcomes include knowledge of the interrelationships among the basic elements within a larger domain of knowledge and includes knowledge of classifications, principles, heuristics, theories, models, and schemas.

The table below shows some *representative* facts and concepts that students will acquire during this course. These may not all be covered, change during the course, or be modified depending on formative evaluation performed during the class.

| **Students will be able to demonstrate their knowledge of** | **as evidenced by** |
|---|---|
| the variables representing plane waves… | identifying these on wave diagrams and correctly using these variables in solving problems. |
| time-frequency conversions and phasor notation… | using phasor notation to simplify differential equations. |
| the concept of impedance… | successfully identifying the effect of impedance on signal propagation (V,E and I,H). |
| the concept of reflection and transmission at interfaces… | explaining in writing or diagrams how signal change at interfaces. |
| the concept of attenuation… | explaining in writing or diagrams how signals change as they propagate. |
| how charges create vector fields and the correct mathematical notation to express these (Coulomb and Gauss' Law)… | by being able to successfully determine area of high and low divergence and curl from diagrams. |
| how charges create scalar fields the correct mathematical notation to express these (Poisson's equation)… | by being able to successfully determine areas of high and low gradient change from diagrams. |
| units, values, and concepts of permittivity and conductivity… | correctly using these variables in solving problems. |
| the concepts of capacitance and inductance and how these affect fields, potentials, and current… | being able to qualitatively estimate which geometrical structures have high or low capacitance and inductance. |
| how the magnetic field arises from moving charges… | being able to explain or diagram the role of relatively on charge motion. |
| how a changing electric or magnetic field can give rise to the other (Faraday's and Ampere's Laws)… | explaining in writing or diagrams how one time varying field can create the other. |
| synthesizing electromagnetics through Maxwell's equations… | explaining in writing or diagrams what each of Maxwell's equations mean. |
| the relations between field, power, flux, intensity… (Poynting vector)… | converting one to the other and describing when each should be used. |
| the concept of reciprocity… | explaining the relation between transmitted and received power in antennas. |
| the concept of superposition of sources… | determining the field and power from a discrete number of point sources at points in space |
| the effective area and gain of radiating structures… | explaining how to choose from multiple antennas and orient an antenna to get the best received signal. |

**ELEC390 Solution Outline Scoring Rubric**

| Category | Scores and Weightings | | | |
|---|---|---|---|---|
| | **5 points = 100%** | **4 points = 80%** | **3 points = 60%** | **0 points = 0%** |
| Correct & Complete: Solution method is appropriate to the problem. | The solution method will lead to the correct answer. Most steps are included. | The solution method is relevant but not completely correct. Many steps are included. | The solution method is relevant but incomplete. | Solution method is wrong, irrelevant, or not present. |
| Grounded: Solution refers to relevant facts, equations, and concepts. | Specific equations and values or constants are referred to from Ulaby (or other sources) for most steps. Concepts are named and used correctly. | Contains some concrete information that is relevant and generally correct. Relevant concepts are generally used and named correctly. | Contains some concrete information but that information is incomplete, irrelevant or wrong. Relevant concepts are used incorrectly. | Does not contain any concrete information. Does not refer to organizing concepts. |
| Actionable: Outlines steps to solve the problem that another person could follow. | Steps are clearly outlined, discrete, and state what needs to be done. | Steps are outlined but fuzzy. The actions needed to complete the step are vague. | Steps are present but are too general to follow, significantly overlap, or are unclear. | Steps cannot be discerned. The procedure is not actionable. |
| Reflective: Identifies what is known and not known. Steps that are not known are clearly identified. | Most information that is needed but not known (and which is given but not needed) is identified. Clearly indicates when next steps are uncertain and possible options. | Some, but not most, information that is needed but not known (and which is given but not needed) is identified. Discusses uncertainties and possible options. | Fails to information that is needed but not known (and which is given but not needed) is identified. Indicates awareness of uncertainties. | Fails to needed and unknown information. Has no awareness of uncertainties. |
| Organized: Work is neat, organized, and, easy to follow. | Train of thought and steps can be easily followed. I did not have to go back and reread any part. | Train of thought and steps are mostly clear. I had to go back and reread some parts. | Train of thought and steps are difficult to understand or follow. I spent a significant amount of time understanding this work. | Too hard to read or follow. Unclear and confusing. |

**Scoring: The overall score on the work is generally a composite of all these factors. However if a score of zero is earned on any part then the entire submission will receive a score of zero.**