DEPARTMENT OF PHYSICS AND ASTRONOMY
TRENT UNIVERSITY

PHYS 4220H: Electromagnetic Theory
2014-2015 FA

Peterborough

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Course Description:

The goal of this course is primarily, starting from Maxwell's Equations, to develop the electromagnetic theory beyond static electric and magnetic systems to dynamic time varying systems. Topics covered are electromagnetic wave theory and propagation in vacuum and matter; waveguide theory; potentials, fields and radiation.

Material delivery

Time Period or Date	Topic	Book Chapter
WEEK 1	review of 3200Y + Maxwell's Equations	7.3
WEEK 2	conservation laws; Poynting's Theorem	8.1
WEEK 3	EM waves; waves in vacuum, energy and momentum;	9.1, 9.2
WEEK 4 & 5	waves in matter, transmission, reflection; absorption and dispersion	9.3, 9.4
WEEK 6 & 7	guided waves, resonant cavities	9.5
October 19-25	---Reading Week—NO CLASSES	
October 27, 14:00-16:00	**Mid-Term**	**In Class**
WEEK 8 & 9	scalar and vector potentials; gauge transformations	10.1
WEEK 9 &10	Retarded potentials from continuous distributions and moving point charges and fields from a moving point charge	10.2, 10.3
WEEK 10 & 11	Radiation from oscillating dipoles and from moving point charges	11.1, 11.2
WEEK 12	REVIEW	

This schedule is somewhat tentative and may change slightly to accommodate the needs of the class.

Required Texts: *Introduction to Electrodynamics,* by David J. Griffiths (4th edition preferred)

Course Pre-requisites: PHYS 3200Y and PHYS-MATH 3150H

Course Format: Please check www.trentu.ca/timetable/ to confirm times and locations.

	Day	**Time**	**Location**
Lecture	MON	14:00-15:50	SC317
Seminar	TUES	16:00-16:50	SC317
Lecture	THURS	10:00-10:50	SC317

Course Evaluation:
Assignments: 35%
Weekly Seminar Quizzes: 15%
Mid-Term Exam: 20%
Final Exam: 30%

Roughly every two weeks, a problem set will be assigned with a well defined due date and time.

The seminar time will be used for two purposes: Primarily, a weekly quiz will be given at the beginning of most seminar sessions, and the remainder of the seminar will be devoted to taking up these topics. When needed, seminar time will be used for lecture make-up time.

By the class drop-date of November 4, 2014, it is expected that you will know approximately 35% of your final grade. This includes the results of your mid-term exam, and some quizzes and assignments.

Late Policy: Late assignments will be deducted 15% total grade, regardless of the reason for lateness, unless arranged in advance of the due-date with the instructor. Late assignments will no longer be accepted for grading after one week of lateness, resulting in a grade of zero.

University Policies

Academic Integrity:
Academic dishonesty, which includes plagiarism and cheating, is an extremely serious academic offence and carries penalties varying from failure on an assignment to expulsion from the University. Definitions, penalties, and procedures for dealing with plagiarism and cheating are set out in Trent University's *Academic Integrity Policy*. You have a responsibility to educate yourself – unfamiliarity with the policy is not an excuse. You are strongly encouraged to visit Trent's Academic Integrity website to learn more: www.trentu.ca/academicintegrity.

Access to Instruction:
It is Trent University's intent to create an inclusive learning environment. If a student has a disability and/or health consideration and feels that he/she may need accommodations to succeed in this course, the student should contact the Student Accessibility Services Office (SAS), (BH Suite 132, 705-748-1281 or email accessibilityservices@trentu.ca). For Trent University - Oshawa Student Accessibility Services Office contact 905-435-5102 ext. 5024 or email nancyhempel@trentu.ca . Complete text can be found under Access to Instruction in the Academic Calendar.

Physics 4220H: Learning Outcomes

By the end of the course, students are expected to be able to...

1. write down, from "memory", Maxwell's Equations in differential form, both in vacuum and in (linear) media.
2. show how the continuity equation—an expression of charge conservation—is implicit in Maxwell's Equations.
3. compare the continuity equation and Poynting's Theorem in terms of conservation laws, and argue, by analogy, that the Poynting vector is an "energy density current" of sorts.
4. describe electromagnetic fields in linear media, including the presence of "displacement currents", displacement field, **D**, and magnetic field **H**; and how they differ from fields **E** and **B**.
5. describe mathematically the energy density and total energy stored in electromagnetic fields, as well as the *flow* of energy.
6. write down, from "memory"—or better yet, derive—the (four) typical boundary conditions for the electric and magnetic field components parallel and perpendicular to an interface between linear media.
7. show how Maxwell's Equations suggest that electricity and magnetism are linked via the propagation of fields at the speed of light.
8. describe the procedure for using typical boundary conditions for electromagnetic fields to derive the Fresnel Equations for reflection and transmission in a dielectric interface in the case of incident-plane and orthogonal polarization.
9. Describe the presence or absence of "Brewster's angle" for reflection off a dielectric interface for transverse-E and transverse-B polarized light. Link this condition to the Fresnel Equations.
10. Generate the Transmission and Reflection coefficients from the Fresnel Equations, and sketch the transmitted and reflected power as a function of incident angle for transverse-E and transverse-B polarized light.
11. calculate/estimate reflection and transmission coefficients from the dielectric function of various materials.
12. describe how material (linear) conductivity can be included in Maxwell's Equations and how this inclusion subsequently leads to absorption.
13. apply boundary conditions to obtain reflection and transmission behaviour of metals and dielectrics.

14. describe the meaning of "skin depth" and use this parameter to calculate electromagnetic attenuation in media.

15. describe the relative phase differences between the electric and magnetic field oscillations in nonconductive and conductive media. Estimate the magnituded of this phase difference as a function of the "quality" of conductor through which the fields propagate.

16. relate the real and imaginary components of the index of refraction (n and k) to the dielectric function.

17. show (or at the very least, describe) how dispersion arises in the dielectric function.

18. describe quantitatively and qualitatively the dielectric function (ϵ) of conductors and insulators.

19. apply boundary conditions in waveguides and cavities to obtain "modes"; use the obtained dispersion relations of such modes to describe the frequency progression of allowed waveguide modes.

20. describe the presence or absence of cut-off frequencies in various devices such as square channel and coaxial waveguides.

21. calculate "skin-depth" or attenuation behaviour of electromagnetic radiation in a conductive channel as a function of frequency and "waveguide" size.

22. describe the meaning and purpose of a "gauge transformation".

23. provide a specific example of a "gauge transformation" and its particular use/application.

24. explain the need for re-parametrizing scalar and vector potentials in "retarded-time".

25. relate the retarded-time formalism to the Lorenz Gauge

26. work with "retarded-time" as a parameter; including the necessary vector geometry and calculus.

27. describe the differences, both fundamental and functional, between near- (or induction) fields and radiation fields.

28. describe quantitatively and qualitatively radiation from oscillating electric and magnetic dipoles.

29. describe at least one outstanding paradox of radiation from accelerating charges (for example, with respect to causality).

30. link the history of the atomic model with the concept of radiation from accelerating charges.