Physics PHYS 354 **Spring Semester 2020**
Electricity and Magnetism II 4 Credit Hours

Information Sheet

"I think that men (and women) of science as well as other men need to learn from Christ, and I think that Christians whose minds are scientific are bound to study science that this view of the glory of God may be as extensive as their being is capable of."

– James Clerk Maxwell, Letter to the Victoria Society, 1875, in L. Campbell and W. Garnett, The Life of James Clerk Maxwell, (Macmillan, London, 1882).

Instructor:	Dr. Mark Yuly		Rm. P106	567-9282
Office Hours:		MTWTF	4:30-5:30 PM	Rm. P106
Schedule:	Lecture	MWF	9:55-11:00 AM	Rm. P118

Catalog Description: An examination of the role of special relativity in electromagnetic phenomena. Maxwell's equations introduced in a relativistic manner and used to investigate the properties of electromagnetic waves. Includes techniques for solving the equations of Laplace and Poisson in electrostatics. Liberal Arts. Corequisite: MATH 261 recommended; Prerequisite: PHYS 353.

Description: The course will begin by introducing several mathematical techniques for solving boundary-value problems in electrostatics. This will be followed by an investigation of the importance of special relativity in electromagnetic phenomena using tensor geometry. Maxwell's equations are introduced in a relativistic manner, and used to investigate the properties of electromagnetic waves.

Objectives: In this class you will become familiar with the basic concepts (2) and formalism (3) of special relativity, and their application to the theory of electricity and magnetism developed last semester. In addition, it is my hope that you will begin to appreciate the elegant and unexpected manner in which God has designed the universe (9). Numbers in parentheses indicate the corresponding departmental learning objectives, available at https://www.houghton.edu/academics/majors-programs/physics/physics-department-mission/.

Learning outcomes: The objectives listed above I hope will be evidenced by the following outcomes:

1. The ability to solve electrostatic boundary-value problems using the method of images (1,2,4).
2. The ability to solve Laplace's equation for rectangular, cylindrical and spherical symmetry using separation of variables (1,2,3,4).
3. Familiarity dealing with 3-vectors and tensors using index notion rather than traditional vector notation (3).
4. The ability to explain the difficulties posed to classical mechanics by the fact that Maxwell's equations are not invariant under Galilean transformations, and how this problem was solved (1,2).
5. Familiarity 4-vectors and tensors and their properties (3).
6. The ability to solve relativistic problems in mechanics using invariant quantities and 4-vectors (2,3,4).
7. The ability to derive the relativistic transformation of electric and magnetic fields, and to calculate them in various reference frames (1,2,3,4).
8. The ability to use the stress tensor to examine the conservation of energy and

momentum in electric and magnetic fields (1,2,3).
9. An understanding of the behavior of electromagnetic waves in various media (1,2).
10. An increased level of mathematical sophistication in your thinking and writing (3,7).
11. The ability to appreciate God's creation in a way you could not prior to this course (9).

Text: Introduction to Electrodynamics (Fourth Edition) by D. J. Griffiths, Pearson, 2013.

Attendance: Excessive absence from class will have a detrimental effect on assigned grades. Please contact the instructor if you plan to be absent. The instructor will decide on a case-by-case basis whether tests can be made-up.

Grades: Grades are assigned according to the Physics Department grading rubric at http://www.houghton.edu/physics/physics-grading-rubric/. The final grade will represent a weighted average of the scores on the homework (50%), the take-home midterm exam (25%), and the comprehensive take-home final examination (25%). Failure to attend both colloquia will result in a 5% reduction (prorated) in the total score for the class.

Homework: Problem Sets are generally to be turned in before 5:00 PM on the due date. They are at https://www.houghton.edu/academics/majors-programs/physics/course-websites/phys-354-electricity-and-magnetism-ii/.

Late homework will not be accepted.

I plan to be very particular about the format of the homework. Sloppy or disorganized work will not be accepted. I will expect the following rules to be followed:

1. Use only one side of your paper.
2. Each new problem is to begin on a new sheet.
3. Copy the problem, in its entirety, at the top of the page, before you begin the solution.
4. Use words to describe each step in the solution.
5. Leave space - do not crowd your work into a tiny area on the page.

I will show you some examples of the format I expect you to follow.

Exams: There will be a take-home midterm exam Feb.21-28 and a take-home final examination Apr. 24-May 4. During the scheduled final exam period we will review the solutions to the final exam questions.

Colloquium attendance: To encourage student awareness of connections between science, mathematics, and Christianity, and their role in society, all students **must attend two** related math and science colloquia (www.houghton.edu/events/category/science-math-colloquium/) over the course of the semester. Students who attend a seminar must submit a summary ($\leq$ 300 words) within one week of the talk. Failure to attend both colloquia will result in a 5% reduction (prorated) in the total score for the class. The summary should indicate the date and the speaker, and should describe the main point of the presentation. If you are required to attend colloquium for another class, then you may turn in the assignment from the other class for credit in this class.

Technology Policy: During class, please silence cell phones and do not use computers for taking notes without talking to me first.

College Support Services: I want you to be aware of some of the services that the college provides that may be helpful for you (more information can be found online or by talking to me).

Academic Support and Accessibility Services
Writing Center
Counseling Services
Office of Vocation and Calling

Self-Reporting of Disabilities: If you have an academic disability that requires special accommodations or modifications, it is up to you to self-report any such disability to the Academic Support and Accessibility Services office (585-567-9622). With appropriate documentation, you will be afforded the necessary accommodations and/or modifications. For more information , go to: http://www.houghton.edu/academics/academic-resources/center-for-academic-success-and-advising/ .

Academic Integrity: From the course catalog: "Honesty is the foundation on which all intellectual endeavors rest. To use the ideas of others without acknowledging the authors of those ideas belies the nature and purpose of academic life. At Houghton, where we strive to live out Christian calling and commitment, personal integrity, including academic honesty, should be the hallmark of all our work and relationships.

Students are expected to exhibit extreme care relative to personal honesty in all academic work, including in-class and out-of-class learning experiences, such as exams, quizzes, journals, papers, research projects, etc. Dishonest work includes but is not limited to the following:

1. Obtaining aid or information without giving due recognition to the sources of such aid or information. Such dishonesty encompasses 1) asking to copy or copying other students' work to claim as one's own on an exam or assignment of any kind and 2) all forms of plagiarism. Plagiarism includes using ideas, words or phrases from any source without citing that source and downloading or purchasing papers or parts of papers from others or the Internet and claiming such work as one's own.
2. Giving aid or information when it is clearly inappropriate to do so, such as providing answers for an exam or writing a portion of a paper or an entire paper for someone, including selling one's work.

See the college catalog athttps://www.houghton.edu/academics/course-catalog/catalog-table-of-contents/ page 39 for the college statement on academic honesty.

Expected Minimum Time Required: For each credit hour, the minimum amount of time expected for course-related work is 45 hours (3 hours per week per credit) giving 10,800 minutes minimum for this class. A more realistic estimate for the time required to complete each task in this class is shown below.

Learning activity	Additional comments	Typical *minimum* time on task	Total time (in minutes)
Class time	Not including take home test days	65 minutes each class, 37 days plus 2-hour final exam period	2525
Assigned reading *181 pages*	Textbook reading with note-taking	8 minutes/page	1448
Homework assignments *8 Problem Sets*		12 hours per problem set	5760
Exams Prep *Midterm and Final*		Midterm: 10 hours Final: 10 hours	1200
Colloquium attendance		Two 60 minute Math and Science colloquia	120
TOTAL			**11,053**

Schedule of class sessions:

1. Monday, Jan. 13 — Topic: **Method of images.** Read: Griffiths, p. 113-129
2. Wednesday, Jan. 15 — Topic: **Example: Point charge outside a grounded sphere.** Assignment: Problem Set #1
3. Friday, Jan. 17 — Topic: **Laplace's equation in rectangular coordinates.** Read: Griffiths, p. 130-140

Monday, Jan. 20 — **MLK Day (no class)**

4. Wednesday, Jan. 22 — Topic: **Example: Infinitely long rectangular box.**

5. Friday, Jan. 24	Topic: Read:	**Laplace's equation in spherical coordinates.** Griffiths, p. 141-150
6. Monday, 27	Topic:	**Laplace's equation in spherical coordinates (continued).**
7. Wednesday, Jan. 29	Topic:	**Example: Hemispheres at constant potential.**
8. Friday, Jan. 31	Topic:	**Example: Hemispheres at constant potential (continued).**
9. Monday, Feb.3		**Work on Problem Set #1** (NIF User Meeting)
10. Wednesday, Feb. 5		**Work on Problem Set #1** (NIF User Meeting)
11. Friday, Feb. 7	Topic: Read: Due: Assignment:	**Boundary value problems with linear dielectrics.** Griffiths, p. 192-195 Problem Set #1 Problem Set #2
12. Monday, Feb. 10	Topic:	**Poisson's equation for electric fields**
13. Wednesday, Feb. 12	Topic:	**Example: Electric field in an atomic nucleus.**
14. Friday, Feb. 14	Topic: Read:	**Geometry in three dimensions.** Hand-out, pages 1-14.
15. Monday, Feb. 17	Topic: Due: Assignment:	**Some simple examples using index notation.** Problem Set #2 Problem Set #3
16. Wednesday, Feb. 19	Topic:	**A more difficult example: multipole expansion.**
17. Friday, Feb. 21	Topic: Read:	**Review of special relativity** Griffiths, p. 502-524
18. Monday, Feb. 24	Topic: Read: Due: Assignment:	**The Galilean and Lorentz transformations.** Griffiths, p. 525-531 Problem Set #3 Midterm Exam (take home)
19. Wednesday, Feb. 26		**Work on Midterm (no class meeting)**
20. Friday, Feb. 28		**Work on Midterm (no class meeting)**
Monday, Mar. 2		**February Break**
Wednesday, Mar. 4		**February Break**
Friday, Mar. 6	:	**February Break**

21. Monday, Mar. 9	Topic:	**The Galilean and Lorentz transformations (continued).**
	Due:	Midterm Exam (by 5 pm)
	Assignment:	Problem Set #4
22. Wednesday, Mar. 11	Topic:	**Geometry in four dimensions**
	Read:	Hand-out, pages 14-27.
23. Friday, Mar. 13	Topic:	**Geometry in four dimensions (continued).**
24. Monday, Mar. 16		**No Class**
25. Wednesday, Mar. 18		**No Class**
26. Friday, Mar. 20		**No Class**
27. Monday, Mar. 23		**Set up for Online/Class housekeeping/**
28. Wednesday, Mar. 25	Topic:	**Geometry in four dimensions (continued).**
29. Friday, Mar. 27	Topic:	**Some special four vectors.**
	Read:	Griffiths, p. 532-537
	Due:	Problem Set #4
	Assignment:	Problem Set #5
30. Monday, Mar. 30	Topic:	**Example problems using four vectors.**
	Read:	Griffiths, p. 537-542
31. Wednesday, Apr. 1	Topic:	**Gauge transformations**.
	Read:	Griffiths, p. 416-422
32. Friday, Apr. 3	Topic:	**Electromagnetic field tensor.**
	Read:	Griffiths, p. 550-565
	Due:	Problem Set #5
	Assignment	Problem Set #6
33. Monday, Apr. 6	Topic:	**Electromagnetic field tensor (continued).**
	Read:	Griffiths, p. 565-570
34. Wednesday, Apr. 8	Topic:	**Relativistic transformation of fields**
Friday, Apr. 10		**Easter Break**
Monday, Apr. 13		**Easter Break**
35. Wednesday, Apr. 15	Topic:	**Relativistic transformation of fields (continued).**
	Due:	Problem Set #6
	Assignment:	Problem Set #7
36. Friday, Apr. 17	Topic:	**Field due to a moving charge.**

37. Monday, Apr. 20	Topic:	**Field due to a moving charge (continued).**
38. Wednesday, Apr. 22	Topic:	**Energy and momentum conservation.**
	Read:	Griffiths, p. 542-549, 360-378
39. Friday, Apr. 24	Topic:	**Energy and momentum conservation (continued).**
	Due:	Problem Set #7
	Assignment:	Take Home Final Exam
40. Monday, Apr. 27		**Work on final examination.**
41. Wednesday, Apr. 29		**Work on final examination.**
42. Monday, May 4 8:00 AM	Due:	**Final Exam**