

Physical Systems and Applied Mathematics, 2016-17  
**Program Syllabus – Spring Quarter Update**  
 sites.evergreen.edu/psam1617

This intermediate-to-advanced program builds on previous introductory work in calculus and calculus-based physics to deepen students' understanding of nature and its representation via physical models and the powerful connections between mathematics and physical theories. In fall and winter, we studied ordinary & partial differential equations, multivariable & vector calculus, and linear algebra; students were able to earn upper division science credit in math with exceptional performance. In fall, we studied classical mechanics, and in winter, we began the study of electricity & magnetism (EM) and quantum mechanics (QM), and had a small project/seminar component that set up for significant advanced lab projects in spring. In spring, we continue to study EM and QM and complete significant advanced lab projects (ALP) or independent work of student design. Earned credit in physics is designed to be upper division. There were partial credit options for the math portions of the program in fall and other partial credit options in winter and spring. We learn to understand our studies in a broader historical, philosophical, and cultural context. We constantly strive to create an intentionally inclusive and anti-bias learning environment that is attentive to and supportive of the unique gifts and background of each student with the goal of equitable outcomes for all.

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office hours: by  
appointment

MONDAY	TUESDAY	WEDNESDAY	THURSDAY
9:00 – 10:00 Quixam CAL West	9:00 – 10:00 EM Problem Session 1 CAL West	9:00 – 10:30 ALP Lab 1 054	9:00 – 10:00 EM Problem Session 3 Lab 1 054
10:00 – 11:00 Quixam Workshop CAL West	10:00 – 11:00 EM Lecture 2 CAL West	10:30 – 11:00 Break	10:00 – 11:00 QM Problem Session 2 Lab 1 054
11:00 – 12:30 Break	11:00 – 12:30 Break	11:00 – 12:00 EM Problem Session 2 Lab 1 054	11:00 – 12:00 Break
12:30 – 1:30 EM Lecture 1 CAL West	12:30 – 1:30 QM Problem Session 1 Lab 1 054	12:00 – 1:00 EM Lecture 3 Lab 1 054	12:00 – 3:30 ALP open time
1:45 – 2:45 QM Lecture 1 CAL West	1:30 – 2:30 QM Lecture 2 Lab 1 054		Python Check-ins Contract Check-ins Individual meetings

**Tentative Schedule (subject to change):**

Week	EM (Griffiths)	QM (Townsend)	Notes
21 (Apr. 2 – Apr. 8)	7.1, 7.2	Ch. 6	M: Winter Exam 2 Re-do, T: EM Special Lab
22 (Apr. 9 – Apr. 15)	7.3	Ch. 6	M: Quixam 1E (7.1-7.2), W: DoA, Th: ALP presentations
23 (Apr. 16 – Apr. 22)	8.1, 8.2, 8.3	Ch. 7	M: Quixam 1Q (ch. 6)
24 (Apr. 17 – Apr. 29)	9.1, 9.2, 9.3	Ch. 7	M: Quixam 2E (7.3-8.3)
25 (Apr. 30 – May 6)	9.4, 9.5, 10.1	Ch. 9	M: Quixam 2Q (ch. 7)
26 (May 7 – May 13)	10.2, 10.3	Ch. 9	M: Quixam 3E (9.1-10.1)
27 (May 14 – May 20)	11.1, 11.2	Ch. 10	M: Quixam 3Q (ch. 9), W: Mentor Day, Academic Fair
28 (May 21 – May 27)	Ch. 12	Ch. 10, 11	M: Quixam 4E (10.2-11.2)
29 (May 28 – Jun. 3)	+ Taylor Ch. 15	Ch. 11	M: holiday, F: Science Carnival
30 (Jun. 4 – Jun. 10)	No new reading		M: Quixam 4Q (ch. 10) & 5Q (ch. 11), T: Quixam 5E (Ch. 12), <b>W: ALP final presentations</b> , Th: Potluck, Wrap
Final Program Conferences (Mon. Jun. 12 & Tue. Jun. 13)			

**Spring Quarter Texts:**

*Introduction to Electrodynamics* (4th Edition). Griffiths. 2012. ISBN: 9780321856562. (EM)

*A Modern Approach to Quantum Mechanics* (2nd Edition). Townsend, 2013. ISBN: 9781891389788. (QM)

**Expected credit distribution, spring quarter:**

Electrodynamics (6 credits); Quantum Mechanics (4 credits); Advanced Lab Projects (2 or 4 or 6 credits) OR Python Programming (6 credits) OR Individual Student work (up to 6 credits)

**Special Needs:** Students who require accommodations for academic work should contact Access Services (<http://evergreen.edu/access/> ph. 360-867-6348/TTY: 360-867-6834). Information about such accommodations is confidential and protected by legal and ethical considerations.

**Awarding of credit:** In order to earn credit, students must demonstrate competency on all coursework, including written exams. All work will be evaluated with the program learning goals (see below) in mind. Students are expected to come to class prepared and to participate actively and positively in class activities. Poor attendance or poor participation in program activities will be mentioned in a student's evaluation. No partial credit in individual subjects.

**Conferences and Evaluations:** All students are invited to participate in a Final Program Conference, which will take place on Monday June 12 and Tuesday June 13. Your self evaluation and Annual or Final Academic Statement must be completed prior to the evaluation conference. Your evaluations of Professor Chowdary and Foster-Grahler must also be posted prior to the evaluation conference.

**Academic Statements:** Students graduating this spring will be supported to produce high quality Final Academic Statements through peer review workshops and particularly with several individual sessions with faculty through the quarter. Final Academic Statements are due by Friday June 16 (Graduation Day) or otherwise your official graduation date on your transcript will be delayed. Returning students will produce a revised Annual Academic Statement, which is due by Thursday May 18 or you will get a registration hold for summer or fall 2017 registration.

### **Program Learning Goals:**

- Strive to create an intentionally inclusive and anti-bias learning environment that is attentive to and supportive of the unique gifts and background of each student with the goal of equitable outcomes for all.
- Improve your ability to articulate and assume responsibility for your own work.
- Strengthen your collaborative skills and the ability to respond in useful ways to the work of colleagues.
- Improve your skills in clear communication of mathematical and scientific ideas, both orally and in writing.
- Improve your reading of technical texts to develop conceptual understanding and procedural skills.
- Develop and utilize increasingly sophisticated mathematical models that describe and explain physical systems.
- Develop deep conceptual understanding and sophisticated problem-solving abilities related to electricity & magnetism and quantum mechanics, while reinforcing, extending, and integrating previous study of classical mechanics.
- Use a computer based algebra system to visualize and solve complex problems in math and physics.
- Develop insight into the fundamental interplay between the experimental, computational, and theoretical aspects of physics through deep and sustained exposure to one or a few pieces of advanced laboratory apparatus.

Our work will take place in a learning community, and we will be responsible for our interactions within the group as well as our individual learning. It is important to keep in mind the institutional-level expectations and approaches that form the backdrop of our work, as described in the "Six Expectations" and "Five Foci":

### **Expectations of an Evergreen Graduate:**

- Articulate and assume responsibility for your own work.
- Participate collaboratively and responsibly in our diverse society.
- Communicate creatively and effectively.
- Demonstrate integrative, independent, critical thinking.
- Apply qualitative, quantitative and creative modes of inquiry appropriately to practical and theoretical problems across disciplines.
- As a culmination of your education, demonstrate depth, breadth and synthesis of learning and the ability to reflect on the personal and social significance of that learning.

### **Five Foci of Learning:**

- Interdisciplinary Study
- Collaborative Learning
- Learning Across Significant Differences
- Personal Engagement
- Linking Theory with Practical Applications

## Course-Scale Learning Goals:

The following Course-Scale Learning Goals are taken from those created for Upper-Division Electrostatics (E&M I) and Upper-Division Electrodynamics (E&M II) and Upper Division Quantum Mechanics I by the Department of Physics and the Science Education Initiative at the University of Colorado at Boulder (contact: Stephanie V. Chasteen, [Stephanie.Chasteen@colorado.edu](mailto:Stephanie.Chasteen@colorado.edu)) with modifications by Krishna M. Chowdary at The Evergreen State College for the academic program *Physical Systems and Applied Mathematics* (PSAM).

- 1) **Intellectual maturity:** Students should accept full responsibility for their own learning. They should be aware of what they do and don't understand about physical phenomena and classes of problems. They should learn to ask thoughtful, sophisticated, specific questions. Students should learn to identify and articulate where they are experiencing difficulty, and take action to move beyond that difficulty (e.g. by appropriately seeking out allowed resources). They should regularly check their understanding against these learning goals and seek out appropriate help to fill in any gaps.
- 2) **Build on earlier studies and make connections to other materials:** Students should deepen their understanding of introductory and junior-level electromagnetism and quantum mechanics, and necessary math skills (in particular, differential equations, linear algebra, and vector calculus, **LG#5**). Students should make connections to other physics material (e.g. mechanics, waves, optics, modern physics), other sciences (e.g. chemistry), and other more broadly interdisciplinary studies.
- 3) **Communication:** Students should be able to justify and explain their thinking and/or approach to a problem or analysis of a physical situation, in either written or oral form.
- 4) **Organized knowledge:** Students should be able to articulate the important ideas from each chapter, section, and/or lecture, thus indicating how they have organized their content knowledge. They should be able to filter this knowledge to access the information they'll need to solve a particular physics problem, and make connections between different concepts. This organizational process should build on knowledge gained in earlier physics classes. For example, students should see the various topics in EM as part of a coherent theory of electromagnetism; i.e., as a consequence of Maxwell's equations.
- 5) **Math/physics connection:** Students should be able to translate a description of a junior-level EM or QM problem into the mathematical equation(s) necessary to solve it; explain the physical meaning of the final solution, including how this is reflected in its mathematical formulation; and be able to achieve physical insight through the mathematics of a problem.
- 6) **Visualization:** Students should be able to sketch or otherwise visually represent a physical situation given e.g., electric or magnetic fields, charge distributions; or e.g., wave function, potential, probability distribution. They should be able to use a computer program to graph physical parameters, create animations of time-dependent solutions, and compare analytic solutions with computations. Students should recognize when each of the two methods (by hand or computer) is most appropriate.
- 7) **Problem-solving techniques:** Students should be able to choose and apply the problem-solving technique that is appropriate for a particular situation (e.g., whether to use the integral or differential forms of Maxwell's equations). They should be able to apply these methods to novel contexts (i.e., solving problems that do not map directly to examples in a textbook), indicating how they understand the essential features of the technique, rather than just the rote mechanics of its application. Some techniques particular to EM and QM include (but are not limited to)
  - ...**Approximations:** Students should be able to effectively use approximation techniques, and recognize when they are appropriate (e.g., at points far away or very close to the source, or when the energy is very high, or when the barrier width is very wide). They should be able to decide how many terms of a series expansion must be retained to find a solution of a given order, and be able to complete a Taylor Series to at least two terms.
  - ...**Symmetries:** Students should be able to recognize symmetries, and be able to take advantage of them when choosing the appropriate method of solution (e.g., correctly applying the Maxwell-Ampere law to calculate the magnetic field of an infinitely long wire, or when parity allows you to eliminate certain solutions).
  - ...**Integration:** Students should be able to write down the line, surface or volume integral required for solving a specific problem, and correctly follow through with the integration.
  - ...**Superposition:** Students should recognize that – in a linear system – a general solution can be formed by the superposition of multiple components, and a specific solution found by applying appropriate boundary conditions.
- 8) **Problem-solving strategy:** Students should be able to draw on an organized set of content knowledge (**LG#4**), and apply problem-solving techniques (**LG#7**) with that knowledge in order to carry out lengthy analyses of physical situations. They should be able to connect all the pieces of a problem to reach a final solution. They should recognize the value for learning the material of taking wrong turns, be able to recover from their mistakes, and persist in working towards a solution even though they don't necessarily see the possibly many steps of the path to that solution when they first begin the problem. Students should be able to articulate what it is that needs to be solved for in a given problem, and know when they have found it.
- 9) **Expecting and checking solutions:** When appropriate for a given problem, students should be able to articulate their expectations for the solution, such as the magnitude or direction of a vector field, the general shape of a wave function, the dependence of the solution on coordinate variables, its behavior at large distances, or problem symmetry. For all problems, students should be able to justify the reasonableness of a solution (e.g., by checking its symmetry, looking at limiting or special cases, relating to cases with known solutions, dimensional analysis, and/or checking the scale/order of magnitude of the answer).

## **Homework, Assignments, and Assessments**

**Reading Notes:** In fall and winter, various tools were made available to help you meet the Program Learning Goal to “Improve your reading of technical texts to develop conceptual understanding and procedural skills.” You should continue to endeavor to produce detailed reading notes that identify key definitions, concepts, theorems, formulas, etc. (e.g. “big concepts” and “big math”) as well as show your work on examples provided in the text and the questions that you have from the reading. We will discuss how to share your questions from the reading.

**Problem Sets:** Each week, substantial homework assignments will be assigned in EM and QM. Problem Sets should be completed in Problem Set Notebooks (PSN) dedicated to each subject (so a separate PSN for each of EM and QM). Bring your PSNs to relevant Quixam sessions for spot checks. You are personally responsible for keeping a complete PSN that demonstrates your own personal understanding of the subject material.

Each week, you will be assigned to contribute several problems from the week’s Problem Set to a collaborative online PSN (using Google Docs). These contributions might be a good quality image of the problem from your own PSN or a typeset solution. These contributions should be made as soon as possible and no later than noon Sundays. The faculty will offer feedback and corrections to contributions, and in the case of missing problems, will supply a brief solution; this will happen on a rolling basis so it is of benefit to contribute your solutions as soon as possible. Student feedback is also welcome. The goal is to have a complete Solutions set available by Sunday evening to help with studying for Quixams.

Collaboration is allowed and encouraged, as is appropriate and responsible use of resources including program tutors. Attempt every problem and get as far as you can on your own first. It is expected that you may struggle with problems before collaboration; it is vital that after collaboration, you are personally able to display understanding of the concepts and mathematics associated with such problems. The first draft of each weekly Quiz and each Exam will be individual efforts, so consider your learning associated with Problem Sets in light of your individual progress.

**Quixam and Quixam Revisions:** The first class meeting each week will be devoted to an individual Quixam in either EM or QM (see the Tentative Weekly Schedule for details). Much of the material is necessarily cumulative, but Quixams will focus on material covered in class and on Problem Sets since the previous Quixam. Calculators and a personally prepared 3 inch by 5 inch note cards will be allowed (notecards prepared for previous Quixams will also be allowed). You will submit the Quixam for faculty to assess. Immediately following the Quixam, we will have a Quixam Revision Workshop where we will work collaboratively to review and revise the Quixam. If you are unsatisfied with your performance on a Quixam, you may submit a Quixam Revision; revisions are due at the beginning of the relevant class on the day immediately following the Quixam.

**Advanced Lab Projects or independent work:** Some students are participating in a Python Programming self-paced course of study or some other individualized independent learning option. Other students are completing Advanced Lab Projects. ***Students in the Python Programming or other independent learning options will produce and sign agreements detailing the expected work. Students completing Advanced Lab Projects will produce customized plans including individual learning goals and weekly schedules.***

**Portfolio:** Throughout the program, you will maintain a portfolio of your work consisting of all the above assignments and assessments as well as any notes or other material that reflect your work to produce a lasting record and resource for your own future reference.