# Physics 431
# Electricity and Magnetism
# Spring, 2017

Meets:
10:00 am – 11:50 am
Tuesday, Thursday
150 Meldrum Hall

Instructor:
Dr. Christopher Cline
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Textbook:
Required: *Introduction to Electrodynamics*, 3rd Ed., David J. Griffiths.
*Electricity and Magnetism*, Berkeley Physics Course, Vol. 2, Edward M. Purcell

**Course Description:** Physics 431 is a junior/senior level course in electricity and magnetism – the study of how electric and magnetic fields behave in vacuum and in various mediums. It represents centuries of experimental and theoretical works by some of the greatest minds in science. Many of our modern conveniences can be traced to their efforts. Originally, electric and magnetic properties were treated as separate subjects but experimental works by Orsted and Faraday provide strong evidences that the two are related. The apex of these works is the four Maxwell's equations. These equations form the first unified theory and today is the basics of what we know as electromagnetic force.

The electromagnetic force is one of the four fundamental forces in nature, the others are gravitational force, weak and strong nuclear forces. The last two forces are extremely short range, existing in the realms of the nucleus. While one might think that the gravitational force is the dominant force, it is the electromagnetic force that holds you together as a person! Indeed it is the electromagnetic force that provides the "glue" that holds much of the things we see around us. This in turn gives "sufficient mass" for the gravitational force to have a significant influence. (If you find that hard to shallow, think what would happen to you if your mass is that of a hydrogen molecule or helium atom.)

This is a course in purely theoretical physics. Electrodynamics as it is currently formulated involves the interaction of electric and magnetic fields with each other and with charges. Both of these fields are vector fields. Accordingly, we will start the course with a review of vectors, vector products, and derivatives of vectors which will, in turn, lead us to a discussion of vector calculus. Along the way we'll pick up such topics as the Dirac delta function and the treatment of vectors in different coordinate systems. We will also need additional mathematics, including multi-variable calculus, differential equations, and a little linear algebra. I will show you how to use these mathematical techniques to solve the physics problems, rather than assuming that you remember them from somewhere else.

If the charges in a particular problem are fixed and if the currents, if any, are constant, then electrodynamics separates into the two separate fields of electrostatics and magnetostatics. As shown in the course outline below, this course treats electrostatics and magnetostatics in vacuum, electromagnetic induction, returning to electrostatics and magnetostatics in matter, and then an introduction to the glory of Maxwell's equations in vacuum. All of electromagnetism and optics are contained in these equations. In spite of their abstract nature and nontrivial mathematical form, many have fallen in love with these equations, and I hope you would love them too. If we have time, we will then look at time-dependent fields, including optics.

**Conditions of enrollment:** Physics 212 (Physics for Scientists & Engineers II), Physics 309 (Mathematical Methods of Physics), Math 203 (Multivariate Calculus), and Math 211 (Linear Algebra) are prerequisites for all students enrolled in this course.

**How to get help:** My office hours are MW 1:00 pm-4:00 pm. If you can't come during any of these hours, I will be happy to make an appointment with you for another time. For me, *the* most enjoyable aspect of teaching is working with students one-on-one. *Please, please* come see me often—*especially* if you run into difficulties with concepts.

**Class Attendance and Participation:** Class meetings are TTh 10:00am-11:50am. Preparation for class, attendance, and participation will be rewarded.

**Learning Goals:** This list represents what we want you to be able to *do* at the end of the course:

**Course Scale Learning Goals**

- **Math/physics connection:** Students should be able to translate a physical description of a junior-level electromagnetism problem to a mathematical equation necessary to solve it. Students should be able to explain the physical meaning of the formal and/or mathematical formulation of and/or solution to a junior-level electromagnetism problem. Students should be able to achieve physical insight through the mathematics of a problem.
- **Visualize the problem:** Students should be able to sketch the physical parameters of a problem (e.g., $E$ or $B$ field, distribution of charges, polarization), as appropriate for a particular problem.
- **Expecting and checking solution:** When appropriate for a given problem, students should be able to articulate their expectations for the solution to a problem, such as direction of a force, dependence on coordinate variables, and behavior at large distances or long times. For all problems, students should be able to justify the reasonableness of a solution they have reached, by methods such as checking the symmetry of the solution, looking at limiting or special cases, relating to cases with known solutions, checking units, dimensional analysis, and/or checking the scale/order of magnitude of the answer.
- **Organized knowledge:** Students should be able to articulate the big ideas from each chapter, section, and/or class period, thus indicating that they have organized their content knowledge. They should be able to filter this knowledge to access the information that they need to apply to a particular physical problem, and make connections/links between different concepts.
- **Communication:** Students should be able to justify and explain their thinking and/or approach to a problem or physical situation, in either written or oral form. Students should be able to write up problem solutions that are well-organized, clear, and easy to read.
- **Build on Earlier Material:** Students should deepen their understanding of Phys 212 and Phys 309 material, i.e., the course should build on earlier material.
- **Problem-solving techniques:** Students should be able to choose and apply the problem-solving technique that is appropriate to a particular problem. This indicates that they have learned the essential features of different problem-solving techniques (e.g., separation of variables, method of images, direct integration). They should be able to apply these problem-solving approaches to novel contexts (i.e., to solve problems which do not map directly to those in the book), indicating that they understand the essential features of the technique rather than just the mechanics of its application. They should be able to justify their approach for solving a particular problem.
    - **Approximations:** Students should be able to recognize when approximations are useful, and use them effectively (e.g., when the observer is very far away from or very close to the source). Students should be able to indicate how many terms of a series solution must be retained to obtain a solution of a given order.
    - **Series expansions:** Students should be able to recognize when a series expansion is appropriate to approximate a solution, and complete a Taylor Series to two terms.
    - **Symmetries:** Students should be able to recognize symmetries and be able to take advantage of them in order to choose the appropriate method for solving a problem (e.g., when to use Gauss' Law, when to use separation of variables in a particular coordinate system).
    - **Integration:** Given a physical situation, students should be able to write down the required partial differential equation, or line, surface or volume integral, and correctly calculate the answer.
    - **Superposition:** Students should recognize that – in a linear system – the solutions may be formed by superposition of components.
- **Problem-solving strategy:** Students should be able to draw upon an organized set of content knowledge, and apply problem-solving techniques to that knowledge in order to organize and carry out long analyses of physical problems. They should be able to connect the pieces of a problem to reach the final solution. They should recognize that wrong turns are valuable in learning the material, be able to recover from their mistakes, and persist in working to the solution even though they don't necessarily see the path to the solution when they begin the problem. Students should be able to articulate what it is that needs to be solved in a particular problem and know when they have solved it.
- **Intellectual maturity:** Students should accept responsibility for their own learning. They should be aware of what they do and don't understand about physical phenomena and classes of problem. This is

evidenced by asking sophisticated, specific questions; being able to articulate where in a problem they experienced difficulty; and take action to move beyond that difficulty.

- **Maxwell's Equations:** Students should see the various laws in the course as part of the coherent field theory of electromagnetism; i.e., Maxwell's equations.

## Overall Course Objectives: Calculation and Computation

Students will be able to:

- Compute gradient, divergence, curl, and Laplacian
- Evaluate line, surface, and volume integrals
- Apply the fundamental theorem for divergences (Gauss' Theorem) in specific situations
- Apply the fundamental theorem for curls (Stoke's Theorem) in specific situations
- Apply Coulomb's Law and superposition principle to calculate electric field due to a continuous charge distribution (uniformly charged line segment, circular or square loop, sphere, etc.)
- Apply Gauss' Law to compute electric field due to symmetric charge distribution
- Calculate electric field from electric potential and vice versa
- Compute the potential of a localized charge distribution
- Determine the surface charge distribution on a conductor in equilibrium
- Use method of images to determine the potential in a region
- Solve Laplace's equation to determine the potential in a region given the potential or charge distribution at the boundary (Cartesian, spherical and cylindrical coordinates)
- Use multipole expansion to determine the leading contribution to the potential at large distances from a charge distribution
- Calculate the field of a polarized object
- Find the location and amount of all bound charges in a dielectric material
- Apply Biot-Savart Law and Ampere's Law to compute magnetic field due to a current distribution
- Compute vector potential of a localized current distribution using multipole expansion
- Calculate magnetic field from the vector potential
- Calculate the field of a magnetized object
- Compute the bound surface and volume currents in a magnetized object
- Compute magnetization, $H$ field, susceptibility and permeability

## Chapter Scale Learning Goals

**Chapter 1:** Vector analysis

Topics:

- Div, grad, curl
- Line, surface, volume integrals
- Curvilinear coordinates
- Dirac delta function
- Vector fields (potentials)

**Prerequisites:** Students should already be able to…

1. Compute correctly div, grad and curl in rectangular coordinates for any test function
2. Do a path integral along a specific path
3. Expand $1/1+\varepsilon$ and $1/1+\varepsilon$ when $\varepsilon$ is very small.

Students will be able to:

1. Evaluate the integral from negative infinity to infinity of the delta function, $\delta(x)$.
2. Evaluate the 3-dimensional divergence of $1/r^2$ in the r-hat direction.
3. Evaluate the integral of a function times the delta function.
4. Be able to evaluate the integral of $1/(x - r)^{3/2}dx$.
5. Give a geometrical description of the divergence theorem, and fundamental theorem for curls.
6. Change a multidimensional integral in Cartesian coordinates to one in another coordinate system using the Jacobian.

**Chapter 2:** Electrostatics

Topics

- Electric field, Coulomb's law
- Gauss' Law, divergence and curl of $E$
- Potential
- Poisson & Laplace equation
- Work & energy
- Conductors

**Prerequisites:** Students should already be able to…

1. State Gauss' Law and construct the 3 Gaussian surfaces.
2. Use Cartesian, spherical and cylindrical coordinates appropriately when constructing integrals and surface and volume elements.

<u>Electric Field</u>

1. Students should be able to state Coulomb's Law and use it to solve for E above a line of charge, a loop of charge, and a circular disk of charge.
2. Students should be able to solve surface and line integrals in curvilinear coordinates (when given the appropriate formulas, as in the inner-front cover of Griffiths).

<u>Divergence and Curl of E; Gauss' Law</u>

1. Students should recognize when Gauss' Law is the appropriate way to solve a problem (by recognizing cases of symmetry; and by recognizing limiting cases, such as being very close to a charged body).
2. Students should be able to recognize that E comes out of the Gaussian integral only if it is constant along the Gaussian surface.
3. Students should be able to recognize Gauss' Law in differential form and use it to solve for the charge density $\rho$ given an electric field $E$.

<u>Electric Potential</u>

1. Students should be able to state two ways of calculating the potential; indicate which is the appropriate formulation in different situations; and correctly evaluate it via the chosen formulation.
2. Students should be able to calculate the electric field of a charge configuration or region of space when given its potential.
3. Students should be able to state that potential is force per unit charge, and give a conceptual description of $V$ and its relationship to energy.
4. Students should be able to explain why we can define a vector potential $V$.
5. Students should be able to defend the choice of a suitable reference point for evaluating $V$, and explain why we have the freedom to choose this reference point.

Work & Energy

- Students should be able to calculate the energy stored in a continuous charge distribution when given the appropriate formula.
- Students should be able to explain in words what this energy represents.

Conductors

- Students should be able to sketch the induced charge distribution on a conductor placed in an electric field.
- Students should be able to explain what happens to a conductor when it is placed in an electric field, and sketch the E field inside and outside a conducting sphere placed in an electric field.
- Students should be able to explain how conductors shield electric fields, and describe the consequences of this fact in particular physical problems (e.g., conductors with cavities).
- Students should be able to state that conductors are equipotentials, that $E = 0$ inside a conductor, that $E$ is perpendicular to the surface of a conductor (just outside the conductor), and that all charge resides on the surface of a conductor.

Maxwell's Equations

- Students should be able to interpret the first and second Maxwell's equations for electrostatics ( $\vec{\nabla} \cdot \vec{E} = \rho/\varepsilon_0$ and $\vec{\nabla} \times \vec{E} = 0$ ) and use them to describe electrostatics.

**Chapter 3:** Special Techniques

Topics

- Laplace's equation
- Boundary conditions and uniqueness
- Method of images
- Separation of variables in Cartesian and spherical
- Multipole expansion

**Prerequisites:** Students should already be able to…

1. Recognize the wave equation in Cartesian coordinates, and state that $e^{ikx}$ is a solution.
2. Recognize the solution to separation of variables in Cartesian coordinates.
3. Recognize that a function can be expanded in terms of a complete basis, such as sin and cos.
4. State that conductors are equipotentials.

Laplace's equation

1. Students should recognize that the solution to Laplace's equation is unique.

Method of Images.

1. Students should realize when the method of images is applicable and be able to solve simple cases.
2. Students should be able to explain the difference between the physical situation (surface charges) and the mathematical setup (image charges).

Separation of variables/boundary value problems

1. Students should be able to state the appropriate boundary conditions on $V$ in electrostatics and be able to derive them from Maxwell's equations.
2. Students should recognize where separation of variables is applicable and what coordinate system is appropriate to separate in.
3. Students should be able to outline the general steps necessary for solving a problem using separation of variables.
4. Students should be able to state what the basis sets are for separation of variables in Cartesian and spherical coordinates (ie., exponentials, sin/cos, and Legendre polynomials.)

5. Students should be able to apply the physics and symmetry of a problem to state appropriate boundary conditions.
6. Students should be able to solve for the coefficients in the series solution for *V*, by expanding the potential or charge distribution in terms of special functions and using the completeness/orthogonality of the special functions, and express the final answer as a sum over these coefficients.

<u>Multipole expansions</u>

1. Students should be able to explain when and why approximate potentials are useful.
2. Students should be able to identify and calculate the lowest-order term in the multipole expansion (i.e., the first non-zero term).
3. Students should be able to sketch the direction and calculate the dipole moment of a given charge distribution.

**Chapter 4:** Electric Fields in Matter

Topics:

- Polarization & dielectrics
- Field of polarized object (bound charges, field inside dielectric)
- Electric displacement
- Linear dielectrics: Susceptibility, permittivity, dielectric constant
- Boundary value problems with dielectrics

<u>Polarization and dielectrics</u>

1. Students should be able to go between two representations of dipoles – as point charges, and as generalized dipole vectors – for simple charge configurations.
2. Students should be able to calculate the dipole moment of a simple charge distribution.
3. Students should be able to describe similarities and differences between a conductor and a dielectric (both shield E, conductor shields E completely, dielectric shields via fixed dipoles, conductor shields via mobile electrons).
4. Students should be able to predict whether a particular pattern of polarization will result in bound surface and/or volume charge.
5. Students should be able to explain the physical origin of bound charge at a macroscopic and microscopic level.

<u>Field of a polarized object</u>

1. Students should be able to sketch the *E* field inside and outside a dielectric sphere placed in an electric field.
2. Students should be able to explain what happens to a dielectric, when it is placed in an electric field.
3. Students should be able to explain the difference between free and bound charge.
4. Students should be able to identify the appropriate boundary conditions on *D* given its relationship to *E* and $Q_f$.

<u>Electric displacement</u>

1. Students should be able to sketch the direction of *D*, *P*, and *E* for simple problems involving dielectrics
2. Students should be able to calculate the *E* field inside a dielectric when given epsilon and the free charge on the dielectric.

<u>Linear dielectrics</u>

1. Students should be able to articulate the difference between a linear and nonlinear dielectric.
2. Students should be able to write down Maxwell's equations (for electrostatics) in matter, when given the appropriate equations in vacuum.
3. Students should be able to identify the appropriate boundary conditions on *D*, given its relationship to *E*.

**Chapter 5: Magnetostatics**

Topics:

- Currents and charge density
- Magnetic fields and forces (Lorentz force law)
- Biot-Savart law
- Divergence and curl of B (Ampere's Law)
- Magnetic vector potential

**Prerequisites:** Students should already be able to…

1. Write down Lorentz force law.
2. Know the right-hand rule and how to apply it.

Currents and charge density

1. Students should be able to calculate current density J given the current I, and know the units for each.
2. Students should be able to explain, in words, what the charge continuity equation $\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{J} = 0$ means.
3. Students should be able to state the vector form of Ohm's Law ( $\vec{J} = \sigma \vec{E}$ ) and when it applies.
4. Students should be able to calculate the current $I$, $K$ and $J$ in terms of the velocity of the particle or in terms of each other.

Magnetic fields and forces

1. Students should be able to describe the trajectory of a charged particle in a given magnetic field.
2. Students should be able to sketch the B field around a current distribution, and explain why any components of the field are zero.
3. Students should be able to explain why the magnetic field does no work using concepts and mathematics.

Biot-Savart Law

1. Students should be able to state when the Biot-Savart Law applies (magnetostatics; steady currents, $d\rho/dt = 0$).
2. Students should be able to compare similarities and differences between the Biot-Savart law and Coulomb's Law.
3. Students should be able to choose when to use Biot-Savart Law versus Ampere's Law to calculate $B$ fields, and to complete the calculation in simple cases.

Divergence and curl of B (Ampere's Law)

1. Students should be able to draw appropriate Amperian loops for the cases in which symmetry allows for solution of the $B$ field using Ampere's Law (ie., infinite wire, infinite plane, infinite solenoid, toroids), and calculate $I_{enc}$.
2. Students should be able to make comparisons between $E$ and $B$ in Maxwell's equations.

Magnetic vector potential

1. Students should be able to explain why the potential $A$ is a vector for magnetostatics, whereas it's a scalar ($V$) in electrostatics, ie., that the source of magnetic fields (the current) is a vector, whereas the source of electric fields (charge) is not.
2. Students should recognize that $A$ does not have a physical interpretation similar to $V$, but be able to identify when it is useful for solving problems.

Separation of variables/boundary value problems

1. Students should be able to state the appropriate boundary conditions on $B$ in magnetostatics and be able to derive them from Maxwell's equations

Maxwell's Equations

1. Students should be able to interpret the third and fourth Maxwell's equations for electrostatics ( $\vec{\nabla} \cdot \vec{B} = 0$ and $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$ ) and use them to describe magnetostatics (i.e., Ampere's Law and Biot-Savart law are just applications of these laws).

**Chapter 6: Magnetic Fields in Matter**

Topics:

- Magnetization – diamagnets, paramagnets, ferromagnets
- Field of magnetized object (bound currents)
- Auxiliary field H
- Linear and nonlinear media: susceptibility, permeability

Magnetization

1. Students should be able to calculate the torque on a magnetic dipole in a magnetic field.
2. Students should be able to explain the difference between para, dia, and ferromagnets, and predict how they will behave in a magnetic field.

The field of a magnetized object

1. Students should be able to predict whether a particular magnetization will result in a bound surface and/or volume current, for simple magnetizations.
2. Students should be able to give a physical interpretation of bound surface and volume current, using Stokes' Theorem.

Auxiliary field *H*

1. Students should be able to calculate $H$ when given $B$ or $M$.
2. Students should recognize that $H$ is a mathematical construction, whereas $B$ and $M$ are physical quantities.
3. Students should be able to use $H$ to calculate $B$ when given $J_f$ for an appropriately symmetric current distribution.
4. Students should be able to articulate in which physical situations it is useful to use $H$.
5. Students should be able to identify the appropriate boundary conditions on $H$ given its relationship to $M$ and $K_f$.

## Course Requirements

**Reading Memos:** It is nearly useless to read a physics text as you would a novel. "Studying" such a text requires that you be an *active* reader, that you remain engaged in a virtual and *appropriately skeptical* conversation with the author. You should, for example: (1) reserve doubt about everything the text says until it thoroughly convinces you, (2) think about situations to which the author's arguments might not apply, (3) make notes in the margins, (4) draw your own sketches and graphs to help visualize situations and functional behaviors, and *especially* (5) fill in all of the missing steps in any mathematical arguments. Indeed it is *all* too tempting to simply take the author's word for everything including the results of any calculation; after all, he or she wouldn't consciously *lie* to you, right? Well, yes; probably. But if you get into that habit, you will become a *passive* reader. Your mind forms no permanent "hooks" on which to store the information being presented. The time spent in the process may well be reduced, but will also have been essentially wasted.

Perhaps mathematician Paul R. Halmos gave the best advice about how to study: "*Study actively. Don't just read the text; fight it! Ask your own questions, look for your own examples, discover your own proofs*." (*I Want to Be a Mathematician*, New York: Springer-Verlag, 1985)

Accordingly, in order to help you form or hone these important good study habits, I will ask you to produce and turn in a "Reading Memo" at the beginning of each day for which there is assigned reading. A "Reading Memo" is an informal running collection of thoughts about and reactions to the material in the text. As you study, keep a pencil in hand and note any questions that occur to you; any surprises, insights, or connections to other things you know about; anything you think may be wrong or incomplete and why you think so; anything you think could be said more clearly and your proposed revision; etc. Beyond their effectiveness at helping you to stay engaged as you study, your Reading Memos will also help me to understand those items and topics that may require more attention in class.

Your Reading Memos will be given full (2 pts) or half credit (1 pt) *purely* on the basis of whether or not it appears that your good faith effort was involved and *not at all* on the basis of format, sophistication, vocabulary, correctness, etc. In order to allow for extraordinary circumstances (*including* absence for *any* reason), I will throw out up to three "missing" Reading Memos.

**Homework:** I will make regular Homework Assignments due at intervals of very approximately a week and a half to two weeks at the beginning of a specified class meeting.

As you surely know by now, the primary purpose of assigned problems in physics is ***absolutely not*** to see if you can get the right answer. Rather, it is for you to practice and then demonstrate that you have learned 1) how to determine the fundamental physical principles that are involved in a described situation and 2) how to apply those principles in a disciplined and orderly fashion. Of course, if you have learned how to do these things, you should expect to get the right answer too, but that is - really - of secondary importance. You will find - indeed, you probably have found - that, given time, an open book, lots of worked examples, and knowledge of the correct answer, it is very often possible to "get the answer" without the slightest understanding of what you are doing. Please guard against this; it is a complete waste of your time because it does not prepare you for, and it obviously will not work on, exams.

Accordingly, we are not - and you should not be - satisfied with problem "solutions" that simply consist of a series of mathematical manipulations leading to a result. Instead, the problem solutions you submit are to be "presented." By this we mean that they should be readable by someone who does not have access to the problem statement; should include written explanations and thoughtful comments about what you are doing and, especially, why; should use well-defined and consistent notation (employing unique and meaningful subscripts and superscripts as necessary); should be accompanied by neatly drawn and carefully labeled diagrams; and should flow in a logical and orderly progression down the page. They should use more space for the written explanatory information than for the mathematics! They should ***not*** include lengthy, multiple-step, purely mathematical manipulations because it only serves to obscure the physics. Do this kind of work on scratch paper and simply say something like "Solving equations 1, 2, and 3 for $x$, $y$, and $z$, we obtain ..." and give the result.

I will not "check" your homework solutions in any serious fashion; it is up to *you* to check them against the solutions that I will hand out and to get answers—from me or others in the class—to any remaining questions you have. I will look over your work only casually and assign a holistic score of 1 to 4 with 4 meaning that the problem set appears to be *exceptional*—complete, *very* well presented, and mostly correct; 3, good—at least nearly complete, clearly presented, and pretty much correct; 2—incomplete or not so clearly presented; 1—not a good faith effort. Problem sets not submitted will receive a 0.

I *strongly* encourage you to form study groups and to discuss with others your readings, questions that come up in and out of class, and how to go about solving problems. The work ***you*** turn in, however, must be ***yours***, based on the understanding ***you*** have acquired. When faced with two write-ups that show any signs of copying, I conclude that at least one person hasn't done the work. In such cases both papers will receive no credit.

I do not accept late Homework Assignments, but, in order to allow for extraordinary circumstances (*including* absence for *any* reason), I will throw out your two lowest scores.

**Subjective Bonus:** A small portion of your grade is also determined by my own overall subjective evaluation of your work in the class. Although it is subjective, my policy is that it will *not* be less than the average of your Reading Memo and Homework scores. It allows me *only* to *reward* students who make contributions to the class that may not be fully recognized, who make particularly effective use of office hours, or who, in any other way, seem to deserve a bit of *additional* credit.

**Exams:** There will be two to three in-class exams. You may use one page/one side of your own handwritten notes, and any crib sheets that I provide you. You may not use your textbook, or work with or gain assistance from anyone except your instructor. Of course, I trust you will do all your own work on the exams. If you are caught cheating on an exam you will receive an F for the exam for the first offense; for a second offense, you will receive an F for the entire course.

**Grading:** Your overall "Course Score" will be calculated using the following relative weights:

| | |
|---|---|
| Reading Memos | 10% |
| Homework | 20% |
| Subjective Bonus | 10% |
| Exams | 20-30% each |

**Academic Integrity:** Please make sure that you have read and fully understood Westminster's Policy on Academic Honesty (and Dishonesty) that appears in the Academic Catalog. My sincere desire is to act as facilitator—not an enforcer—for your studies in physics. Accordingly, I operate on the assumption that all of our interactions are based on openness, honesty, and good faith. I expect all of us to be honest and to treat each other fairly and with respect. Because our trust in each other is absolutely *crucial* to the effectiveness of our relationship, I take an uncompromising stance, as should you, on the necessity for sanctions when it is violated.

**ADA Statement:** Westminster College seeks to provide equal access in higher education to academically qualified students with physical, learning, and psychiatric disabilities. If you need disability-related accommodations in this class, have emergency medical information you wish to share with me, or need special arrangements in case the building must be evacuated, please inform me immediately. Please see me privately after class or in my office. Disability Services authorizes disability-related academic accommodations in cooperation with the students themselves and their instructors. Students who need academic accommodations or have questions about their eligibility should contact Karen Hicks, Disability Services Coordinator, in the START Center (801-832-2280) or email *disabilityservices@westminstercollege.edu*.

**Title IX:** Title IX of the Education Amendments of 1972 prohibits sex discrimination against any participant in an educational program or activity that receives federal funds. Westminster is committed to providing a safe and non-discriminatory learning, living, and working environment to all members of the Westminster community and does not discriminate on the basis of sex. This includes on the basis of gender, gender identity, gender expression, or sexual orientation. The College's Title IX policy strictly prohibits sexual assault, sexual harassment, gender-based harassment, gender-based discrimination, sexual exploitation, interpersonal violence (dating violence, domestic violence, stalking), and retaliation for making a good faith report of prohibited conduct or participating in any proceeding under the policy. The policy and accompanying procedures are available at *www.westminstercollege.edu/titleix* and discuss prohibited conduct, resources, reporting, supportive measures, rights, investigations, and sanctions for violations of the policy.

If you want to make a report of prohibited conduct, you may contact Westminster's Title IX Coordinator, Jason Schwartz-Johnson, or report an incident online. Jason can be reached at 801-832-2262, *jsj@westminstercollege.edu*, or in Malouf 107. You can also reach out to Deputy Coordinators Scott Gust at 801-832-2449 or Julie Freestone at 801-832-2573. Please note that to the extent permitted by law, the College aims to protect the privacy of all parties involved in the investigation and resolution of reported violations of the Policy. However, the College has a duty to investigate and take actions in response to reports and cannot guarantee confidentiality or that an investigation will not be pursued. The Counseling Center is a confidential resource, and by law the counselors who work there cannot reveal confidential information to any third party unless there is an imminent threat of harm to self or others.

**As a professor, I am a responsible employee and am required to report any information I obtain regarding conduct that may violate the policy to the Title IX Coordinator, so that students can receive supportive measures and referrals to resources, they are aware of their options, and the safety of the campus community can be ensured**. If you begin to disclose an incident of prohibited conduct, I may interrupt you because I want to make sure that you have had the opportunity to discuss the incident with confidential resources on and off campus first. If you need supportive measures inside or outside the classroom because of an incident of prohibited conduct, please reach out to the Title IX Coordinator for assistance.

**Title VI:** Title VI of the Civil Rights Act of 1964 prohibits discrimination based on race, color, or national origin in any program or activity receiving federal financial assistance. In addition to these, Westminster policy prohibits discrimination or harassment based on ethnicity, age, religion, veteran status, or genetic information in any of its programs or activities. If you encounter this type of discrimination or harassment, or feel that you have been retaliated against for reporting prohibited conduct or participating in any related proceeding, you can contact the Equal Opportunity Officer, Jason Schwartz-Johnson, at 801-832-2262. **As a professor, just as with Title IX, I am a responsible employee and am required to report any information I obtain regarding discrimination or harassment to the Equal Opportunity Officer for further review**.