College of Arts and Sciences
Department of Physics and Astronomy
University of South Carolina

Graduate Student Handbook

Department of Physics and Astronomy

Jones Physical Sciences Building

712 Main Street Room 404

Columbia, SC 29208

P: (803) 777-4121

F: (803) 777-3065

physics.sc.edu

Handbook Effective Date
August 2014

UNIVERSITY OF SOUTH CAROLINA

University of South Carolina
Department of Physics and Astronomy
Graduate Student Handbook
Table of Contents

University of South Carolina
Department of Physics and Astronomy
Graduate Student Handbook

This handbook is intended to compliment and reflect The Graduate School's regulations as outlined in the *Graduate Studies Bulletin* (http://bulletin.sc.edu/). It outlines the Department of Physics and Astronomy's academic requirements for the Master of Science and Doctor of Philosophy programs. In certain circumstances, exceptions to these requirements may be made by the entire faculty. Graduate students are encouraged to become familiar with the policies outlined in both this handbook and the *Graduate Studies Bulletin*.

I. EXPECTED UNDERGRADUATE BACKGROUND

Admission

Adequate preparation for graduate study ordinarily presupposes a bachelor's degree in physics or an allied field. Students who lack some of the usual undergraduate courses in physics may be required to take additional course work as a part of their program.

Prior to their admission to this department, entering graduate students are expected to have passed with a grade of C or better the following courses or their equivalent:

Quantum Physics (PHYS 501, 502)
Mechanics (PHYS 503)
Electromagnetic Theory (PHYS 504)
Kinetic Theory and Statistical Mechanics (PHYS 506)
Nuclear Physics (PHYS 511)
Solid State Physics (PHYS 512)

Mathematics through Advanced Calculus, including ordinary and partial differential equations and vector analysis, also should have been completed in the undergraduate program. Students with deficiencies in these courses must make them up during their initial two years of graduate studies as explained in the M.S. and Ph.D. Program Requirements.

II. COURSE REGISTRATION AND ACADEMIC ADVISEMENT

The department has an advisement committee, which provides academic advisement for all M.S. students and Ph.D. students. These students should consider the Advisement Committee to be their official advisor.

Students should register via the Banner System (my.sc.edu) after being advised by the Advisement Committee or their advisor. Please note the following:

- A departmental advisement form must be filled out in consultation with the advisor and the Director of Graduate Studies.
- Students cannot drop any credits without approval from the Advisement Committee.

- All graduate students must be enrolled in at least one credit hour during the summer session.
- Research (PHYS 760 and PHYS 761) must be approved by the professor in charge of the section.
- Thesis Preparation (PHYS 799) and Dissertation Preparation (PHYS 899) must be approved by the professor in charge of the section and the Director of Graduate Studies.
- Changes in the approved course schedule made after advisement must have the consent of the Director of Graduate Studies.
- The Advisement Committee will recommend specific actions to the Physics faculty if these advisement procedures are not followed. Failure to follow the Advisement Committee's recommendations may result in immediate termination of TA appointments.

III. GENERAL ISSUES

- All teaching assistants are expected to spend 20 hours per week on teaching duties, as per university policy.

- All TAs must be on campus no later than the official Faculty Reporting Day at the beginning of the fall semester, and at least 3 working days before classes begin for the spring semester.

- The TA appointment is given for one year and is subject to annual evaluation before renewal.

- All students must maintain an e-mail address and inform the Assistant to the Director of Graduate Studies of their current address, phone number, and e-mail address. Any changes should be reported as soon as possible.

- Graduate students are strongly encouraged to utilize research resources within the department. In particular, they should participate in colloquia and seminars both by attendance and by making their own presentations.

- Students are required to have a PhD committee formed within six months of passing the A to C examination. This committee will review the student's performance of students each semester to monitor his or her education and research performance to ensure efficient and timely progress of their PhD degree completion.

- At the end of each academic year, all students are required to complete a "Resume of Activity" form which addresses individual education/research performance (courses taken, labs taught, abstract submitted, presentations done, etc.). This form (together with the assessment mentioned above for students who have passed the A-to-C exam) will be used for evaluating the student's performance and renewal of TA appointment.

- If a student receives a grade of D+ or below in a course, he/she must re-take the course.

- Students are encouraged to keep in touch with the department after they graduate. We urge them to inform us of their new address, phone number, e-mail address, and employment.

IV. FIRST AND SECOND YEAR OF GRADUATE STUDY

- All teaching assistants are expected to spend 20 hours per week on teaching duties, as per university policy.

- All TAs must be on campus no later than the official Faculty Reporting Day at the beginning of the fall semester, and at least 3 working days before classes begin for the spring semester.

- The TA appointment is given for one year and is subject to annual evaluation before renewal.

- All students must maintain an e-mail address and inform the Assistant to the Director of Graduate Studies of their current address, phone number, and e-mail address. Any changes should be reported as soon as possible.

- Graduate students are strongly encouraged to utilize research resources within the department. In particular, they should participate in colloquia and seminars both by attendance and by making their own presentations.

- Students are required to have a PhD committee formed within six months of passing the A to C examination. This committee will review the student's performance of students each semester to monitor his or her education and research performance to ensure efficient and timely progress of their PhD degree completion.

- At the end of each academic year, all students are required to complete a "Resume of Activity" form which addresses individual education/research performance (courses taken, labs taught, abstract submitted, presentations done, etc.). This form (together with the assessment mentioned above for students who have passed the A-to-C exam) will be used for evaluating the student's performance and renewal of TA appointment.

- If a student receives a grade of D+ or below in a course, he/she must re-take the course.

- Students are encouraged to keep in touch with the department after they graduate. We urge them to inform us of their new address, phone number, e-mail address, and employment.

V. SEQUENCE OF EVENTS

Sequence of Events for an M.S. degree:

1. Courses
2. File program of courses
3. Thesis given to Director of Graduate Studies, thesis director, and second reader (the student must make an appointment with The Graduate School to review his/her thesis immediately following a successful presentation)
4. Thesis defense and Comprehensive Exam at least 30 days before graduation

Sequence of Events for a Ph.D. degree

1. Courses
2. Admission to Candidacy Exam after one/two years
3. Residency requirement
4. Ph.D. committee to be formed
5. Program to be filed with The Graduate School
6. Proposal submitted to Director of Graduate Studies and Ph.D. committee members
7. Proposal defense and Comprehensive Exam at least one week later but no more than six months after the Admission to Candidacy Exam
8. Ph.D. dissertation to be defended at least one year but no more than five years after the Comprehensive Exam
9. Dissertation to Director of Graduate Studies and Ph.D. committee members (the student must make an appointment with The Graduate School to review his/her dissertation immediately following a successful presentation)
10. Dissertation defense at least two weeks after dissertation is submitted to Director of Graduate Studies and Ph.D. committee members (dissertation defense must take place at least 30 days before graduation)

VI. MASTER OF SCIENCE REQUIREMENTS

Students working toward an M.S. degree are required to file a Program of Study as stated in the *Graduate Studies Bulletin*. Some credit for courses completed at other institutions may be granted by the Director of Graduate Studies subject to restrictions specified in the *Graduate Studies Bulletin*.

Summary of Requirements
Course Work
Thesis
Comprehensive Examination
Thesis Defense

Course Work

A minimum of thirty semester hours of course work is required. At least 18 hours of the minimum course credit requirements must be obtained in graduate courses (700 level). Quantum Mechanics (PHYS 711) and one of the following:

Classical Mechanics (PHYS 701)
Classical Field Theory I (PHYS 703)
Classical Field Theory II (PHYS 704)
Statistical Thermodynamics (PHYS 706)
Quantum Mechanics (PHYS 712)

must be included in the program. Up to 6 hours of Thesis Preparation (PHYS 799) may be counted. The following courses are not applicable to the 18-hour minimum requirement:

Graduate Seminar (PHYS 730)
Selected Topics in Physics (PHYS 740)
Research (PHYS 760 and PHYS 761)

It is expected that the entering student has taken the seven 500-level courses or their equivalents mentioned earlier. If some of these 500-level courses or their equivalents have not been taken, they must be completed during the initial two years of graduate studies. Up to 12 hours of 500-level courses can be used to complete the 30-hour requirement.

Thesis

The thesis involves either (a) the solution of an acceptable research problem chosen by the student or suggested by his/her advisor, or (b) a lucid, informative discussion, in the nature of a review article and not obtainable elsewhere, on some currently important topic.

Comprehensive Examination

The student must pass a comprehensive oral examination, which covers material contained in the Bachelor of Science program, as well as graduate-level work which the student has completed at the time. The examination is ordinarily administered as part of the thesis defense.

Thesis Defense

The student must submit the thesis to the Director of Graduate Studies and faculty committee consisting of the thesis director and one reader at least two weeks before the date of the examination. The committee will administer the comprehensive examination/thesis defense. A satisfactory performance is required for a degree.

VII. SAMPLE M.S. PROGRAM

First Year

Fall Semester

PHYS 501	Quantum Physics I (3 credits)
PHYS 503	Mechanics (4 credits)
PHYS 506	Thermal Physics (3 credits)
PHYS 515	Mathematical Physics I (3 credits)
PHYS 730	Graduate Seminar (1 credit)
File the degree program	

Spring Semester

PHYS 502	Quantum Physics II (3 credits)
PHYS 504	Electromagnetic Theory (4 credits)
PHYS 512	Solid State Physics (3 credits)
PHYS 730	Graduate Seminar (1 credit)
PHYS 761	Research (2 credits)

Second Year

Fall Semester

PHYS 711	Quantum Mechanics I (3 credits)
PHYS 7xx	700-level courses (6 credits)
PHYS 730	Graduate Seminar (1 credit)
PHYS 760	Research (2 credits)

Spring Semester

PHYS 511	Nuclear Physics (4 credits)
PHYS 7xx	700-level course (3 credits)
PHYS 761	Research (1 credit)
PHYS 799	Thesis Preparation (4 credits)

500-level courses may or may not be necessary depending on the student's prior preparation.

VIII. DOCTOR OF PHILOSOPHY REQUIREMENTS

The Ph.D. degree is awarded to those students who have satisfied the faculty that their knowledge of, and insight into, physics and their demonstrated ability in planning and carrying out research publishable in standard refereed physics journals have prepared them for a scholarly career in physics with the potential for continued professional growth and achievement. The primary means of demonstrating this is a dissertation based on original research carried out by the student. M.S. degree students who have finished their M.S. degree at USC and want to continue with the USC Ph.D. program should apply to the Admissions Committee.

Some credit for courses completed at other institutions may be granted by the Director of Graduate Studies subject to restrictions specified in the *Graduate Studies Bulletin*.

Summary of Requirements
Course Work
Admission to Candidacy Examination
Residency Requirement
Foreign Language
Teaching Experience
Dissertation Proposal and Comprehensive Examination
Dissertation
Dissertation Defense

Course Work

A minimum of sixty semester hours of graduate-level course work is required (or 30 past an M.S. degree). The minimum course requirements for the doctorate are satisfactory completion of:

PHYS 701	Classical Mechanics (3 credits)
PHYS 703	Classical Field Theory I (3 credits)
PHYS 704	Classical Field Theory II (3 credits)
PHYS 706	Statistical Thermodynamics (3 credits)
PHYS 711	Quantum Mechanics I (3 credits)
PHYS 712	Quantum Mechanics II (3 credits)
PHYS 713	Advanced Quantum Theory (3 credits)
PHYS 7xx	Advanced 700-level courses (9 credits)

Less prepared students are advised to take 500-level courses, but are not required to do so. Additionally, they may be advised to take one or more but not all of the 500-level courses. For

example, if they are strong in one area but weak in another, they may need to take the 500 courses in the weak areas and take the 700-level courses in the strong areas. If the Advisement Committee finds the student deficient in his/her mathematical background, then the committee may advise the student to take Mathematical Physics I and II (PHYS 515 and 516). All students are expected to take one or more advanced graduate courses in fields outside of their specialty to broaden their background. Before deciding upon a research field, a student may take Research (PHYS 760 or 761) to become familiar with the research work being carried out by a particular research group.

The nine credits of advanced graduate courses may include both regular courses (no limit) and topics courses (no more than 3 credit hours). Graduate Seminar (PHYS 730), Selected Topics in Physics (PHYS 740), Research (PHYS 760 and 761), Dissertation Preparation (PHYS 899) and 700-level review courses do not count towards the nine hours of advanced graduate courses.

Admission to Candidacy Examination ("A to C" or Qualifying Examination)
The purpose of the Admission to Candidacy Examination is to determine whether the student is sufficiently well-grounded in the fundamental subject matter of physics, since only then will he/she be permitted to undertake a doctoral research program. The examination will consist of four written parts: Classical Mechanics, Electricity and Magnetism, Quantum Mechanics, and Modern Physics. The test covers the material normally given in a standard physics major undergraduate program plus that in the core graduate-level courses: Classical Mechanics (PHYS 701), Classical Field Theory I and II (PHYS 703 and PHYS 704), and Quantum Mechanics (PHYS 711 and PHYS 712). The "follow-up" oral exam is required for all students taking the A to C exam to clarify possible issues in the written parts of the exam. The exam will be given only once per year (normally in January). Passing this exam is a prerequisite to attaining the designation of "Ph.D. Candidate" and to the submission of a dissertation proposal.

A student will be permitted no more than three attempts at the entire exam. The first attempt, which is optional, must be made before the beginning of the student's second year of graduate study. While the decision whether to take the "free try" or not is at the discretion of the student, it is strongly recommended; there is no risk and it is possible the student may pass one or more sections if not the whole exam.

Students who do not complete the core 700-level courses during their first year of graduate study must take the Admission to Candidacy exam before the beginning of their fourth year and must pass the exam before the beginning of their fifth year.

Students who complete the core 700-level courses in their first year must take the exam before the beginning of their third year of study, and must pass the exam before the beginning of their fourth year.

A passing grade on the Admissions to Candidacy Exam is a grade of 50% on all sections tested. Students are given credit for passing sections of the exam if they score greater than 50% on that section and over 35% on all the sections tested. On the next attempt, the student is not required to retake the sections passed in previous attempts.

The faculty may establish requirements for the candidate to fulfill during his/her Ph.D. program to meet deficiencies that are noted during the exam. If he/she fails the final attempt, he/she cannot

continue in the physics doctoral program except for special cases decided during a general faculty meeting.

After admission to candidacy and the selection of a research director, a doctoral committee will be appointed by the research director with the approval of the Director of Graduate Studies and the Dean of The Graduate School to provide guidance and oversee the student's program until its completion. This committee shall include at least three members of the Physics faculty and one member from the faculty of another department. The research director shall be chairman, and the committee should meet at least twice a year and report to the Director of Graduate Studies

Residency Requirement for Doctoral Program
The residency requirement consists of 18 graduate credits in the student's program within a period of three consecutive major semesters (fall/spring). For more information, refer to the *Graduate Studies Bulletin*.

Foreign Language
A reading knowledge of one modern foreign language is required. This is normally demonstrated by passing an exam administered by the Department of Languages, Literatures, and Cultures (http://www.cas.sc.edu/dllc/Geninfo/reading_exam.html). French, German, Spanish, or Russian is recommended. Other modern foreign languages may be used with the approval of the Director of Graduate Studies. Students for whom English is a foreign language may use their knowledge of English to satisfy this requirement.

Teaching Experience
Each candidate for the Ph.D. degree must have demonstrated an ability for effective teaching. This requirement is met by service as an instructor of a laboratory or a recitation section in an elementary course in physics. These teaching assignments are supervised by a member of the faculty, and it is to the faculty member that the ability for effective teaching must be demonstrated. At the end of each semester each student will be given an evaluation of his/her teaching performance by the professor in charge of the course.

Dissertation Proposal and Comprehensive Examination
After passing the Admission to Candidacy Examination the student must prepare and defend a research proposal within six months. This time requirement is necessary for the student to maintain the status of candidate for the doctoral degree. The proposal will be written and circulated to the doctoral committee at least one week before the day of the presentation. The doctoral committee will then conduct an examination of the proposed research and on the student's general background knowledge, the latter being referred to as the Comprehensive Examination. The committee will vote to pass or fail the student on both parts of the examination and perhaps make an additional recommendation. Furthermore, the examination must be held <u>not less than one year</u> before the dissertation defense. Students failing the comprehensive portion will be asked to repeat it at a time set by their doctoral committee. If the substance of the dissertation is markedly changed after the proposal is given, a new proposal may be required (to be scheduled not less than one year before the dissertation defense).

Dissertation

The dissertation should demonstrate that the Ph.D. candidate has mastered the field in which he/she has chosen to do research, is capable of doing independent scholarly work, and is able to formulate conclusions that will in some respect increase the extent of and/or improve our understanding of what is already known. In order to be acceptable as a Ph.D. dissertation, a manuscript reporting a significant part of the doctoral research results must have been submitted to a refereed research journal.

The maximum period permitted by the Graduate School for completion of the dissertation is five years after the Dissertation Proposal/Comprehensive Examination date. However, full- time physics graduate students are expected to complete their research in a considerably shorter time. Their progress will be reviewed every year at the beginning of the fall term by their doctoral committee, and failure to make reasonable progress can result in termination of financial support.

Dissertation Defense

The completed dissertation must be defended by the student before his/her doctoral committee at an oral examination. This oral examination consists of two parts. In the first part, which is open to all department faculty members and graduate students, the student will present a summary of his/her doctoral work and entertain questions from the audience. The second part is an examination of the student's dissertation. Only members of the doctoral committee may be present during the second part. The examination committee chairman will be someone other than the research director.

A copy of the completed dissertation must be submitted to the Director of Graduate Studies and to each of the members of the doctoral committee at least two weeks before the examination, and the examination itself must take place no less than thirty days before the candidate expects to receive the degree.

IX. REPRESENTATIVE CURRICULA FOR DOCTORAL PROGRAM

Two representative curricula are given on the next two pages. The first would be followed by students who must make up undergraduate deficiencies, while the second is intended for students prepared to take the graduate level courses immediately. Many students will follow programs between these two extremes.

Recommended Ph.D. Course Schedule (prepared student)

First Year

Fall Semester

PHYS 5xx	500-level course (3-4 credits)
PHYS 5xx	500-level course (3 credits)
PHYS 5xx	500-level course (3 credits)
PHYS 515	Mathematical Physics I (3 credits)
PHYS 730	Graduate Seminar (1 credit)

Spring Semester

PHYS 5xx	500-level course (3-4 credits)
PHYS 5xx	500-level course (3-4 credits)
PHYS 5xx	500-level course (3 credits)
PHYS 516	Mathematical Physics II (3 credits)
PHYS 730	Graduate Seminar (1 credit)

Second Year

Fall Semester

PHYS 701	Classical Mechanics (3 credits)
PHYS 703	Classical Field Theory I (3 credits)
PHYS 711	Quantum Mechanics I (3 credits)
PHYS 730	Graduate Seminar (1 credit)
PHYS 760	Research (2 credits)

Spring Semester

PHYS 704	Classical Field Theory II (3 credits)
PHYS 712	Quantum Mechanics II (3 credits)
PHYS 5xx	500-level course (3 credits)
PHYS 761	Research (3 credits)

File the degree program

Take the Admission to Candidacy Examination

Third and Fourth Years

PHYS 706	Statistical Mechanics (3 credits)
PHYS 713	Advanced Quantum Theory (3 credits)
PHYS 7xx	Advanced 700-level courses (9 credits)
PHYS 760	Research (x credits)
PHYS 761	Research (x credits)
PHYS 899	Dissertation Preparation (12 credits)

Recommended Ph.D. Course Schedule (well-prepared student)

First Year

Fall Semester

PHYS 701	Classical Mechanics (3 credits)
PHYS 703	Electromagnetic Theory I (3 credits)
PHYS 711	Quantum Mechanics I (3 credits)
PHYS 730	Graduate Seminar (1 credit)
PHYS 760	Research (2 credits)

Spring Semester

PHYS 704	Electromagnetic Theory II (3 credits)
PHYS 712	Quantum Mechanics II (3 credits)
PHYS 7xx	700-level course (3 credits)
PHYS 730	Graduate Seminar (1 credit)
PHYS 761	Research (2 credits)

Take the Admission to Candidacy Examination

Second, Third, and Fourth Years

PHYS 706	Statistical Mechanics (3 credits)
PHYS 713	Advanced Quantum Theory (3 credits)
PHYS 7xx	Advanced 700-level courses (6 credits)
PHYS 760	Research (x credits)
PHYS 761	Research (x credits)
PHYS 899	Dissertation Preparation (12 credits)

X. AWARDS

The Department of Physics and Astronomy will award three graduate students every year - one for teaching, one for research, and one for service. The award amounts are $1000 each.

Every year one graduate student will be awarded the Physics and Astronomy Graduate Student Teaching Award based on performance in teaching and grading of physics and astronomy courses. Nominations for the award can be made by any member of the department faculty and should be accompanied by a written endorsement of the candidate. Comparative evaluations of GTAs from the laboratory manager, the professor in charge of labs, and other teaching faculty will play an important role in deciding who receives the award. The recipient will be chosen by the department chairperson and the Director of Graduate Studies in consultation with appropriate personnel.

Every year one graduate student will be awarded the Physics and Astronomy Graduate Student Research Award based on research performance. Nominations for the award can be made by any member of the department faculty and should be accompanied by a written endorsement of the candidate. Publications submitted by a student and/or other concrete evidence of research achievements will play an important role in deciding who receives the award. The recipient will be chosen by the department chairperson and the Director of Graduate Studies in consultation with appropriate personnel.

Every year one graduate student will be awarded the Physics and Astronomy Graduate Student Service Award based on service and volunteer work. Nominations detailing the student's contributions can be made by any member of the department faculty, and should be accompanied by a written endorsement of the candidate, which will play an important role in determining who receives the award. The recipient will be chosen by the department chairperson and the Director of Graduate studies in consultation with appropriate personnel.

Students may receive a departmental award only once in their graduate career, and students past their fifth year of graduate studies (second year for M.S. students) are automatically ineligible for the award.

XI. GRADUATE COURSE DESCRIPTIONS

Overview

The Department of Physics and Astronomy offers programs in physics leading to the degrees of Master of Science, and Doctor of Philosophy; the Master of Arts in Teaching is offered in cooperation with the College of Education.

Fields of Specialization

Research opportunities are currently available in theoretical physics, general relativity, astrophysics, experimental and theoretical hadronic physics, high energy physics, neutrino physics, chemical physics, experimental and theoretical solid state physics, magnetic resonance, magnetic properties, cryogenics, transport properties, high temperature superconductivity, computational physics, and physics education.

Course Descriptions

Astronomy (ASTR)

533 – Advanced Observational Astronomy I. (1-3) (Prereq: consent of instructor) Development of a combination of observational techniques and facility at reduction of data. A maximum of eight hours per week of observation, data reduction, and consultation. Offered each semester by arrangement with the department.

534 – Advanced Observational Astronomy II. (1-3) A continuation of ASTR 533. Up to eight hours per week of observation, data reduction, and consultation.

599 – Topics in Astronomy. (3) (Prereq: consent of instructor) Readings and research on selected topics in astronomy. Course content varies and will be announced in the schedule of classes by suffix and title.

Physics (PHYS)

The minimum prerequisites for all 500 level courses listed below are two years of physics and mathematics through calculus. Further prerequisites are listed where applicable.

501 – Quantum Physics I. (3) A self-contained treatment of quantum theory and its applications, beginning with the Schroedinger equation.

502 – Quantum Physics II. (3) (Prereq: PHYS 501) Advanced topics in quantum physics, plus topics in special relativity, high-energy physics, and cosmology.

503 – Mechanics. (4) Classical mechanics of particles, systems, and rigid bodies; discussion and application of Lagrange's equations, introduction to Hamiltonian formulation of mechanics.

504 – Electromagnetic Theory. (4) (Prereq: PHYS 503) Field theory of electric and magnetic phenomena: Maxwell's equations applied to problems in electromagnetism and radiation.

506 – Thermal Physics and Statistical Mechanics. (3) Principles of equilibrium thermodynamics, kinetic theory, and introductory statistical mechanics.

509 – Solid State Electronics. (4) Topics include: basic electrical circuits, electronic processes in solids, operation and applications of individual solid state devices, and integrated circuits. Three lecture and three laboratory hours per week.

510 – Digital Electronics. (3) (Prereq: PHYS 509) Basic operation of digital integrated circuits including microprocessors. Laboratory application of microcomputers to physical measurements.

511 – Nuclear Physics. (4) (Prereq: PHYS 502) An elementary treatment of nuclear structure, radioactivity, and nuclear reactions. Three lecture and three laboratory hours per week.

512 – Solid State Physics. (4) (Prereq: PHYS 502) Crystal structure; lattice dynamics; thermal, dielectric, and magnetic properties of solids. Free electron model for metals. Band structure of solids, semiconductor physics. Three lecture and three laboratory hours per week.

514 – Optics, Theory and Applications. (4) Geometrical and physical optics; the wave nature of light, lenses and optical instruments, interferometers, gratings, thin films, polarization coherence, spatial filters, and holography. Three lectures and one three-four hour laboratory per week.

515 – Mathematical Physics I. (3) Analytical function theory including complex analysis, theory of residues, and saddlepoint method; Hilbert space, Fourier series; elements of distribution theory; vector and tensor analysis with tensor notation.

516 – Mathematical Physics II. (3) (Prereq: PHYS 515) Group theory. Linear second-order differential equations and the properties of the transcendental functions; orthogonal expansions; integral equations; Fourier transformations.

517 – Computational Physics. (3) Application of numerical methods to a wide variety of problems in modern physics including classical mechanics and chaos theory, Monte Carlo simulation of random processes, quantum mechanics, and electrodynamics

521 – Biophysics. (4) Principles of physics applied to living systems: diffusion, friction, low Reynolds-number world, entropy, free energy, entropic/chemical forces, self-assembly, molecular machines, membranes.

522 – Biophysics Laboratory. (3) (Prereq: PHYS 521) Laboratory experiments based on topics covered in PHYS 521.

531 – Advanced Physics Laboratory I. (1-3) A laboratory program designed to develop a combination of experimental technique and the application of the principles acquired in formal course work. A maximum of eight hours per week of laboratory and consultation.

532 – Advanced Physics Laboratory II. (1-3) A continuation of PHYS 531. Up to eight hours per week of laboratory and consultation.

599 – Topics in Physics. (1-3) (Prereq: consent of instructor) Readings and research on selected topics in physics. Course content varies and will be announced in the schedule of classes by suffix and title.

701 – Classical Mechanics. (3) Generalized coordinates, Lagrangian and Hamiltonian formulations, variational principles, transformation theory, and Hamilton-Jacobi equation.

703 – Classical Field Theory I. (3) Development of classical fields; Maxwell's equations; boundary value problems; radiation theory.

704 – Classical Field Theory II. (3) A continuation of PHYS 703.

706 – Statistical Thermodynamics. (3) Statistics of Boltzmann, of Fermi and Dirac, and of Bose and Einstein, with applications.

708 – General Relativity and Cosmology. (3) (Prereq: PHYS 701, PHYS 704) Introduction to the basic concepts of general relativity and a discussion of problems of current interest.

711 – Quantum Mechanics I. (3) A development of non-relativistic quantum mechanics.

712 – Quantum Mechanics II. (3) A continuation of PHYS 711.

713 – Advanced Quantum Theory. (3) (Prereq: PHYS 712) Second Quantization. Relativistic formulations of quantum mechanics.

714 – Quantum Field Theory. (3) (Prereq: PHYS 713) Theory of quantized fields. Introduction of renormalization. A continuation of PHYS 713.

715 – Many-Body Quantum Theory. (3). (Prereq: PHYS 713) Effective field theory, particle-hole, quasiparticles.

721 – Subatomic Physics. (3). (Prereq: PHYS 511) Baryons and mesons, quarks and leptons; symmetries; electromagnetic and wek interactions, QCD, and the standard model; experimental tools in subatomic physics.

722 – Advanced Nuclear Particles. (3) (Prereq: PHYS 721) Nuclear and hadronic structures and reactions.

723 – Advanced Particle Physics. (3) (Prereq: PHYS 721) Introduction to gauge theories; particle physics and experiments.

725 – Condensed Matter Physics. (3) (Prereq: PHYS 512) The crystalline state of matter and its main characteristics. Electromagnetic and thermal properties of metals, semiconductors, and insulators.

726 – Advanced Condensed Matter Physics. (3) Advanced topics in Solid State Physics, superconductivity, Quantum Hall Effect, and Anderson Localization.

727 – Magnetic Resonance. (3) Basic theory. Electron spin resonance. High resolution and wideline nuclear magnetic resonance. Moessbauer effect. Magnetic resonance and dielectric relaxation.

729 – Applied Group Theory. (3) Groups and representations. Full rotational group. Angular momentum. Ligand field theory. Application to atomic, molecular, and nuclear physics.

730 – Graduate Seminar. (1) Presentation by the student of a designated topic. May be repeated for credit.

731 – Extragalactic Astrophysics. (3) (Prereq: PHYS 701, PHYS 703, and ASTR 211) Extragalactic astrophysics, including nearby and distant galaxies, active galaxies, galaxy clusters, large-scale structure, galaxy formation/evolution, scale structure, basic of cosmology, cosmic radiation backgrounds, and observational constraints on cosmological models.

740 – Selected Topics in Physics. (1-3 per registration) Course content varies and will be announced in the schedule of classes by suffix and title.

745 – Topics in Nuclear Physics. (1-3 per registration) Course content varies and will be announced in the schedule of classes by suffix and title.

750 – Topics in Solid State Physics. (1-3 per registration) Course content varies and will be announced in the schedule of classes by suffix and title.

751 – The Physics of Radiation Therapy. (3) Description of ionizing and non-ionizing radiation, interaction of radiation withmatter, and radiation detection and dosimetry.

752 – Health Physics – Radiation and Nuclear Physics. (3) Radioactive decay and ionizing radiation. Calculation of occupational exposure and biological effects of radiation exposure. Introduction to Radiological Control Systems, Shielding, Dose Determination, Safety Protocols.

753 – The Physics of Medical Imaging. (3) Describing basics of imaging science, x-ray imaging modalities including basic principles, detectors, scattered radiation, planar imaging, CT, fluoroscopic imaging, nuclear medicine imaging, ultrasound and MRI, and computers in imaging.

755 – Topics in Theoretical Physics. (1-3 per registration) Course content varies and will be announced in the schedule of classes by suffix and title.

760 – Research. (1-6) Introduction to and the application of the methods of research.

761 – Research. (1-6) Introduction to and the application of the methods of research.

781 – Astronomy for Teachers. (3) Primarily for M.A.T./I.M.A. and M.Ed. students. Not available for M.S. and Ph.D. credit in physics. A one-semester survey of astronomy. Observational techniques and current developments.

782 – Topics in Contemporary Physical Sciences for Teachers. (variable 3-4) Primarily for M.A.T. and M.Ed. students. Not available for M.S. and Ph.D. credit in physics. Discussions designed to provide teachers with simple physical explanations of subjects including: nuclear energy, black holes, quarks, strange particles, perception of color integrated circuits, computers, T.V. games, and other topics of current interest. With four hours credit a laboratory will be included to give laboratory experience in the subject areas covered in class.

783 – Modern Physics for Teachers. (3) Primarily for M.A.T. and M.Ed. students. Not available for M.S. and Ph.D. credit in physics. Basic concepts of modern physics. The experimental basis for quantum theory and the theory of relativity. Fundamental concepts of modern physics.

784 – Topics in Light and Sound for Teachers. (3) Primarily for M.A.T. and M.Ed. students. Not available for M.S. and Ph.D. credit in physics. Topics in modern optics and acoustics are discussed in a framework appropriate for school teachers.

785 – Electronics for Teachers. (3) Primarily for M.A.T. and M.Ed. students. Not available for M.S. and Ph.D. credit in physics. Basic electronics with emphasis on measurement and laboratory procedures. Operation and application of semiconductor devices and integrated circuits.

786 – Teaching Physics on the Internet. (3) Web-based resources for assigning and grading individualized homework and tests and for creating instructional units in physics and physical sciences. Not available for M.S./Ph.D. physics majors.

787 – Design of Physics Laboratory and Demonstration Experiments for Teachers. (3) Primarily for M.A.T. and M.Ed. students. Not available for M.S. and Ph.D. credit in physics. Design and performance of demonstrations and experiments to display physical phenomena to students. Qualitative and quantitative experiments.

788 – Physics for AP Teachers. (3) Preparation of teachers for developing and teaching an advanced placement course in physics. Primarily for M.A.T./I.M.A. and M.Ed. students. Not available for M.S. or Ph.D. credit in physics.

789 – Physics for Teachers of Mathematics. (3) Teacher preparation for creating and solving word problems using conservation laws and symmetries found in physics and physical science and linked to the South Carolina Mathematical Standards.

799 – Thesis Preparation. (1-9)

899 – Dissertation Preparation. (1-12)

XII. PROGRAM RELATED FORMS

M.S. and Ph.D. Student Progress and Information

The student progress and information forms are used only in the Department of Physics and Astronomy. They serve as guides to assist students in planning and tracking their progress in the graduate program.

Programs of Study

All degree students must file a program of study in The Graduate School. The program of study is a list of courses that fulfill degree requirements. It must be approved by the advisor, the director of graduate studies, and the Dean of The Graduate School as stated in the *Graduate Studies Bulletin*.

Doctoral Committee Appointment Request

Once a student has been admitted to candidacy, a doctoral committee should be formed. The committee must consist of at least three members from the faculty of the Department of Physics and Astronomy and one member from the faculty of another department. The committee must be approved by the Director of Graduate Studies and the Dean of The Graduate School.

MS STUDENT INFORMATION

NAME _____ **SSN** _____

START DATE _____ **AREA OF STUDY** _____

DEGREE DATE _____ **MAJOR PROFESSOR** _____

THESIS TITLE _____

- **PROGRAM OF STUDY DATE** _____
- **COMMITTEE MEMBERS**
  - **1ST READER** _____
  - **2ND READER** _____
- **COMP/DEFENSE DATE** _____

- **AT LEAST 18 HOURS 700 LEVEL**
  MUST INCLUDE 711 AND 701, 703, 704, 706, OR 712
  – UP TO 6 HOURS OF 799 MAY BE USED
  – CANNOT USE 730, 740, 760, 761

COURSE	DATE	GRADE	CREDITS
711			3
7___			
7___			
7___			
7___			
7___			
7___			

- **UP TO 12 HOURS 500 LEVEL** (IF APPLICABLE)

COURSE	DATE	GRADE	CREDITS
5___			
5___			
5___			
5___			

- **ADDITIONAL COURSES**

COURSE	DATE	GRADE	CREDITS

PHD STUDENT INFORMATION & COURSEWORK

NAME _____ **SSN** _____

START DATE _____ **AREA OF STUDY** _____

DEGREE DATE _____ **MAJOR PROFESSOR** _____

DISSERTATION TITLE _____

- **FOREIGN LANGUAGE** _____ / _____ **Language** _____
- **ADMITTED TO CANDIDACY** _____ / _____

  Free Trial: Date __ / ____ ☐ **Pass** ☐ **Fail Sections to Retake:** _____
  Attempt 1: Date __ / ____ ☐ **Pass** ☐ **Fail Sections to Retake:** _____
  Attempt 2: Date __ / ____ ☐ **Pass** ☐ **Fail**

- **DOCTORAL COMMITTEE** ____ / ____ / _____

  1. Chair _____ **4. Outside** _____
  2. Member _____ **Dept** _____
  3. Member _____ **5. Other** _____

- **PROGRAM OF STUDY** _____ / ____ / _____
- **COMPS / PROPOSAL** _____ / ____ / _____
- **DEFENSE** _____ / ____ / _____

➢ **REQUIRED COURSES**

Course	Date	Grade	Credits
701			3
703			3
704			3
706			3
711			3
712			3
713			3

➢ **DISSERTATION PREPARATION** (12 credits)

Course	Date	Grade	Credits
899			
899			
899			
899			
899			
899			

➢ **9 ADDITIONAL CREDITS OF 700 LEVEL***

Course	Date	Grade	Credits
7__			
7__			
7__			

*not 730, 740, 760, 761

➢ **RESEARCH** (760, 761)

Course	Date	Grade	Credits
76_			
76_			
76_			
76_			
76_			
76_			
76_			
76_			
76_			

- **ADDITIONAL COURSES**

Course	Date	Grade	Credits	Course	Date	Grade	Credits

- **ADDITIONAL INFORMATION**