DEGREE INFORMATION

INDIANA UNIVERSITY

DEPARTMENT OF PHYSICS

REQUIREMENTS FOR THE M.A.T., M.S., AND PH.D. DEGREES

August 30th, 2020 Edition

The Physics Department at Indiana University has a strong commitment to excellence in its graduate education programs. Our prime objective for the graduate students enrolled in our Department is to ensure that they receive superior training in an atmosphere that allows each student to develop his/her potential to the fullest. This note is issued to acquaint all graduate and prospective graduate students with some specific requirements and procedures pertaining to graduate work in the Department. The general scope of these requirements and procedures is essentially the same as that existing in almost all other major physics departments. All students ought to be fully aware of them. Consistent with the philosophy of considering the individual needs and abilities of each student and how s/he can best be served by our program, it is to be understood that the following requirements are flexible and can be waived by consent of the Physics Faculty in particular instances.

For general rules concerning advanced degrees, the student should consult the Bulletin of the Graduate School. Note that all grades from graduate physics courses taken at I.U. will be used when calculating the graduate grade point average; other courses may also be included.

IMPORTANT NOTE: Courses that are not in the Graduate School Bulletin DO NOT COUNT toward the 90-hour requirement. This includes English proficiency courses for international students, physical education (HPER) courses, and most courses numbered at the 300 or 400 level. Be sure to read page 13 in the Graduate School Bulletin and check the course listings before you enroll in these classes. It is your responsibility to make sure you meet your degree requirements. If you have questions about the 90-hour requirements, check with the staff in the Academic Administration Office in Swain Hall West.

The graduate school dean may review a grade record at any time and may place a student on academic probation if the record justifies such action. When the grade point average of the student falls below 3.0, or the student is not making progress toward the degree, the dean will notify the student that he or she has been placed on probation. Unless the student brings this record up to a 3.0 grade point average, or begins making satisfactory progress in the next semester of enrollment, the student will not ordinarily be allowed to continue in the University Graduate School.

A student's course work is planned each semester in consultation with members of the Graduate Advising and Counseling Committee, which typically consists of five faculty members. The chairperson of this committee is the "head Graduate Adviser"; s/he is generally available for consultation throughout the year. This Committee is consulted concerning all matters of degree progress.

I. MASTER OF ARTS FOR TEACHERS

Admission to this program requires completion of at least eight hours of undergraduate physics courses.

Requirements for the M.A.T. degree are selected to help prepare future teachers of high school physics, and to acquaint teachers in service with modern developments in physics.

A candidate for the M.A.T. degree in physics must complete 36 hours with a grade point average of at least 3.1. These hours should be chosen as follows.

(i) At least 20 hours in physics courses selected from P301, P309, P331-P332, P340, P350, P360, or courses numbered P400 or higher. Especially recommended are P301, P309, P331-P332, P360, P451, P453, and P454.

(ii) At least 16 hours made up from courses selected from mathematics, astronomy, chemistry, computer science, and graduate education. These courses are subject to the approval of the Graduate Adviser.

Note that equivalent courses which have been used elsewhere (for example, to fulfill previous degree requirements) may not be used again as part of the above 36 hours for the M.A.T.degree. Candidates for the M.A.T. must obtain a teacher's certificate (or license) by the time they complete the M.A.T.

II. THE M.S. IN PHYSICS

For admission to this program, a bachelor's degree with a major in physics or courses in the following subjects or their equivalents is expected: general physics, modern physics, electricity and magnetism, physical optics, thermodynamics and statistical mechanics, three semesters of calculus, and a course in differential equations.

A. Course Work

A candidate for the M.S. degree in physics must complete 30 credit hours of graduate work. These must include a minimum of 20 hours in physics. Of these 20 hours in physics, at least 14 hours must be in physics courses numbered P501 or higher. Seminar, research, and reading courses may not be counted toward this 14 hour requirement.

The physics courses numbered P501 and higher used to satisfy this requirement must be passed with a grade point average of at least 3.0. Physics courses below P501 must each be passed with a grade of 3.0 or higher to count toward this degree.

There is no language requirement for this degree.

B. The M.S. Examination

Passing this written examination is required for the M.S. degree, unless a student pursues a research-based M.S. degree (see below). The examination is offered in August and consists of specially designated problems (usually eight) on the concurrent Physics Qualifying Examination (see below). The designated problems are in the areas of mechanics, electromagnetism, quantum mechanics, thermodynamics/statistical mechanics, and special relativity.

A student may take the Master's Examination a total of twice, including any attempts at the full Ph.D. qualifying examination. The first attempt must be in the August following matriculation, and the second attempt must be made the next year. For this purpose only, students admitted in the Spring semester will be treated as if they had been admitted the following Fall.

Students who take the Ph.D. Qualifying Examination (see below) are automatically considered to be taking the Master's Examination, unless they have previously passed the Master's Examination. Passing the Ph.D. Qualifying Examination automatically implies passing the Master's Examination.

C. Research-Based M.S. Degree

In lieu of taking the written M.S. Examination, students may meet a set of research requirements to obtain the M.S. in Physics degree. In order to do so, a student must:

(i) Accumulate at least 3 credit hours of P800 or 802 (with a passing grade), or equivalent research experience as determined by the Director of Graduate Studies, before their third semester in the program begins.

(ii) Formally choose, in consultation with the Director of Graduate Studies, to pursue a research-based degree by the end of their 3rd semester. (Students who have not consulted with the DGS and obtained permission to pursue a research-based degree will be required to pass the M.S. Examination as described in Section B above to receive the M.S. in Physics degree.)

(iii) Accumulate at least 8 credit hours of P800 or 802 (with passing grades) by the end of the summer following their 4th semester.

(iv) The student will give an oral presentation on their research before a committee to be approved by the DGS. Successful execution of this presentation will thereby constitute satisfactory completion of an oral Final Examination.

(v) A Master's thesis is optional.

Students pursuing the exam-based MS may not switch into the research-based MS track without re-applying to the program.

III. THE M.S. IN BEAM PHYSICS AND TECHNOLOGY

In collaboration with the U.S. Particle Accelerator School (USPAS), the IU Department of Physics has established a national program leading to a Master of Science Degree in Beam Physics and Technology. Admission requirements are the same as for the M.S. degree.

A total of 30 credit hours with grade point average 3.0 or above are required for the Master of Science degree, including six IU/USPAS courses (18 credit hours); classical mechanics (at least 3 credit hours) and electromagnetism (at least 3 credit hours) equivalent to IUB-Phys 441 and IUB-Phys 506, each with a grade of B or above; and a Master's thesis course (6 credit hours).

The six IU/USPAS courses can be chosen as follows:

Required: Introduction to Accelerator Physics (3 credit hours)

Required: Laboratory course or Computation Methods course (3 credit hours)

The remaining four courses (12 credit hours) would be selected from courses which appear in the IU/USPAS syllabus and referred to in the IU Graduate Bulletin as Physics special topics courses P571, P671 or P672. Students must satisfy the Indiana University residence requirement. At approximately the midpoint of this program, the student's progress will be reviewed to determine whether his/her progress towards the Master's degree is satisfactory.

The requirements for classical mechanics and electromagnetism can be fulfilled at a qualified university and transferred for IU credit. The thesis will be evaluated by the thesis advisor and a thesis committee co-chaired by an IU Physics Department faculty member. An oral defense of the thesis or a written final examination is required and should take place at Indiana University.

IV. Dual Master of Science Degree in Physics and Master of Science Degree in Environmental Science

This program is a two-year, 51 credit hours sequence of courses and research that provides depth and breadth in both environmental science and physics. The student must complete a minimum of 21 credit hours in each of the degree programs. Both degrees are awarded when the student meets the degree requirements of the Department of Physics and the School of Public and Environmental Affairs (SPEA).

A. Admission

Students interested in this dual program must apply and be accepted by both the Department of Physics and the School of Public and Environmental Affairs. The degree is designed to be completed in two years, but must be completed within six years.

B. Requirements

The dual M.S. in Physics and M.S.E.S. in SPEA program requires a minimum of 51 credit hours distributed among six components: physics core; environmental science core; economics, policy, and law competencies; tool skills; environmental chemistry concentration; and professional experience. Each candidate should take a 3 credit hour course during which they participate in a team to carry out an integrative project that addresses a multidisciplinary problem. Capstone course credit may be double-counted to either concentration or tool skill requirement.

The capstone requirement may be met in one of the following ways: (1) SPEA-V 600, Capstone in Public and Environmental Affairs, sections with an environmental focus. (2) An alternative course with a similar structure, such as SPEA-E560, Environmental Risk Analysis or other approved course.

V. THE PH.D. IN PHYSICS

For admission to this program, a bachelor's degree with a major in physics, or courses in the following subjects or their equivalents, are expected: general physics, modern physics, electricity and magnetism, physical optics, thermodynamics and statistical mechanics, three semesters of calculus, and a course in differential equations.

A. General

The requirements for the Ph.D. degree include a minimum of 90 hours of graduate credit. These consist of course work and supervised reading and research.

It is to be emphasized that (1) course work, while essential, is not the main criterion for obtaining the Ph.D.; (2) the candidate must show his or her ability to do research, and present a publishable thesis; (3) the candidate should show a broad grasp of the field of physics; (4) the candidate should also acquire teaching skills and experience while in residence at IU. In the latter context, all Ph.D. candidates are required to undertake supervised teaching as an AI for at least one semester. No student may hold an AI after completing their third year of the Ph.D. program if they are on academic probation. This teaching will take the form of either laboratories or discussion sections. In order to accomplish this goal, all Ph.D. candidates must pass the IU Test of English Proficiency for Associate Instructors by the end of their second year of study.

B. Course Work

1. Core Courses

The following courses form a foundation for more advanced graduate studies:

P521 Theoretical Mechanics I
P506-507 Advanced Electricity and Magnetism I-II
P511-512 Quantum Mechanics I-II
P556 Thermodynamics/Statistical Mechanics I

It is *strongly* recommended that all these courses be taken in the first year. This should adequately prepare a student for the Ph.D. Qualifying Examination.

2. Course Requirements

Students must at all times during the academic year be signed up for a minimum of nine credit hours per semester at the 501 level or above. These credit hours can include research credit but *cannot* include courses previously taken for credit at I.U.

There are no language requirements for the Ph.D. degree.

Inside Major

A student first selects one of the areas of Accelerator Physics, Biological Physics, Chemical Physics, Condensed Matter Physics, High-Energy Physics, Mathematical Physics, or Nuclear Physics as his/her major area of specialty. This should be done in consultation with the Graduate Adviser, at the beginning of the second year of residence. The area of specialty should reflect the student's intended research interest for the Ph.D. thesis.

The inside major requirement in Accelerator Physics is P671 and one of the courses P633, P634, P640, P641, or P672. In Biological Physics the requirement is P575 and one of the courses P581, P582, P583. In Chemical Physics the requirement is P615 (or P557) and one course chosen from P614, P616, P625, or P627. In Condensed Matter Physics the requirement is two courses from P557, P615, P616, P627, and P657. In High-Energy Physics the requirement is two courses from P622, P635, P636, P640, P641, P665, P707, or P708. In Mathematical Physics the requirement is two courses from P555, P609, P610, P622, P625, P637, P638, P647, or P743. In Nuclear Physics the requirement is two courses from P626, P630, P633, P634, P640, P641. The grade point average for these courses must be 3.0 or better. Note that any mathematics courses suited to the students' field will be subject to approval by advisers of the Department of Physics.

Minor

To ensure that the prospective Ph.D. student acquires a broad grasp of physics beyond the core courses, each student is required to have a minor area. This can be done either as an Inside Minor, i.e., within Physics, or as an Outside Minor.

Inside Minor: Each student who is a candidate for the Ph.D. degree in physics has the option of satisfying the minor requirement by demonstrating greater breadth and depth in important areas of physics outside his/her area of thesis research. The inside-minor requirements for students taking the Ph.D. in Physics are as follows. For all inside majors except Biological Physics, each student takes either P621 (Relativistic Quantum Field Theory I) or P625 (Quantum Many-Body Theory I). In addition, for all inside majors, each student must take one course from at least two of the areas listed below, that fall outside the set of courses meeting their major requirement:

(i) Accelerator Physics: P570, P671, P672
(ii) Chemical or Condensed Matter Physics: P557, P615, P616, P657, P627
(iii) High-Energy Physics: P535, P635, P636, P640, P641, P665, P707, P708
(iv) Mathematical Physics: P522, P555, P609, P610, P622, P625, P637, P638, P647, P743
(v) Nuclear Physics: P535, P626, P630, P633, P634, P640, P641
(vi) Biological Physics: P575, P581, P582, P583, P676
(vii) Electronics: P540, P541
(viii) Astrophysics: P630, P637, P638

The two courses must not appear in the same list above. Note that P535 (Introduction to Nuclear and Particle Physics) cannot be counted toward the inside minor for students specializing in either Nuclear Physics or High-Energy Physics. For students specializing in other fields, P535 can be counted once toward the inside minor, and can be considered as a course in either Nuclear Physics or High-Energy Physics for that purpose.

The grade point average for courses satisfying the inside minor requirement must be 3.0 or better. Courses used to satisfy the inside major requirements cannot also be used to satisfy the inside minor requirements.

Outside Minor: Programs of study for outside minors are determined by the individual departments and typically require 6 to 12 hours of course work. Recommended outside fields are mathematics, chemistry, astronomy, biology, biochemistry, and computer science. All minors must be approved by the graduate adviser of the Department of Physics. A path of particular interest to some students is an interdisciplinary, interdepartmental Ph.D. minor offered in Scientific Computing described in detail in Section VIII.

Outside Minor in Physics: For students in other Departments who wish an outside minor in Physics, the requirement is a minimum of six hours at the 501 level or above. The grade point average for the six hours must be at least 3.0. Students who wish to receive the Physics Minor should bring their Nomination to Candidacy form to the Physics Academic Administration Office for a signature upon completion of this requirement.

3. Qualifying Examination

The official Qualifying Examination is required by the Graduate School. All students must take the qualifier at the end of their first year, in August. A second attempt is allowed at the end of the second year. For this specific purpose only, students who entered graduate school in January will follow the same schedule as students who entered the following August. A student may not take the Qualifying Examination more than twice. Not attempting the Qualifying Examination at the required time constitutes an automatic failure.

The examination consists of two five-hour written tests covering the subject matter of mechanics/relativity, electromagnetism, quantum mechanics, and thermodynamics/statistical mechanics at the level of the first-year core graduate courses in physics.

The passing of the Qualifying Examination is based not only on the student's performance on the written examination, but also on his/her performance in courses and, in particular, in research. It represents the faculty's judgment, based on all available evidence, on whether a student should become a Ph.D. candidate.

4. Candidacy Seminar

A Candidacy Seminar is required of all students pursuing the Ph.D. degree.

As soon as possible after passing the qualifying examination, a student should select a dissertation adviser and identify an area of research for the dissertation. A Candidacy Committee must be chosen, consisting of the adviser and at least three other faculty members (normally someone who will subsequently serve on the Advisory Committee for the dissertation).

At any time after the *first* qualifier attempt, and before the start of the sixth semester, the student must present to the Candidacy Committee a Seminar outlining the proposed subject of the future dissertation. If they have not completed this requirement by the beginning of the sixth semester, they are to be placed on academic probation. Students are required to form their research committees prior to giving the seminar, and members of the committee must attend the seminar and certify they are satisfied with what they heard. The Seminar is to be open to other faculty, staff, and students at the University, and the student is responsible for scheduling it. No grade will be assigned, but the Committee will provide oral comments to the student on the performance and will sign a Seminar Form to be placed in the student's file. Seminar Forms are available in the Physics Academic Administration office. A student who is unsuccessful in the first attempt at the Qualifying Examination is strongly urged to present the Candidacy Seminar in their second year so as to bolster the evidence in favor of becoming a Ph.D. candidate.

5. Nomination to Candidacy

Before a student is formally admitted to candidacy by the Graduate School, certain requirements must be met. The student must have completed the minor requirement and have passed the Qualifying Examination. The Graduate School requires at least an eight-month interval between the formal nomination to candidacy and the date of the completion of work for the doctorate. It is the responsibility of the student to see that s/he is admitted to candidacy at the proper time. Check with the Physics Academic Administration Office for further information.

6. The Ph.D. Committee and Dissertation Examination

As soon as a student passes the Qualifying Examination s/he will select an initial Ph.D. advisory committee of two faculty members whose responsibility is to supervise the student's progress toward the degree. Usually one of these two faculty members will become the student's thesis adviser.

An expanded Ph.D. committee (which usually includes the members of the advisory committee) is formed after the student's official admission to candidacy. The full committee shall consist of at least four faculty members from the student's major and minor fields. It is the student's responsibility to choose a member of the faculty of the Physics Department as the chairperson of his/her Ph.D. committee, and to obtain the faculty member's acceptance. All final decisions concerning the adequacy of the candidate's training and the satisfaction of applicable regulations rest with the Ph.D. committee. The Graduate School requires that the committee be nominated and approved at least six months prior to the final oral Ph.D. dissertation examination. Forms for the appointment of the student's committee are available in the Physics Academic Administration Office.

A Proposal for the student's dissertation topic must be submitted at the time the committee is nominated. This Proposal should contain a clear statement of the proposed research, an outline of the methods and resources to be used, an indication of the questions which will be answered by the study, and a statement concerning the contribution which the study will make to the student's discipline. The Proposal should be one or two pages in length.

The final oral Dissertation Examination will be conducted by the candidate's Ph.D. committee. It consists of a presentation by the candidate followed by questions on the candidate's major and minor fields of work, as well as his/her thesis. The candidate should check in the Physics Academic Administration Office regarding the procedures of this examination.

Thesis Requirements

There are detailed procedures and requirements for the submission of a thesis to the Graduate School. An updated version of these may be obtained from the Physics Academic Administration Office. Further information may be obtained from the Graduate School, Kirkwood Hall 111, 855-9343.

7. Biophysics Track

Students who wish to take this degree option will be in residence in the Department of Physics and subject to the above requirements for the Ph.D. in Physics, with the following modifications.

(1) In the first year of study, students in Biophysics are expected to take P521 (Classical Mechanics); P506 (Electricity and Magnetism I); P556 (Thermodynamics/Statistical Physics I); P575 (Introduction to Biophysics); one course selected from P581 (Modeling and Computation in Biophysics), P582 (Biological and Artificial Neural Networks), P583 (Signal Processing and Information Theory in Biology); and one course out of P507 (E&M 2), P540/541 (Analog and Digital Electronics), P551 (Advanced Physics Lab), or P460 (Optics Lab); depending on the total number credit hours taken, the student may add one credit hour of research (P802).

(2) In the second year of study, students are expected to take P511 (Quantum Mechanics I); P609(Computational Physics I); P676 (Selected Topics in Biophysics); Two 500-600 level courses, each 3-4 credit hours, selected in coordination with the research advisor, in the general area of the student's planned thesis research.

(3) In rare cases, exceptions to the requirements (1) and (2) may be made to accommodate a student's particular research interest.

(4) The major and minor requirements are met by the above courses.

(5) The Qualifying Examination consists of two parts: (a) a specially designated part (normally the first day) of the Physics Qualifying Examination, covering theoretical mechanics, electromagnetism and statistical physics at the level of P506, P521, P556; and (b) a separate examination in Biophysics, covering topics based on the first year biophysics coursework. Part (a) must be taken for the first time at the end of the first year of study, in August. A second attempt is allowed at the end of the second year. With advance approval of the Graduate Advisor, a student may be granted permission to attempt part (a) before undertaking the first year of courses; such an attempt will count as one of the two allowed attempts.

VI. THE PH.D. IN ASTROPHYSICS

Students who wish to take this degree with a minor in astronomy will be in residence in the Department of Astronomy. Those who wish to take a minor in physics will be in residence in the Department of Physics and subject to the above requirements for the Ph.D. in Physics, with the following modifications:

(1) A special committee consisting of members of both departments will be set up for each student to advise on his/her course of study. This is usually done at the beginning of the second year. Basic preparation should include courses in calculus, differential equations, mechanics, heat, light, electricity and magnetism, and general astronomy.

(2) The second minor shall be astronomy.

(3) The Qualifying Examination consists of: (1) a specially designated part (normally the first day) of the Physics Qualifying Examination, covering theoretical mechanics, electromagnetism and statistical physics at the level of P506, P521, P556; and (b) a selected set of four of the eight topics covered in the Astronomy Qualifying Examination.

(4) The thesis research may be conducted under the direction of a faculty member of the Department of Physics or the Department of Astronomy.

VII. THE PH.D. IN CHEMICAL PHYSICS

Students who wish to take this degree with an emphasis in physical chemistry will be in residence in the Department of Chemistry and should consult that department for regulations. Those who desire the degree with an emphasis in physics will be in residence in the Department of Physics and subject to the above requirements for the Ph.D. in Physics, with the following modifications.

(1) The basic Physics requirements will be completion of the core courses along with P615 or P557 (Solid State Physics I), and one among P616 (Solid State Physics II), P623 (Quantum Many Body Theory), or P657 (Statistical Mechanics II). In rare cases, exceptions to these requirements may be made to accommodate a student's particular research interest.

(2) The minor will be taken in the Chemistry department. This minor requires that the student take at least two Chemistry courses at the 500 level or above. Any courses at this level are acceptable, with the exception of graduate seminars and of C561 (Quantum Mechanics) and C567 (Statistical Mechanics), as the latter courses directly overlap material covered in the Physics core courses. The Chemistry courses used to satisfy the minor should be chosen according to the research interests of the student, in consultation with his/her research advisor.

(3) The thesis research may be conducted under the direction of a faculty member of the Department of Physics or the Department of Chemistry.

VIII. THE PH.D. IN MATHEMATICAL PHYSICS

Students who wish to take this degree with a first minor in mathematics will be in residence in the Department of Mathematics and should consult that department for regulations. Those who desire a first minor in theoretical physics will be in residence in the Department of Physics and subject to the above requirements for the Ph.D. in Physics, with the following modifications.

(1) A special advisory committee consisting of members of both departments will be set up for each student to advise on his/her course of study. This is usually done at the beginning of the second year. Basic undergraduate preparation should include courses in advanced calculus, linear algebra, modern algebra, complex variables, classical mechanics, electromagnetism, quantum mechanics, modern physics, thermodynamics and statistical mechanics. In addition, knowledge of the following fields is highly desirable: real analysis, differential equations, probability, topology, differential geometry and functional analysis.

(2) Required courses are determined by the advisory committee on the basis of the individual's previous training and his/her main field of interest.

(3) The minor will usually consist of theoretical physics and mathematics. The requirements will be determined by the student's advisory committee.

(4) Candidates are required to pass Qualifying Examinations in both the Physics and Mathematics Departments. Candidates resident in the Department of Physics must pass the standard Physics Qualifying Exam described above, while those resident in Mathematics can choose instead to pass special oral Qualifying Examinations covering two areas of graduate-level physics. The areas to be covered in these oral examinations and the committee of examiners are determined by the student in consultation with his/her advisory committee. The physics and mathematics qualifying examinations may be taken at different times and in either order. Students should consult the Mathematics Department regarding their Qualifying Exam requirements for the Math-Physics Ph.D.

(5) The thesis research may be conducted under the direction of a faculty member of the Department of Physics or the Department of Mathematics.

IX. THE PH.D. MINOR IN SCIENTIFIC COMPUTING

Indiana University has developed an interdisciplinary, interdepartmental Ph.D. minor in Scientific Computing. This is a formal recognition of changes in science that have been prominent for the last 20 years, changes that have introduced a powerful and entirely new mode of research. The increasing availability of high performance computers has led to a method of scientific inquiry based on mathematical models solved by means of numerical computations, analyzed and viewed by means of advanced computer graphics. Carrying out research by these means is necessarily interdisciplinary, calling on advanced skills in areas that span many classical divisions of academia. The new Ph.D. minor in scientific computing allows the interdepartmental education necessary to better equip students for research within this new paradigm.

Scientific computing courses are generally organized into four categories: numerical analysis, scientific applications, scientific visualization, and high performance computing. Students are encouraged to develop expertise in more than one of those areas.

A. Requirements

The following requirements are drawn from the IU Graduate Bulletin. Students wanting to minor in Scientific Computing should initially meet with an advisor in the Department of Physics, and then contact a member of the Graduate Committee on Scientific Computing (GCSC). A list of the current members of the GCSC is maintained at the Web address http://www.indiana.edu/~scicomp/minor.html . The intent of the minor is to develop multidisciplinary computational skills, exposing students to applications and methods outside their major department.

X Twelve hours of credit in approved courses, six hours of which must be outside the student's major department

X Students develop their course of study with two faculty, one from the Department of Physics and the

other a member of the GCSC from outside the Department of Physics. The Physics Department advisor is preferably a representative on the GCSC.

X The proposed course of study must be submitted for approval by the Graduate Committee on Scientific Computing. If approved, a letter detailing the course of study will be signed by the Committee Chair with copies given to the student and the Department of Physics.

X Significant changes to the course of study need to undergo the same process of development and approval.

X Certification of completion of the minor requirements will be by the Committee Chair or an appointedrepresentative.

X Official records of each student=s approved course of study will be kept by the COAS Dean's Office.

B. Courses

The following is a partial list of courses which can be taken for scientific computing credit. The list is not an exhaustive one and other courses can be used to meet the requirement. However, students must in any case develop their course of study in consultation with two faculty as detailed above, and this should be done in advance of actually taking any of the courses.

Astronomy A550 (Stellar Interiors)

Astronomy A570 (Structure of the Galaxy)

Chemistry C668 (Topics Course: Physics-chemical Modeling and Nonlinear Dynamics)

Computer Science C481-C482 (Computer Graphics)

Computer Science B573 (Introduction to Scientific Computing)

Computer Science B673 (Advanced Scientific Computing)

Computer Science B689 (Topics in Graphics and Human Computer Interaction)

Geological Sciences G514 (Geophysical Signal Analysis)

Geological Sciences G612 (Inverse Methods in Geophysics)

Geological Sciences G614 (Methods in Exploration Seismology)

Mathematics M571-M572 (Numerical Analysis)

Mathematics M441-M442 (Partial Differential Equations) Mathematics M447-

M448 (Mathematical Models and Applications) Physics P410 (Computing

Applications in Physics)

Physics P609 (Computational Physics)

Physics P700 (Topics Course: Monte Carlo Methods in Physics)

Biophysics track year 1

Good fit for Biophysics

PHYS-P 500 Seminar (1 cr.) Reports on current literature. Graduate students and staff participate.

PHYS-P 504 Practicum in Physics Laboratory Instruction (1 cr.)

PHYS-P 506 Electricity and Magnetism I (4 cr.)

PHYS-P 507 Electricity and Magnetism II (4 cr.)

PHYS-P 508 Current Research in Physics (1 cr.)

PHYS-P 511 Quantum Mechanics I (4 cr.)

PHYS-P 512 Quantum Mechanics II (4 cr.) ‘

PHYS-P 518 Scattering Methods in Materials Science (3 cr.)

PHYS-P 521 Classical Mechanics (3 cr.)

PHYS-P 522 Advanced Classical Mechanics (3 cr.)

PHYS-P 535 Introduction to Nuclear and Particle Physics (3 cr.)

PHYS-P 540 Digital Electronics (3 cr.)

PHYS-P 541 Analog Electronics (3 cr.)

PHYS-P 551 Modern Physics Laboratory (3 cr.)

PHYS-P 555 Quantum Computation and Information (3 cr.)

PHYS-P 556 Statistical Physics (3 cr.)

PHYS-P 557 Solid State Physics (3 cr.)

PHYS-P 570 Introduction to Accelerator Physics (3 cr.)

PHYS-P 571 Special Topics in Physics of Beams (3 cr.)

PHYS-P 575 Introduction to Biophysics (3 cr.)

PHYS-P 581 Modeling and Computation in Biophysics (3 cr.)

PHYS-P 582 Biological and Artificial Neural Networks (3 cr.)

PHYS-P 583 Signal Processing and Information Theory in Biology (3 cr.)

PHYS-P 609 Computational Physics (3 cr.)

PHYS-P 610 Computational Physics II (3 cr.)

PHYS-P 615 Condensed Matter Physics I (3 cr.)

PHYS-P 616 Condensed Matter Physics II (3 cr.)

PHYS-P 621 Relativistic Quantum Field Theory I (4 cr.)

PHYS-P 622 Relativistic Quantum Field Theory II (4 cr.)

PHYS-P 625 Quantum Many-Body Theory I (3 cr.)

PHYS-P 626 Quantum Many-Body Theory II-Nuclear (3 cr.)

PHYS-P 627 Quantum Many-Body Theory II-Condensed Matter (3 cr.)

PHYS-P 630 Nuclear Astrophysics (3 cr.)

PHYS-P 633 Theory of the Nucleus I (3 cr.) P: P512.

PHYS-P 634 Theory of the Nucleus II (3 cr.) P: P512.

PHYS-P 635 Frontier Particle Physics I (3 cr.)

PHYS-P 636 Frontier Particle Physics II (3 cr.)

PHYS-P 637 Theory of Gravitation I (3 cr.)

PHYS-P 638 Theory of Gravitation II (3 cr.)

PHYS-P 640 Subatomic Physics I (3 cr.)

PHYS-P 641 Subatomic Physics II (3 cr.)

PHYS-P 647 Mathematical Physics (3 cr.)

PHYS-P 657 Statistical Physics II (3 cr.)

PHYS-P 665 Scattering Theory (3 cr.)

PHYS-P 671 Special Topics in Accelerator Physics (3 cr.)

PHYS-P 672 Special Topics in Accelerator Technology and Instrumentation (3 cr.)

PHYS-P 676 Selected Topics in Biophysics