NDSU Department of Physics

Graduate Student Handbook

Department of Physics

North Dakota State University

Fargo, ND 58108-6050

January 2024

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2. Graduate Program

The Department of Physics offers graduate study leading to M.S. and Ph.D. degrees. We also offer an Accelerated Bachelor's to Master's degree for advanced undergraduate students. As a research-intensive department, we have broad expertise spanning experimental, theoretical, and computational physics. Graduate research may involve specialized training in the following areas: biophysics, chemical physics, computational physics, condensed matter physics, materials science, physics education research, polymer physics, soft matter physics, and statistical mechanics.

3. Faculty Research Interests

John Buncher Physics Education Research

Yongki Choi Experimental Biophysics, Nanobiotechnology

Warren Christensen Physics Education Research: Student Content Understanding, Curriculum Development

Andrew Croll Soft Materials: Experimental Studies of Polymers, Diblock Copolymers, Thin Films, Pattern Formation, and Mechanics

Alan Denton Soft Materials: Theory and Simulation of Phase Behavior of Charged Colloids, Polyelectrolytes, and Polymer-Nanoparticle Mixtures

Erik Hobbie Nanomaterials: Experimental Studies of Nanoparticles,

Polymers, Optics, and Rheology

Mila Kryjevskaia Physics Education Research: Student reasoning and physics

Andrei Kryjevski Nanomaterials: First-Principles Description of Electronic Properties of Nanomaterials, Nuclear Theory, Fermi Systems

Sylvio May Soft Matter and Biophysics: Theoretical Studies of Stability and Phase Behavior of Complexes between Lipid Membranes and Associated Biopolymers

Alexander Wagner Soft Matter: Simulation of Phase Separating Fluids using the Lattice Boltzmann Method, mapping Molecular Dynamics to Lattice Boltzmann, fundamental Computational Physics.

4. Graduate Course Offerings

PHYS 611	**Optics for Scientists and Engineers**
PHYS 611L	**Optics for Scientists and Engineers Lab**
PHYS 613	**Lasers for Scientists and Engineers**
PHYS 615	**Elements of Photonics**
PHYS 662	**Thermal and Statistical Physics**
PHYS 681	**Condensed Matter Physics**
PHYS 685	**Quantum Mechanics I**
PHYS 686	**Quantum Mechanics II**
PHYS 752	**Mathematical Methods in Physics I**
PHYS 753	**Mathematical Methods in Physics II**
PHYS 758	**Statistical Physics**
PHYS 761	**Electromagnetism**
PHYS 771	**Quantum Physics I**
PHYS 772	**Quantum Physics II**
PHYS 781	**Solid State Physics**
PHYS 782	**Condensed Matter Physics**
PHYS 790	**Graduate Seminar**
PHYS 798	**Masters Thesis**
PHYS 899	**Doctoral Dissertation**

Course Availability

Courses numbered 600 are offered annually. Courses numbered 700 and above are offered when needed. The core Ph.D. courses (PHYS 752, 758, 761, 771, 781) and PHYS 782 are typically offered on a six-semester cycle. Contact your advisor for details.

For a complete listing of courses offered at NDSU during a given semester, see the class schedule published by the Office of Registration and Records.

Course Descriptions

PHYS 611: Optics for Scientists and Engineers

3 credits, offered every fall

Introduction to modern optics. Geometric optics, electromagnetic nature of light, polarization, interference, diffraction, fiber optics.

Prereq: PHYS 252. Coreq: PHYS 611L. Cross-listed with ECE.

PHYS 611L: Optics for Scientists and Engineers Laboratory

1 credit, offered every fall

Required laboratory for PHYS/ECE 611. Ten optics experiments plus a major related optics project.

Coreq: PHYS 611. Cross-listed with ECE.

PHYS 613: Lasers for Scientists and Engineers

3 credits, offered in the spring of odd-numbered years

Lecture and laboratory introduction to lasers. Spontaneous and stimulated transitions, line-broadening, gain, gain saturation, optical resonators, Fabry-Perot interferometers, theory of laser oscillation, rate equations, transverse modes, coherence, and Gaussian beams.

PHYS 615: Elements of Photonics

3 credits, offered in the spring of even-numbered years

Analysis of optical systems using the matrix formulation, wave propagation in anisotropic media, electro-optic effect and laser modulation, physical origin of optical nonlinearities, phase matching, optical second harmonic and parametric generation.

PHYS 662: Thermal and Statistical Physics

3 credits, offered in the fall of every year

Classical postulates and laws of thermodynamics; cyclic processes and entropy; thermodynamic potentials, equilibrium, stability, and phase transitions; Maxwell-Boltzmann distribution, applications to classical gases and magnets; quantum statistics, Bose-Einstein and Fermi-Dirac distributions, applications to quantum gases.

PHYS 681: Condensed Matter Physics

3 credits, offered in the spring of every year

Introduction to the physics of soft condensed matter, composed of polymers, colloids, amphiphiles, and liquid crystals, and of hard condensed matter, including metals, semiconductors, and superconductors, emphasizing phase transitions and materials properties (electrical, magnetic, optical, elastic).

Coreq: PHYS 486

PHYS 685: Quantum Mechanics I

3 credits, offered in the fall of every year

Operators, one-dimensional wells and barriers, Schrodinger equation, uncertainty, duality, Born interpretation, unstable states, bosons and fermions, central force problems, angular momentum, spin.

PHYS 686: Quantum Mechanics II.

3 credits, offered on demand

Continuation of PHYS 685. Perturbation theory, angular momentum addition, variational schemes, WKB method, scattering theory, time-dependent problems.

Prereq: PHYS 685

PHYS 752: Mathematical Methods in Physics I

3 credits, offered on demand

Review of practical mathematical methods routinely used by physicists, including applications. Focus on differential equations, variational principles, and other selected topics.

Cross-listed with MATH 782. Typically taught by the Department of Physics.

PHYS 753: Mathematical Methods in Physics II

3 credits, offered on demand

Tensor analysis, matrices and group theory, special relativity, integral equations and transforms, and selected advanced topics.

Prereq: PHYS 752. Cross-listed with MATH 783. Typically taught by the Department of Mathematics.

PHYS 758: Statistical Physics

3 credits, offered on demand

Review of thermodynamics and statistical mechanics; Monte Carlo and molecular dynamics simulation; applications to phase transitions.

Prereq: PHYS 462/662

PHYS 761: Electromagnetism

3 credits, offered on demand

Review of Maxwell's equations, radiation, collisions between charged particles, dynamics of relativistic particles and fields.

Prereq: PHYS 361

PHYS 771: Quantum Physics I

3 credits, offered on demand

Schrodinger equation, wave packets, uncertainty, angular momentum, spin, second quantization, harmonic oscillator, resistance mechanisms.

Prereq: PHYS 486

PHYS 772: Quantum Physics II

3 credits, offered on demand

Continuation of PHYS 771

Prereq: PHYS 771

PHYS 781: Solid State Physics

3 credits, offered on demand

Crystal structure and binding, reciprocal lattices and x-ray diffraction, lattice vibrations, thermal properties, free electron model, band theory, magnetism, superconductivity.

Prereq: PHYS 485/685

PHYS 782: Condensed Matter Physics

3 credits, offered on demand

An introduction to soft condensed matter, focusing on colloids, polymers, liquid crystals, surfactants, and biological systems. Topics will include characterization of soft materials, interparticle interactions, structure, equilibrium phase behavior, non-equilibrium properties, and practical applications.

Prereq: PHYS 462/662

PHYS 790: Graduate Seminar

1-3 credits, offered every semester

Each student will present a seminar on a literature topic or current research and attend all other seminars.

PHYS 798: Masters Thesis

1-10 credits, offered every semester

Masters Thesis research

PHYS 899: Doctoral Dissertation

1-15 credits, offered every semester

Doctoral Dissertation research

5. Degree Requirements

The Graduate Program Coordinator or Chair shall assign to each incoming graduate student a temporary advisor, who shall assist in the selection of courses. During the first semester, the student is expected to discuss potential projects for thesis research with faculty members. By the beginning of the second semester, the student must have a permanent research supervisor. By the end of the second semester, the student must have filed a plan of study, selected a thesis topic, and secured two additional faculty members for the Advisory Committee. One additional member from outside the Department of Physics will be appointed by the Graduate School. The student and supervisor may suggest potential outside members.

Master of Science

The M.S. program requires the completion of at least 30 graduate credits, numbered 601-798, of which:

- at least 10 credits are Physics courses numbered 601-689 or 700-789;
- at least 16 credits are didactic courses numbered 601-689 or 700-789;
- between 6 and 10 credits are Physics 798 (Master's Thesis);
- at least one credit must be Physics 790 Graduate Seminar.

Students are strongly encouraged to attend all seminars and colloquia.

Accelerated Master of Science Program

Students must meet all requirements of the Physics Bachelor and Master programs. For the Master's degree, students must earn at least 30 graduate credits, numbered 601-798, with these conditions:

1. At least 21 credits are didactic Physics courses from this list:

   PHYS 611, 611L, 613, 615, 655, 662, 663, 681, 685, 686, 752, 758, 761, 771, 781, 782

   Up to 15 credits from this list may count toward the Bachelor's program requirements.

   It is recommended that students take the 600-level of PHYS 455/655, 462/662, 485/685, and 486/686 while fulfilling the requirements for the Bachelor's degree.

2. Between 6 and 8 credits are PHYS 798 (Master's Thesis), with the goal to publish a paper based on the thesis research, although this is not a requirement to graduate.
3. At least one credit is PHYS 790 Graduate Seminar.
4. Research Plan:

Students in the Accelerated Master's program must prepare a plan of research before the end of the first semester of the final year. A written plan must be submitted and orally presented to the advisory committee for feedback. The plan should be three to five pages (plus references) and should contain the following sections: (1) Background and Motivation, (2) Objectives, (3) Methods, (4) Preliminary Results, (5) Anticipated Significance, (6) References. Students will be expected to demonstrate a thorough understanding of the relevant background and literature.

Doctor of Philosophy

The Ph.D. program requires the completion of at least 90 graduate credits, numbered 601-799, of which

- 27 or more must be in letter-graded courses
- 16 are required Physics core courses (752, 758, 761, 771, 781, 790)
- No more than 12 credits are in non-Physics courses

Up to 30 credits from a previously earned Master's degree may be approved to fulfill up to 30 of the required 90 doctoral program credits.

Students are strongly encouraged to attend all seminars and colloquia.

Comprehensive Examination

By the end of their 4th semester, doctoral students are expected to

- submit a written report that summarizes their research results so far and details a research plan for the rest of their research work
- give a talk about their research accomplishments and plans
- pass an oral examination by the Advisory Committee to confirm candidacy

Students who pass the comprehensive examination and, at the time of the exam, have completed 30 credits (16 of which are didactic) will earn a Master's degree and be eligible to participate in commencement that semester. Students should choose the Ph.D. + Master's option from the drop-down menu on the Doctoral Degree Plan of Study and on the Request to Schedule Examination. After students have passed the comprehensive examination, they should complete the Exit Survey and the Degree Application. A link to these items will be e-mailed to them by the Graduate School.

Students who fail the comprehensive examination will be given the opportunity to repeat the examination in the next semester. However, this examination can be repeated only once. Alternatively, students may elect to work toward a Master's degree.

Timing

Master's students should strive to submit their thesis for examination by the end of their second year and doctoral students by the end of the fourth year. The final examination consists of a public seminar, followed by a private examination by the Advisory Committee. Before graduation, the Advisory Committee's comments on the thesis must be satisfactorily addressed.

For the comprehensive and final examinations, students must submit the appropriate forms to the Graduate School.

6. Graduate Credit Transfer/Substitution Policy for Ph.D. Program

Students who have completed graduate-level courses at another institution may request transfer/substitution credit for up to nine credits of coursework. (In exceptional cases, a student may petition the Department Chair and the Graduate Program Coordinator to transfer up to 15 credits of coursework. Approval from the student's supervisory committee is required prior to filing the petition.)

A recommendation by the Department to grant the request will be based on the following guidelines:

1. For a course to be accepted as a transfer/substitution for one of our program's 700-level core courses, it must be deemed equivalent based on a comparison of syllabus and textbook. Course equivalency is not required for 600-level courses.

2. The student must have earned a minimum grade of 'B' in the course.

3. The student must demonstrate satisfactory performance in all coursework during the first semester by earning a minimum grade of ‘B’ in each course.

4. The courses must not be internship, individual study, special topics, or research courses and must have been earned within a 10-year period from the time of the student’s final defense.

5. Approval of the student's supervisory committee and of the Graduate Program Coordinator is required. Students are encouraged to meet with the supervisory committee and the Graduate Program Coordinator prior to submitting the plan of study for approval.

After approval, the credits should be listed in the Transfer/Substitution Credits section of the Plan of Study.

Note: These transfer/substitution credits can only be used to substitute required courses at NDSU if the M.S. credits from previously earned degrees were not already used to reduce the number of required NDSU credits from 90 to 60, as described in the *Doctor of Philosophy* subsection of Section 5.

7. Advising and Evaluation of Students

A. Upon admission to the Graduate Program, every student is assigned a temporary supervisory committee by the Graduate Coordinator or Chair. During the first semester, students are expected to discuss potential projects for thesis research with faculty members. By the beginning of the second semester, each student must have a permanent research supervisor. Failure to secure a supervisor will be grounds for dismissal. By the end of the second semester, the student must have filed a plan of study, selected a thesis topic, and secured two additional faculty members for the supervisory committee. The committee is encouraged to convene at least once per semester and meet at least once per year to review the progress of the student. The committee must meet with the student at least once per year to provide guidance and review the progress.

B. To remain in good academic standing, a student must receive a grade of 'B' or higher in every course. A grade of 'C' or lower in any course places a student on internal probation and may be grounds for dismissal.

C. By April 15 of each year, a student must submit to the committee an annual report addressing the student's progress in research and the plan of study, including completed courses and plans for taking the comprehensive exam. By May 1, a student adviser (with feedback from the student's committee members) must supplement the report with an evaluation of student progress. Within 14 days of receiving the adviser's evaluation, the student may meet with the Chair or Graduate Program Coordinator to discuss the evaluation and may respond in writing. The student report and the adviser's evaluation, signed by the student, must be submitted to the graduate program coordinator by May 15. Both documents will be placed in the student's personnel file. Failure to make satisfactory progress may be grounds for dismissal.

D. Each Ph.D. student, by the end of their fourth semester, is expected to take the comprehensive exam (see "Degree Requirements" on homepage). After passing the comprehensive exam, a student in the Ph.D. program automatically progresses to Ph.D. candidacy and is granted a nonterminal Master's degree. If unsuccessful on the first attempt, a student may retake the comprehensive exam within six months. After two unsuccessful attempts to pass the comprehensive exam, a student may earn a terminal Master's degree by completing

and defending a paper or thesis. The report/proposal prepared for the comprehensive exam may serve as a basis for the Master's paper/thesis, which should include some original (though not necessarily publishable) work.