NDSU Department of Physics

Graduate Student Handbook

Department of Physics

North Dakota State University

Fargo, ND 58108-6050

August 2016

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1. Contact

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2. Graduate Program

The Department of Physics offers graduate study leading to the M.S. and Ph.D. degrees. Advanced work may involve specialized training in the following areas: biophysics, computational physics, condensed matter, laser applications, materials science, optics, chemical physics, soft matter, statistical mechanics, physics education and polymer physics.

Research and academic programs are tailored to meet individual needs and interests. Soon after their arrival, new students are strongly urged to visit faculty members to discuss research opportunities.

We are a research-intensive department, with expertise spanning experimental, theoretical, and computational physics. Active areas of research include nanomaterials, soft condensed matter, biophysics, and physics education research. When applying, please indicate your area(s) of research interest. If you wish to work with a particular faculty member, we recommend contacting that individual informally to discuss the availability of research opportunities.

3. Faculty Research Interests

John Buncher Physics Education Research

Yongki Choi Nano-bio-physics, Nano-electronics, Single-Molecule science

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

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

Naresh Sen Physics Education Research

Alexander Wagner Soft Matter: Simulation of Phase Separating Fluids using the Lattice Boltzmann Method

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 in the spring of every year

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

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 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 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 required to attend all seminars and colloquia.

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 the required physics courses (752, 758, 761, 771, 781, 790)
- No more than 12 credits are in non-physics courses

Credits used to satisfy the requirements for the M.S. degree may be included in the total.

Students are required to attend all seminars and colloquia.

Comprehensive Examination

By the end of their 4th semester, doctoral students must

- 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.

If the student fails the comprehensive examination, she/he will be given the opportunity to repeat the examination in the next semester. However, this examination can be repeated only once. Alternatively, the student may elect to work toward a Master's degree.

Doctoral Video

Doctoral students are required to create a 2-3 minute video summarizing the results of their dissertation research for a lay audience. The video should be produced during a student's final semester of study and shown at the final defense for approval by the supervisory committee.

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. Advising and Evaluation of Students

1. 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.

2. 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.

3. To assess the progress of a student, the faculty supervisor must submit to the Chair an annual review by the end of the spring semester. The letter should address the student's progress in research and the plan of study, including completed courses and plans for taking the comprehensive exam. A copy of the evaluation letter will be given to the student. A second copy, signed by the student, will be placed in the student's personnel file. Within 14 days of receiving the letter, the student may meet with the Chair or Graduate Coordinator to discuss the evaluation and may respond in writing. Failure to make satisfactory progress may be grounds for dismissal.

4. Each Ph.D. student, by the end of his/her fourth semester, must 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.