Physics and Astrophysics

http://www.physics.und.edu

FACULTY: Barkhouse, Dewar, Kim (Chair), Lee, Marasinghe (Graduate Director), Oncel, Schwalm, Tung and Young

Degrees Granted: Master of Science (M.S.), Doctor of Philosophy (Ph.D.) and Five-Year B.S.-M.S.

The Department of Physics and Astrophysics offers graduate programs leading to the Master of Science and Doctor of Philosophy degrees. Current research in the department emphasizes solid-state physics, materials science, astrophysics, and health physics. Departmental facilities permit both theoretical and experimental research investigations.

Details pertaining to admission requirements, degree requirements and courses offered can be found in the Degree section.

Master of Science (M.S.)

Mission Statement and Program Goals

The primary functions of the Physics and Astrophysics Department are teaching, research and service. In accordance with the mission of the University, the department provides courses for physics majors and minors, and service courses to students in other programs in the College of Arts & Sciences and other units of the University.

Goal 1: Students will acquire competency in graduate level physics including mechanics, electromagnetism, quantum mechanics, and theoretical methods.

Goal 2: Students will acquire in-depth exposure to research.

Goal 3: Students will acquire skills in oral presentations and acquire experience in writing research papers.

Goal 4: Students will develop analytical skills needed as a professional physicist.

Doctor of Philosophy (Ph.D.)

Student Learning Goals

Goal 1: Students will acquire competency in graduate level physics including mechanics, electromagnetism, quantum mechanics, statistical physics, and theoretical methods.

Goal 2: Students will acquire skills to carry out programs of independent research at a research laboratory or as a university faculty member.

Goal 3: Students will acquire skills in oral presentations and acquire experience in writing research papers.

Goal 4: Students will develop analytical skills needed as a professional physicist.

Five-year B.S.-M.S. Degree Program

Mission Statement and Program Goals

Goal 1: To give high-achieving physics students an opportunity to earn a M.S. degree a year earlier than at most other institutions.

Goal 2: To attract more high-achieving students to our undergraduate program.

Master of Science (M.S.)

Admission Requirements

The applicant must meet the School of Graduate Studies' current minimum general admission rquirements as published in the graduate catalog.

1. A four-year bachelor's degree from a recognized college or university.
2. A cumulative Grade Point Average (GPA) of at least 2.75 for all undergraduate work (2.5 for M. Engr.) or a GPA of at least 3.0 for the junior and senior year of undergraduate work (based on a 4.0 scale).
3. Completed a minimum of 21 semester credits of undergraduate physics, plus mathematics through differential equations or the equivalent.
4. Coursework should include intermediate courses in mechanics, electricity and magnetism, optics, thermal physics, and modern quantum physics. Adequate preparation in general chemistry is also necessary.
5. Satisfy the School of Graduate Studies' English Language Proficiency requirements as published in the graduate catalog.
6. An applicant without satisfactory undergraduate training may be admitted to the program, but will be required to remove deficiencies by completing the necessary undergraduate courses without receiving graduate credit for them.
7. Ph.D. applicants are encouraged to submit the Graduate Record Examination scores for the general test and advanced physics test.

Degree Requirements

Students seeking the Master of Science degree at the University of North Dakota must satisfy all general requirements set forth by the School of Graduate Studies as well as particular requirements set forth by the Physics and Astrophysics Department.

The program is designed to provide the student with basic physics courses at the graduate level and an introduction to research.

1. Minimum of 30 semester credits in a major field, including the credits granted for the thesis and the research leading to the thesis.
2. At least one-half of the credits must be at or above the 500-level.
3. A maximum of one-fourth (usually 8-9 semester credits) of the credit hours required for the degree may be transferred from another institution.
4. Complete the following courses:

PHYS 509	Methods of Theoretical Physics	3
PHYS 539	Quantum Mechanics	3
PHYS 541	Theory Electricity Magnetism	3
PHYS 545	Analytical Mechanics	3

5. Complete six additional hours from the following:

PHYS 510	Methods of Theoretical Physics	3
PHYS 540	Quantum Mechanics	3
PHYS 542	Theory of Electricity and Magnetism	3

6. Complete research project and PHYS 998 Thesis (4-9 credits).

Doctor of Philosophy (Ph.D.)

Admission Requirements

The applicant must meet the School of Graduate Studies' current minimum general admission rquirements as published in the graduate catalog.

Applicants who are seeking admission to School of Graduate Studies must meet all of the minimum general School of Graduate Studies admission requirements identified in the graduate catalog. In addition, prospective students must fulfill the requirements for admission to the graduate program in Physics and Astrophysics.

1. Successful completion of a master's degree (Some programs permit bypassing the master's degree and allow for direct admission to the Ph.D. degree. Check specific department requirements for admission.)
2. An overall GPA of 3.0 for all graduate work.
3. Completed all undergraduate preparation.

4. Presentation of scores on the GRE General Test and advanced physics test is recommended.
5. Be recommended for doctoral work by the department.

Degree Requirements

Students seeking the Doctor of Philosophy degree at the University of North Dakota must satisfy all general requirements set forth by the School of Graduate Studies as well as particular requirements set forth by the Physics and Astrophysics Department.

The degree is a research degree and is conferred only in recognition of high achievement in independent scientific research and scholarship.

1. Completion of 90 semester credits beyond the baccalaureate degree.
2. Maintenance of at least a 3.0 GPA for all classes completed as a graduate.
3. With approval of a student's Faculty Advisory Committee, up to one-half of the work beyond a master's degree (maximum of 30 semester credit hours) may be transferred from another institution that offers post-master's degrees in the discipline
4. In addition to PHYS 590 Research, the coursework will amount to approximately 36 hours.
5. Completion of a regular core of courses which includes:

PHYS 509	Methods of Theoretical Physics	3
PHYS 510	Methods of Theoretical Physics	3
PHYS 539	Quantum Mechanics	3
PHYS 540	Quantum Mechanics	3
PHYS 541	Theory Electricity Magnetism	3
PHYS 542	Theory of Electricity and Magnetism	3
PHYS 543	Statistical Physics	3
PHYS 545	Analytical Mechanics	3
PHYS 549	Seminar	1

6. Completion of several specialized graduate level courses in physics in order to obtain the in-depth training essential for the development of their research interest.
7. Completion of at least nine semester hours of graduate work, (400 level or above) in a single related field.
8. After successful completion of the first two semesters of coursework, students who entered the program with a bachelor's degree will take a written qualifying examination, which covers undergraduate and first-year graduate level courses. Students with a master's degree will take this examination in the second semester of enrollment.
9. A student who fails to perform satisfactorily in this examination may be re-examined after waiting one semester. In general, no student will be allowed to take the qualifying examination more than twice.
10. No student may proceed formally toward the Ph.D. degree until this examination has been passed.
11. Written doctoral comprehensive examination in physics will normally be taken in the fifth semester of graduate enrollment. This must be completed before advancement to candidacy is granted.
12. Candidates for the Ph.D. must complete a research investigation. Upon satisfactory completion of the research investigation, the student is required to prepare a dissertation covering the research.

At the final oral examination, the candidate presents and defends the dissertation.

Five-Year B.S.-M.S. Degree

Five-year B.S.-M.S. Degree Program in Physics

The program will **use only the existing courses** in the Department of Physics and Astrophysics, Department of Mathematics, and Department of Chemistry.

The program course requirements include the following courses:

PHYS 251C	University Physics I	3
PHYS 251CL	University Physics I Lab	1
PHYS 252C	University Physics II	3
PHYS 252CL	University Physics II Lab	1
PHYS 253C	University Physics III	3
PHYS 253CL	University Physics III Lab	1
PHYS 317	Mechanics I	3
PHYS 318	Mechanics II	3
PHYS 324	Thermal Physics	3
PHYS 325	Optics	3
PHYS 325L	Optics Laboratory	1
PHYS 327	Electricity and Magnetism I	3
PHYS 328	Electricity and Magnetism II	3
PHYS 415	Undergrad Research Experience	3
PHYS 428	Advanced Physics Laboratory	2
PHYS 431	Quantum Mechanics I	3
PHYS 432	Quantum Mechanics II	3
PHYS 509	Methods of Theoretical Physics	3
PHYS 510	Methods of Theoretical Physics	3
PHYS 539	Quantum Mechanics	3
PHYS 540	Quantum Mechanics	3
PHYS 541	Theory Electricity Magnetism	3
PHYS 542	Theory of Electricity and Magnetism	3
PHYS 545	Analytical Mechanics	3
PHYS 590	Research	1-16
MATH 165	Calculus I	4
MATH 166	Calculus II	4
MATH 207	Introduction to Linear Algebra	2
MATH 265	Calculus III	4
MATH 266	Elementary Differential Equations	3
MATH 352	Introduction to Partial Differential Equations	3
CHEM 121	General Chemistry I	3
CHEM 121L	General Chemistry I Laboratory	1
CHEM 122	General Chemistry II	3
CHEM 122L	General Chemistry II Laboratory	1
Total Credits		92-107

Courses

PHYS 509. Methods of Theoretical Physics. 3 Credits.
An introduction to the mathematical methods currently used in physics.

PHYS 510. Methods of Theoretical Physics. 3 Credits.
A continuation of Physics 509 introduction to the mathematical methods currently used in physics.

PHYS 511A. Physics for Teachers I. 3 Credits.
Prerequisite: PHYS 511L.

PHYS 511B. Physics for Teachers I. 3 Credits.
Prerequisite: PHYS 511A.

PHYS 511L. Physics for Teachers I Lab. 2 Credits.
Prerequisite: Department consent.

PHYS 512A. Physics for Teachers II. 3 Credits.
Prerequisite: PHYS 512L.

PHYS 512B. Physics for Teachers II. 3 Credits.
Prerequisite: PHYS 512A.

PHYS 512L. Physics for Teachers II Lab. 2 Credits.
Prerequisites: PHYS 511L and PHYS 511B.

PHYS 513A. Physics for Teachers III. 3 Credits.
Prerequisite: PHYS 513L.

PHYS 513B. Physics for Teachers III. 3 Credits.
Prerequisite: PHYS 513A.

PHYS 513L. Physics for Teachers III Lab. 2 Credits.
Prerequisites: PHYS 512L and PHYS 512B.

PHYS 520. Cosmology. 3 Credits.
Cosmology is the study of the origin, structure, and evolution of the Universe. This graduate-level course will provide an overview of recent developments in cosmology, including; the Big Bang model, inflation, the cosmic microwave background, baryogenesis, the expanding universe, Hubble's constant and the distance scale, and dark energy. On demand.

PHYS 525. Galaxies. 3 Credits.
This graduate-level course will provide an overview of the formation and evolution of galaxies. Topics include; galaxy classification, formation of spheroids and disk galaxies, galactic dynamics, interstellar medium, dark matter, mass models, spiral structure formation, large-scale structure, and high redshift galaxies. On demand.

PHYS 535. Solid State Physics. 3 Credits.
The crystal lattice, electron theory of metals and semiconductors, and transport phenomena in solids.

PHYS 536. Solid State Physics II. 3 Credits.
Lattice vibrations, phononelectron interactions, and cooperative phenomena in solids.

PHYS 539. Quantum Mechanics. 3 Credits.
The Schroedinger equation, perturbation methods, and simple quantum mechanical systems.

PHYS 540. Quantum Mechanics. 3 Credits.
Matrix methods, spin, and scattering phenomena.

PHYS 541. Theory Electricity Magnetism. 3 Credits.
Electrostatics, magnetostatics, electromagnetic waves.

PHYS 542. Theory of Electricity and Magnetism. 3 Credits.
Special theory of relativity, scattering of charged particles, and radiation.

PHYS 543. Statistical Physics. 3 Credits.
The Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics, and their application to the description of physical systems.

PHYS 545. Analytical Mechanics. 3 Credits.
Variational methods. Lagrange's equations, oscillations, Hamilton equations, and special relativity.

PHYS 549. Seminar. 1 Credit.
Repeatable to 3 credits.

PHYS 550. Special Topics. 1-3 Credits.
Investigation of special topics in advanced physics; the subject matter determined by studentfaculty interest. Prerequisite: Consent of department. Repeatable to 6 credits.

PHYS 590. Research. 1-16 Credits.
Repeatable.

PHYS 996. Continuing Enrollment. 1-12 Credits.
Repeatable. S/U grading.

PHYS 997. Independent Study. 2 Credits.

PHYS 998. Thesis. 1-9 Credits.
Repeatable to 9 credits.

PHYS 999. Dissertation. 1-18 Credits.
Repeatable to 18 credits.

Undergraduate Courses for Graduate Credit

PHYS 402. Computers in Physics. 3 Credits.
Computer applications in physics, that may include data analysis, numerical simulation, symbolic and algebraic programming, parallel computing, computer interfacing and/or experimental physics applications. Prerequisites: PHYS 252 and knowledge of a higher-level computer programming language, or consent of instructor. On demand.

PHYS 428. Advanced Physics Laboratory. 2 Credits.
Advanced undergraduate experiments in physics, using modern techniques and instrumentation. Classic experiments leading to the current understanding of physical theory. Prerequisite: PHYS 253 or approval of instructor. F, odd years.

PHYS 431. Quantum Mechanics I. 3 Credits.
An introduction to quantum mechanics with applications to atomic structure. Prerequisite: PHYS 253. Prerequisite or Corequisite: PHYS 317 or approval of department. F, even years.

PHYS 432. Quantum Mechanics II. 3 Credits.
Further development of basic quantum theory with application to atomic, molecular, solid state and nuclear physics. Prerequisite or Corequisite: PHYS 431 or consent of instructor. S, odd years.

PHYS 434. Nuclear Physics. 3 Credits.
Introduction to the theory of atomic nuclei, fundamental forces and sub-atomic particles. Prerequisite: PHYS 253 or approval of instructor. F, odd years.

PHYS 437. Introductory Solid State Physics. 3 Credits.
A general introduction to solid state phenomena. Prerequisite: PHYS 253 or approval of instructor. F, even years.

PHYS 460. Introduction to Astrophysics. 3 Credits.
Nature of stars. Topics include celestial mechanics, relativity, optics, stellar birth, stellar interiors and evolution, nucleosynthesis, stellar death, compact objects, black holes, neutron stars, white dwarfs, binaries and variable stars. Some topics include the use of computer tools to solve problems. Prerequisite: PHYS 253 or approval of instructor. F, even years.

PHYS 461. Introduction to Astrophysics II. 3 Credits.
Galaxies and the universe. Topics include structure and evolution of galaxies, the Milky Way, stellar populations, globular clusters, interstellar medium, big bang, Hubble and the distance scale, radio galaxies, quasars, jets, blazars, clusters and superclusters of galaxies and cosmology. Some topics include the use of computer tools to solve problems. Prerequisite: PHYS 460 or approval of instructor. S, odd years.

PHYS 492. Special Problems. 1-3 Credits.
Selected problems in physics or astrophysics. Prerequisite: Approval of the department. Repeatable to 9 credits. On demand.