698.07 (1-2) Internship in Developmental/Adapted Physical Education
Supervised hands-on experience teaching physical education to students with disabilities.
Pre: HP 4/511, 4/545

698.08 (1-10) Internship: Intramural-Recreational Sports Management
Supervised field experience related to the student's academic specialization of IM/Recreational Sports Management associated with the graduate tract in the discipline of sport administration (Dept. of Human Performance)
Pre: Grad. student/professor consent

698.14 (1-8) Internship: Elementary Physical Education
Directed study in an elementary school setting.
Pre: Grad. student, permission from school district, presently licensed teacher

698.25 (1-10) Internship: Exercise Physiology Laboratory
Designed to provide the student with hands-on experience working in the MSU Exercise Physiology Laboratory.

698.26 (1-10) Internship: Sport Psychology
Supervised field experience related to the student's academic specialization of sport psychology associated with the graduate tract in Psychological Aspects of Sport in the Department of Human Performance.
Pre: Grad. student/professor consent

699 (1-4) Thesis
Course requires completion of thesis paper.
Pre: Grad. student/professor consent.

PHYSICS MS

PHYSICS EDUCATION MS

(DISCIPLINE-BASED)

College of Science, Engineering, & Technology
Physics & Astronomy Department
N141 Trafton Science Center • 507-389-5743

Chair: Louis Schwartzkopf, Ph.D.
Interim Graduate Coordinator: Hai-shen Wu, Ph.D.

Edward Borchardt, Ph.D., Paul Eskridge, Ph.D., Robert Herickhoff, Ph.D., Steven Kipp, Ph.D., Igor Kogoutiouk, Ph.D., Mark Pickar, Ph.D., James Pierce, Ph.D., Hai-sheng Wu, Ph.D., Youwen Xu, Ph.D.

The Department of Physics and Astronomy presents several opportunities for study at the graduate level. The Master of Science is offered as the professional degree in physics. This degree is designed for students wishing to prepare themselves for doctoral study, or for work in a research/industrial position. A student who meets the state entrance and graduation requirements for the Master of Science in Physics may choose to emphasize the instrumentation area by including appropriate Electrical Engineering or Electronic Engineering Technology courses. Students interested in teaching at a community college may elect the M.S. Community College track. Teacher certification is not required for this track.

The Master of Science in Physics Education is designed for individuals interested in strengthening their background in secondary school teaching. Previous teacher licensure is usually required.

Admission. Interested students should complete the general admission requirements of the College of Graduate Studies.

Degree Completion. A graduate student in physics should complete a Plan of Study during the first part of the second semester, prior to the completion of the first 11 graduate credits of the program at Minnesota State University. This will require close consultation between the student and the initial advisor. The comprehensive written exam will then be taken toward the end of the second semester. Please contact the Physics and Astronomy Department graduate coordinator for additional information.

Financial Assistance. The Department of Physics and Astronomy has a limited number of graduate assistantships available. Information and application materials can be obtained from the department graduate coordinator. Consult the front of this bulletin for more information on financial aid and graduate assistantships.

PHYSICS MS

(Thesis Plan Only - 30 cr)

Required Core (12-15 cr)

PHYS	607	Intro. to Research (2)
PHYS	641	Math Physics I (4)
PHYS	642	Math Physics II (4)
PHYS	699	Thesis (1-6), minimum 3 cr

Required Physics Electives (8-11 cr)
Choose any 500/600 level Physics elective courses approved by the student's advisor

Required General Electives (7 cr)
Choose any 500/600 level elective courses approved by the student's advisor

Additional Requirements:
A reading knowledge of a foreign language or a demonstrated ability in computer programming is required. Fifty percent of all courses must be taken at the 600 level. A written exam and a thesis and its oral defense are required.

COMMUNITY COLLEGE TRACK
(Thesis Plan - 30 cr)
(Alternate Plan Paper - 34 cr)

Required Physics Electives Core (9-17 cr)
PHYS 697 Internship (4-8)
In addition, choose any 500/600 level Physics elective courses approved by the student's advisor. Students who would like to have "internship" listed as "Internship in College Teaching" should contact the Graduate Dean.

Required Education Electives (minimum 6 cr)
EDFN 610 Philosophy of Education (3)
EDFN 670 The Community College (3)
EDFN 671 Introduction to College Teaching (3)

Required General Electives (6 cr)
Choose any 500/600 level elective courses from outside of physics and outside of professional education, approved by the student's advisor.

Required Research Methods (3 cr)
Choose a research methods course approved by the student's advisor.

Required Thesis or Alternate Plan Paper
PHYS 694 Alternate Plan Paper (1-2)
PHYS 699 Thesis (1-6) minimum 3 cr

Additional Requirements:
A reading knowledge of a foreign language or a demonstrated ability in computer programming is required. Fifty percent of all courses must be taken at the 600 level. A written exam is required. A thesis and its oral defense is required, if the thesis option is chosen.

PHYSICS EDUCATION MS (DISCIPLINE-BASED)

(Thesis Plan - 30 cr)
(Alternate Plan Paper - 34 cr)

Teaching licensure is usually a prerequisite to pursuing this degree, since this degree does not lead to initial teaching licensure. Students who desire initial licensure should consult the Master of Arts in Teaching (MAT) program.

Required Physics Electives (9-17 cr)
Choose any 500/600 level elective courses approved by the student's advisor.

Required Education Electives (6 cr)
Choose any 500/600 level Education elective courses approved by the student's advisor from the following:
EDFN 600, 601, 610, 612, 620, 621, 640, 641, 677
CI 501, 520, 522, 602, 617, 631, 654, 656, 663, 665, 666, 676
CSP 570
EDAD 652, 665

Required General Electives (6 cr)
Choose any 500/600 level elective courses approved by the student's advisor.

Required Research Methods (3 cr)
Choose a research methods course approved by the student's advisor.

Required Thesis or Alternate Plan Paper
PHYS 694 Alternate Plan Paper (1-2)
PHYS 699 Thesis (1-6) minimum 3 cr

Additional Requirements:

Fifty percent of all courses must be taken at the 600 level. A written exam is required. A thesis and its oral defense is required, if the thesis option is chosen.

COURSE DESCRIPTIONS

Physics

504 (2) Physics and Society
Relations between physics and other intellectual communities: e.g., philosophy, humanities, social sciences, the arts. V
Pre: Con

517 (2) Biophysics
Thermodynamic relationships; energy flow in living systems; metabolic heat generation and loss; homeostasis; atomic and molecular bonds in nucleic acids, proteins, and carbohydrates; hormonal regulation; cell metabolism; negative feedback control in living systems; cancer therapy; imaging; disease states; new theories and paradigms. V
Pre: PHYS 212 or 222 and MATH 122

535 (3) Modern Physics I
Special Theory of Relativity. Quantum nature of waves and particles: photons, de Broglie wavelength of matter and wave packet description of particles, Bohr model of hydrogen. Schrodinger wave equation in one-dimension: energy quantization, potential barriers, simple harmonic oscillator, and one-electron atoms. X-ray and optical excitation of multielectron atoms. Molecular spectra. S
Pre: PHYS 212 or 222 and MATH 122

536 (3) Modern Physics II
Topics include the nuclear force, interactions of nuclear particles with matter, radioactive decay, nuclear structure, nuclear reactions, fusion, fission, elementary particles, and the quark model. F
Pre: PHYS 435/535

541 (4) Mechanics
Rectilinear motion of a particle, general motion of a particle in three dimensions, Newtonian mechanics including harmonic oscillations, forced oscillations, central forces and orbital motion, collisions, noninertial reference systems, dynamics of a system particles, rigid body motion, Lagrangian and Hamiltonian mechanics, normal coordinates. F
Pre: PHYS 212 or 222 and MATH 223 and 321

547 (3) Electricity and Magnetism I
Electrostatic fields, magnetostatic fields, steady

currents, electromagnetic induction. Review of vector algebra. F
Pre: PHYS 212 or 222 and MATH 223, 321, or 422

548 (3) Electricity and Magnetism II
Electromagnetic waves, propagation and radiation of waves, and electrodynamics and relativity. S
Pre: PHYS 447 or 547

553 (3) Solid State Physics
Atoms in crystals, wave in crystals, thermal vibrations of the crystal lattice, free electron model, band theory of solids, semiconductors and PN junctions, magnetism, and superconductivity.
S (of odd calendar years)
Pre: PHYS 212 or 222 and MATH 122

557 (3) Optics
Geometric optics, wave optics, properties of light and matter, optics of transformations, and quantum optics.
S (of odd calendar years)
Pre: PHYS 222 and MATH 122

561 (4) Quantum Mechanics
A systematic development of foundations of quantum mechanics. Observables, operators, state functions, expectation values. Matrix formulation of eigenvalue problems. The hydrogen atom, electron spin, angular momentum, and perturbation theory. F
Pre: PHYS 435/535, 441/541, and MATH 321

565 (3) Computer Applications in Physics
Numerical solutions of physics problems and computer simulations of physical systems. Interfacing computers with scientific equipment for experiment control, data acquisition, and data analysis. F
Pre: PHYS 212 or 222 and familiarity with some programming language, or Con

567 (4) Semiconductor Device Physics
Introduction to theory and techniques of integrated circuit fabrication processes. Oxidation, photolithography, etching, diffusion of impurities, ion implantation, epitaxy, metallization, material characterization techniques, and VLSI process integration, their design and simulation by SUPREM. Same as EE 575. F
Pre: PHYS 435/535 and 453/553

568 (1) Semiconductor Device Physics Laboratory
Introduction to integrated circuit fabrication processes, device layout, mask design, and experiments related to wafer cleaning, etching, thermal oxidation, thermal diffusion, photolithography, and metallization. Fabrication of basic integrated circuit elements: pn-junctions, resistors, MOS capacitors, simulation or the fabrication process by SUPREM. Same as EE 480. F
Pre: PHYS 467/567

573 (3) Statistical Physics
Statistical mechanics, kinetic theory, thermodynamics.
S (of even calender years)
Pre: PHYS 212 or 222 and MATH 223 and 321

575 (2) Advanced Laboratory
Experiments in modern physics, including solid-state physics and optics. Requires more independent work than introductory laboratories. S
Pre: PHYS 436 or 536 or Con

580 (2) Laboratory Experiences in Physical Science
For prospective teachers in elementary schools. Topics include weather, weather forecasting and record keeping, simple machines, electricity, chemistry, sound, light, and others. May not count as a physics elective. Not available for P/N grading. F,S,SS
Pre: PHYS 101

582 (4) Teaching Methods and Materials in Physical Science
Current methods of teaching all physical sciences with emphasis on physics and chemistry. For students planning to teach at a middle school, secondary school, college, or university. May not count as a physics elective. S
Pre: C&I 447, one year of Chemistry and one year of physics or con.

584 (2) Middle/Junior High Science Teaching
Current methods of teaching all sciences with emphasis on physical science, physics, chemistry, and earth science. S

Pre: Majority of required courses completed, or Con

590 (2-4) Workshop
A short course devoted to a specific topic in physics. May be repeated for credit on each new topic. V

591 (1-8) In-service
A course designed to upgrade the qualifications of a person on-the-job. V

595 (1-3) Selected Topics
A course in an area of physics not regularly offered. Topic and credit assigned by department each time offered. V

607 (2) Introduction to Research
Use of the library, electronic and machine shop practices, vacuum and cryogenic techniques, research interests of faculty. F

641 (4) Mathematical Physics I
Vector and tensor analysis; coordinate systems; determinants, matrices, and group theory; infinite series; functions of a complex variable. F

642 (4) Mathematical Physics II
Differential equations; Sturm-Liouville theory; Bessel, Legendre, and other special functions; Fourier series; integral transforms; integral equations; calculus of variations. S
Pre: PHYS 641

675 (1-4) Selected Topics
A course in an area of physics not regularly offered. Topic and credit assigned by department each time

offered. V

677 (1-4) Individual Study
Special arrangements must be made with an appropriate faculty member or the department office. May be repeated for credit on each new topic. V

680 (1) Curriculum Study in Physics
Presentation and discussion of curricular developments. V

681 (2) Demonstration in Physics
Materials, techniques, and procedures. V

691 (1-4) In-Service
A course designed to upgrade the qualifications of persons on-the-job. V

692 (1-2) Seminar
May be repeated for credit on each new topic. V

694 (1-2) Alternate Plan Paper V

695 (1-6) Research V

696 (1-2) Independent Reading
Special arrangements must be made with an appropriate faculty member or the department office. May be repeated for credit on each new topic. V

698 (1-8) Internship
Provides student the opportunity to gain expertise and experience in a special field under the supervision of a qualified person. V

699 (1-6) Thesis V

Astronomy

520 (3) Stellar Astrophysics
Blackbody radiation, radiative transfer, atomic structure, spectroscopic notation, excitation, ionization, absorption and emission coefficients, line profiles, analysis of stellar spectra. Alt F
Pre: AST 225 and PHYS 222

521 (3) Stellar Structure
The gaseous state, degenerate matter, equations of stellar structure, polytropes, models of stellar interiors and atmospheres, stellar evolution, nucleosynthesis, stellar endpoints. Alt S
Pre: AST 520

530 (3) Galactic Structure
Structure, kinematics, and dynamics of our galaxy.
Pre: AST 225, PHYS 222, MATH 223, and COMS 272

540 (5) Relativistic and Nonthermal Astrophysics
Radio, infrared, ultraviolet, x-ray, and gamma-ray astronomy. Nonthermal radiation mechanisms. Special and general relativity. White dwarfs, neutron stars, and black holes. Active galactic nuclei, accretion disks, and quasars. Cosmology. Alt S
Pre: AST 225, MATH 223, PHYS 222 and COMS 272

591 (1-6) In-Service
A course designed to upgrade the qualifications of persons on-the-job. V

594 (1-6) Workshop
A short course devoted to a specific astronomical topic. May be repeated for credit on each new topic. V

595 (1-4) Selected Topics
A course in a particular area of astronomy not regularly offered. May be repeated for credit on each new topic. V
Pre: Consent

677 (1-6) Individual Study
Special arrangements must be made with an appropriate faculty member or the departmental office. May be repeated for credit on each new topic.
Pre: Consent

691 (1-6) In-Service
A course designed to upgrade the qualifications of persons on-the-job. V
Pre: Consent

694 (1-2) Alternate Plan Paper
Pre: Consent V

POLITICAL SCIENCE MA

PUBLIC ADMINISTRATION MA

PUBLIC ADMINISTRATION/ URBAN & REGIONAL STUDIES (JOINT) MA

College of Social and Behavioral Sciences
Political Science Department
109 Morris Hall • 507-389-2721

Chair: Doran Hunter, Ph.D.
Graduate Coordinator: John Parham, Ph.D.

Abdalla Battah, Ph.D., Sue Burum, J.D., Carl Ellstrom Ph.D., Tom Inglot, Ph.D., Joe Kunkel, Ph.D., Ph.D., Mark Robbins, Ph.D., Carolyn Shrewsbury, Ph.D., Jackie Vieceli, Ph.D.

Political Science, with its well-balanced curriculum and diverse and experienced faculty, offers two graduate programs for students pursuing academic and professional interests dealing with public policy questions and issues. The Political Science Department offers Master of Arts and Master of Arts in Public Administration degrees. The Political Science Department also collaborates with the Institute of Urban and Regional Studies to offer the Joint Program in Public Administration and Urban Studies.

Graduates of these programs are successfully pursuing a variety of challenging careers. Many occupy important positions with federal, state or local units of government. Others who have gone on to receive doctorates