APPLIED PHYSICS M.S.

Degree: Master of Science
https://www.towson.edu/fcsm/departments/physics/grad/applied/

Program Director: Dr. Rajeswari Kolagani
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Towson University’s Master of Science in Applied Physics is designed to prepare its graduates for leadership positions in a wide range of science and technology careers in industry and academia. The program has components designed for students who intend to embark on a career immediately upon graduation, as well as for those who are seeking to enhance their prospects for admission to doctoral programs. The program is certified by the Council of Graduate Schools as a Professional Science Master's program (PSM), a graduate degree that represents an innovation in response to the workforce needs in science and technology sectors. The program delivers a strong graduate education in applied physics, together with skills related to project management, teamwork, advanced communication and interdisciplinary problem solving. Additionally, thesis and non-thesis research courses are available for students who plan to pursue a doctoral program.

The physics content of the program aims to impart specialized knowledge in select areas of applied physics, while also emphasizing a broad set of skills which include laboratory techniques involving fabrication and characterization of materials and devices, physical measurements employing advanced instrumentation, computational modeling and simulations, data analysis and laboratory automation. The program imparts knowledge and skills associated with teamwork, project management, communication and leadership through courses in project management and technical writing. In addition, there are internship and research components that allow students to acquire real-life problem-solving experience by working on site at technology enterprises or by participating in faculty-led research projects in applied physics.

Accelerated Bachelor’s-Master’s Program

Students may also earn an M.S. in Applied Physics through the Department of Physics accelerated bachelor’s and master’s program. Qualifying undergraduate students are screened into the accelerated BS-MS program in their junior or senior year. The accelerated program allows students to complete the master’s degree in a shorter time frame by taking up to 9 units of graduate level courses as undergraduates, with these courses satisfying both the undergraduate and master’s degree curriculum requirements. Prospective applicants should contact the program director for details.

Please see the Undergraduate Catalog for information on the accelerated bachelor’s-master’s program.

Admission Requirements

This program admits fall and spring terms only.

- A baccalaureate degree in physics or a related field such as chemistry, mathematics or engineering from a regionally accredited college or university.* Students who have not majored in physics will qualify for admission if their undergraduate education included two calculus-based courses in physics and at least two upper-level physics courses. Students without a degree in physics and/or adequate preparation may be required to take remedial courses and/or additional 500-level electives from the curriculum, based on a case-by-case analysis.
- An undergraduate GPA of at least 3.00 is required for full admission and at least 2.75 for provisional admission.

Non-immigrant International Students

Program Enrollment: F-1 and J-1 students are required to be enrolled full-time. The majority of their classes must be in-person and on campus. See the list of programs that satisfy these requirements, and contact the International Student and Scholars Office with questions.

Admission Procedures: See additional information regarding Graduate Admission policies and International Graduate Application online.

*See Exceptions to Policy in Graduate Admissions.

Application Requirements

Required documents for application:

- A résumé including names and contact information for three references;
- official transcripts;
- one recommendation on the Official Recommendation Form;
- and a brief statement of purpose indicating academic and professional objectives.

Degree Requirements

The degree will require completion of a minimum of 37 total units of course work. Students with inadequate undergraduate preparation in physics may be required to take more than 37 units due to additional courses that may be needed to remedy deficiencies in undergraduate course work. 19 of the 37 units of course work will consist of the physics content courses, split between 10 units of core courses from Group A and 9 units of electives from Group B. Another 9 units are assigned for courses in Group C which belong to the ‘plus’ category. The remaining 9 units are distributed among the Group D courses that comprise 3 units of research with faculty and 6 units for thesis and/or internship.

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<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>PHYS 685</td>
<td>PROFESSIONAL SCIENCE MASTERS SEMINAR</td>
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<td>Select 9 units from the list below.</td>
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<tr>
<td>ASTR 503</td>
<td>ASTROPHYSICAL TECHNIQUES</td>
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<td>PHYS 555</td>
<td>INTRODUCTORY QUANTUM MECHANICS</td>
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<td>PHYS 557</td>
<td>SOLID STATE PHYSICS</td>
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<tr>
<td>PHYS 641</td>
<td>LABORATORY TECHNIQUES AND INSTRUMENTATION</td>
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<tr>
<td>PHYS 670</td>
<td>COMPUTATIONAL PHYSICS</td>
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Group B: Electives

A minimum of 9 units are required, of which at least 6 units must be from 600-level courses.

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<tbody>
<tr>
<td>PHYS 512</td>
<td>MODERN PHYSICS II</td>
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<td>PHYS 533</td>
<td>BASIC ELECTRONICS</td>
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<td>PHYS 534</td>
<td>DIGITAL ELECTRONICS</td>
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<td>PHYS 550</td>
<td>MECHANICS</td>
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Thesis Description of thesis and/or non-thesis options with industry or other technology workplaces. be chosen to allow the student to be involved in faculty collaborations actively and function as a team. Whenever possible, research topics will research will be structured so that students will need to collaborate thesis research with the faculty mentor in lieu of the internship. Thesis whenever possible, although this cannot always be guaranteed. will make all attempts to help student placement in paid internships place for a total minimum duration of 300 hours. The program faculty component will require the students to work on site at a potential work place. Students will undertake a 3-unit research course with a faculty mentor, graduate programs

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<thead>
<tr>
<th>Group C: 'Plus' Courses</th>
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<tbody>
<tr>
<td>EBTM 604 INTRODUCTION TO PROJECT MANAGEMENT</td>
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<tr>
<td>EBTM 625 PROJECT LEADERSHIP AND COMMUNICATION</td>
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<tr>
<td>EBTM 750 PROGRAM AND PORTFOLIO MANAGEMENT</td>
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<tr>
<td>ENCE 662 Introduction to Project Management ¹</td>
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<td>ENCE 688 Global Project Management ¹</td>
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<td>ENCE 665 Management of Project Teams ¹</td>
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<tr>
<td>PRWR 621 BUSINESS WRITING</td>
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<td>PRWR 623 TECHNICAL WRITING AND INFORMATION DESIGN</td>
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<tr>
<th>Group D: Thesis/Internship</th>
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<tr>
<td>PHYS 795 APPLIED PHYSICS RESEARCH</td>
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<td>PHYS 799 PHYSICS MASTERS INTERNSHIP</td>
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<td>PHYS 897 PHYSICS THESIS</td>
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<td>PHYS 898 PHYSICS THESIS</td>
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| Total Units | 37 |

¹ These courses are offered online by the Department of Project Management at the Clark School of Engineering, University of Maryland, and are available to students enrolled in this program.

**Description of thesis and/or non-thesis option for graduate programs**

Students will undertake a 3-unit research course with a faculty mentor, followed by 6 units of internship at an employer facility. The internship component will require the students to work on site at a potential work place for a total minimum duration of 300 hours. The program faculty will make all attempts to help student placement in paid internships whenever possible, although this cannot always be guaranteed. Alternatively, students will have the option to take 6 units of continued thesis research with the faculty mentor in lieu of the internship. Thesis research will be structured so that students will need to collaborate actively and function as a team. Whenever possible, research topics will be chosen to allow the student to be involved in faculty collaborations with industry or other technology workplaces.

**Description of thesis and/or non-thesis options**

**Thesis**

Subsequent to successful completion of a 3 unit research course, students will successfully complete 6 units of thesis research under the supervision of a faculty member who will serve as the chair of the master’s thesis committee.

**Research Practicum**

Subsequent to successful completion of a 3 units research course, students will enroll in 6 units of research practicum which involves successful completion of a research project under the supervision of a faculty member.

**Internship**

Students will successfully complete 6 units of internship at an employer facility. The internship component will require the students to work on site at a potential work place for a total minimum duration of 300 hours. Students are expected to take the initiative in proactively seeking internship opportunities, utilizing available resources. The program faculty will assist students in finding internships whenever possible.

1. Demonstrate content knowledge in areas of applied physics that are relevant to the current scientific and technology enterprises.
2. Demonstrate knowledge and skills for the measurement and control of physical variables as well as transduction of changes in these variables through physical phenomena.
3. Demonstrate knowledge of using and/or developing computer models and simulations of physical phenomena and processes; acquire and analyze data from experiments.
4. Acquire advanced skills related to scientific and technical communication and presentation in a variety of formats including seminars, project proposals, instruction documents etc. Design and deliver oral and written presentations employing scientific and professional formats such as technical seminars, project proposals and instructional documents using appropriate advanced technology and communication modes.

**Astrophysics Courses**

**ASTR 503 ASTROPHYSICAL TECHNIQUES (3)**
Observational astronomy using the department's telescope and NASA archival data, emphasizing equipment operating principles, scientific methods, signal statistics, data reduction. Includes imaging and photometry with Charge-Coupled Devices in addition to spectroscopy, space observations, radio astronomy. Prerequisites: ASTR 161 and ASTR 162; and PHYS 212 (or PHYS 242 or PHYS 252).

**Physics Courses**

**PHYS 507 INTRO MATH PHYS (3)**
As the mathematical maturity of the students will allow, selected topics will be examined such as the generalized expressions for forces and potentials, vector analysis, applications of Fourier series and complex variables, and solutions of the harmonic oscillator and wave equations. Three lecture hours. Prerequisites: PHYS 212 or PHYS 242; MATH 274.

**PHYS 511 MODERN PHYSICS (3)**
Special relativity, the quantum theory, atomic structure and spectra, and nuclear structure and reactions are the main topics covered by the course. Other topics that may be covered involve molecular, solid state, and high energy physics. Four lecture hours. Prerequisites: MATH 274; PHYS 212 or PHYS 242.
PHYS 512 MODERN PHYSICS II (3)
Co-listed with PHYS 312 which is a required course for the Applied and General tracks of the Physics major. Application of special Relativity and Quantum theory to the various disciplines in physics including solid state physics, nuclear physics, elementary particles and cosmology. Students taking this course for graduate credits will be expected to attend special lectures and seminars, undertake guided in-depth study of selected topics and complete additional assignments which may include presentations and term papers. Prerequisite: PHYS 311 or consent of instructor.

PHYS 533 BASIC ELECTRONICS (4)
Circuit components, characteristics of semiconductors, electrical measurements, method of circuit analysis, electronic devices. Three lecture hours and one three-hour laboratory. Prerequisite: PHYS 212 or PHYS 222 or consent of instructor.

PHYS 534 DIGITAL ELECTRONICS (4)
Subjects covered will be basic concepts of digital electronics such as: gates, logic modules, truth tables, digital codes, sequential systems, semiconductor memories, decade counters, etc. The laboratory program is designed to give students firsthand experience on the material covered in lecture using integrated circuits and LED display systems. Two hours lecture and three hours laboratory. Prerequisite: MATH 115 or equivalent.

PHYS 535 ELECTRONICS (3)
Principles of transistors with emphasis on their design and construction and an introduction to logic circuits. Two lecture hours and one two-hour laboratory. Prerequisites: PHYS 305 and PHYS 335.

PHYS 537 INTRODUCTION TO MICROPROCESSOR BASED DIGITAL SYSTEMS (3)
Introductory course on basic microcomputer concepts. Topics covered include basic structure and organization of microcomputers, digital logic design, assembly language programming, memory elements and applications. Hardware-oriented experiments will be conducted providing practical experience in interfacing the microcomputer to a variety of instruments and input-output devices. Two hours lecture and two hours laboratory. Prerequisite: PHYS 337.

PHYS 541 INTERMEDIATE PHYSICS LABORATORY I (3)
First semester: the measurement of several fundamental physical constants. Exploration of classical and modern research methods: lasers, holography, optical and nuclear spectroscopy. Second semester: several advanced experiments and a research project. Familiarization with machine shop procedure, vacuum and other experimental techniques. Five laboratory hours. Prerequisite: PHYS 311 (may be taken concurrently).

PHYS 542 INTERMEDIATE PHYSICS LABORATORY II (3)
First semester: the measurement of several fundamental physical constants. Exploration of classical and modern research methods: lasers, holography, optical and nuclear spectroscopy. Second semester: several advanced experiments and a research project. Familiarization with machine shop procedure, vacuum and other experimental techniques. Five laboratory hours. Prerequisite: PHYS 341.

PHYS 550 MECHANICS (4)
Systems of coordinates, kinematics and transformations; newtonian dynamics of particles; linear systems, oscillations and series techniques; calculus of variations and the Lagrangian and Hamiltonian formulations; application of Lagrangians to gravitation/central force motion. Optional; nonlinear oscillations. Prerequisite: PHYS 242, PHYS 307 or consent of instructor.

PHYS 551 MECHANICS II (3)
Continuation of PHYS 351. Rotation transformations; perturbation and Green's function techniques in solution of oscillating systems; collisions; rotating frames of reference and dynamics of rigid bodies (including Euler's angles, precession, notation); theory of coupled small oscillations. Optional; special relativity; continuum mechanics. Prerequisite: PHYS 351.

PHYS 552 THERMODYNAMICS AND KINETIC THEORY (3)
Principles and laws of classical thermodynamics applied to simple irreversible processes, including chemical, elastic, electric and magnetic phenomena; thermodynamic functions and Maxwell's relations; the conservation equations in elementary kinetic theory, fluctuations and irreversible transfer effects. Three lecture hours. Prerequisites: PHYS 212 or PHYS 243, MATH 274 (may be taken concurrently with PHYS 243 or by permission).

PHYS 553 PHYSICAL OPTICS (3)
Electromagnetic theory of light, wave solutions, interference, diffraction, scattering, radiation from coherent and incoherent sources, elementary theory of masers and lasers. Three lecture hours. Prerequisite: PHYS 354 or consent of instructor.

PHYS 554 ELECTRICITY AND MAGNETISM (4)
Electrostatics, magnetostatics and electromagnetic radiation, including Divergence Theorem and Stoke's Theorem, electrostatics in free space and dielectric materials, the Biot-Savart Law, the magnetic vector potential, inductance and electromotance, magnetic materials, Maxwell's equations in free space and in materials, boundary value problems (Snell's and Fresnel's Laws). Prerequisite: PHYS 243, PHYS 307 or consent of instructor.

PHYS 555 INTRODUCTORY QUANTUM MECHANICS (3)
The Schroedinger equation, states of one particle in one dimension, potential barrier problems in one dimension, the harmonic oscillator, system of particles in one dimension, motion in three dimensions, angular momentum, spin, application to atomic physics. Prerequisites: PHYS 311, PHYS 351 (may be taken concurrently).

PHYS 556 INTRODUCTION TO STATISTICAL MECHANICS (3)
Distribution functions, microcanonical, canonical and grand canonical ensembles, the partition function and thermodynamics relations. Fermi-Dirac and Bose-Einstein statistics, some simple models and applications, the Maxwell-Boltzman transport equation and the hydrodynamic equation, transport coefficients. Three lecture hours. Prerequisite: PHYS.

PHYS 557 SOLID STATE PHYSICS (3)
Crystal structure, wave propagation in periodic structures, the Fermi gas, energy bands, magnetism are present as a central theoretical core for the study of the solid state. Some of the basic models, concepts and manifest properties of solids are also included. Prerequisites: PHYS 311, PHYS 351, and PHYS 354.

PHYS 559 NUCLEAR PHYSICS (3)
A lecture and problem course dealing on an introductory level concerning experimental and theoretical method for the study of nuclear structure. Topics to be covered include: properties of nuclei, electromagnetic transition and beta decay; nuclear models, nuclear reactions and two-body interactions.
PHYS 561 OPTICS FUNDAMENTALS (4)
Develops the fundamental concepts relating to geometric optics, wave optics, and quantum optics and provides exposition to selected advanced topics emphasizing practical applications of optical techniques, measurements, design, and instrumentation. Instructional topics include lenses and mirrors, lens aberrations and design, optical instruments, interference, diffraction, polarization, absorption and scattering, lasers, holography and the dual nature of light. Prerequisites: PHYS 243 and PHYS 341 or consent of the instructor.

PHYS 570 SPECIAL TOPICS IN PHYSICS (1-4)
Special topics in the area of physics. Special topics will be determined by current interests of the faculty and the needs of the curriculum. Prerequisite: department consent.

PHYS 571 SPECIAL TOPICS IN PHYSICS (1-4)
Special topics in the area of physics. Special topics will be determined by current interests of the faculty and the needs of the curriculum. Prerequisite: department consent is required.

PHYS 585 PHYS SEMINAR I (1)
Students participate in colloquia on topics of current interest in physics research under guidance instructor. One lecture hour. Prerequisite: Senior standing or consent of instructor.

PHYS 586 PHYS SEMINAR II (1)
Students participate in colloquia on topics of current interest in physics research under guidance instructor. One lecture hour. Prerequisite: Senior standing or consent of instructor.

PHYS 590 INDEPENDENT STUDY IN PHYSICS (1-4)
Prerequisites: At least junior status and one course in the physics department; may be repeated for a maximum of 6 credits.

PHYS 591 DIRECTED READINGS (1-4)
Prerequisite: At least junior status and one course in the physics department; may be repeated for a maximum of 6 credits.

PHYS 595 RESEARCH PROBLEMS IN PHYSICS (1-3)
Individual project in any branch of physics. Students can choose either to work on projects or in areas suggested by physics faculty. At the completion of a project, the student must write a formal research paper on the work done. Students may register for this more than once but at different levels. Prerequisite: Permission of the instructor who will direct the proposed work.

PHYS 596 RESEARCH PROBLEMS IN PHYSICS (1-3)
Individual project in any branch of physics. Students can choose either to work on projects or in areas suggested by physics faculty. At the completion of a project, the student must write a formal research paper on the work done. Students may register for this more than once but at different levels. Prerequisite: Permission of the instructor who will direct the proposed work.

PHYS 641 LABORATORY TECHNIQUES AND INSTRUMENTATION (3)
An introduction to experimental methods of fabrication and characterization of advanced materials and devices including analytical techniques and instrumentation employed in applied research and in industry; computer-based data acquisition and experimental control, materials fabrication and characterization, cryogenic and vacuum techniques.

PHYS 658 MAGNETISM AND MAGNETIC MATERIALS (3)
Fundamental principles of magnetism as well as techniques and applications based on these principles. Isolated magnetic moments, exchange interaction, magnetic ordering and magnetic structures, magnetic resonance techniques, phase transitions, magnetic excitations, magnetoresistance, spin electronics.

PHYS 662 SPECTROSCOPIC AND MICROSCOPIC TECHNIQUES (3)
An introduction to modern spectroscopic and microscopic techniques employed in the measurement of novel nanoscale and condensed matter materials. Techniques include absorption, Fourier-transform, Raman, and fluorescence spectroscopies; near-field microscopies; atomic force microscopies; scanning tunneling and transmission electron microscopies/spectroscopies. Three lecture hours.

PHYS 663 FUNCTIONAL ELECTRONIC MATERIALS (3)
This course provides advanced, state of the art knowledge of functional electronic materials employed in current and emerging technologies, including metals, dielectrics, semiconductors, superconductors and magnetic materials. Topics of emphasis will include electronic phenomena that underlie technological applications, structure property correlations and opportunities and challenges associated with engineering the material properties in thin film/nanoscale structures for device applications.

PHYS 664 NANOTECHNOLOGY (3)
An introduction to structures and processes which occur at the nanometer length scale. Topics include properties of nanostructures, nanofabrication, and nanomechanics.

PHYS 670 COMPUTATIONAL PHYSICS (3)
The use of computational techniques in the study of applied physics. The emphasis is on the modeling and analysis of physical systems as applied to physics and astronomy, and on the analysis of experimental data. Topics covered include error analysis, analysis of oscillatory and periodic motions, waveforms, advanced curve fitting techniques, spectral analysis, systems of equations, diffusion equation, Schrodinger Equation, finite element analysis, molecular dynamics simulation, Metropolis algorithm and Monte Carlo simulations. Two hours lecture and one hour laboratory.

PHYS 680 SPECIAL TOPICS IN PHYSICS (1-4)
Special topics in the area of physics. Special topics will be determined by current interests of the faculty and the needs of the curriculum. May be repeated for a maximum of 9 units. Prerequisite: department consent.

PHYS 685 PROFESSIONAL SCIENCE MASTERS SEMINAR (1)
Guest speakers from industry, government agencies, national laboratories and non-profit organizations will share various aspects of their professional environments. The seminar course will offer students opportunities to network with potential employers and also serve as a forum for sharing internship projects and experience with faculty and peers. Course is S/U grading.

PHYS 690 INDEPENDENT STUDY (3)
Independent study of a topic in one of the sub-disciplines of physics. The study will be commensurate with the breadth and depth expected at the Master’s level. Prerequisite: consent of department.
**PHYS 795 APPLIED PHYSICS RESEARCH (3)**
Students will undertake research in applied physics under the guidance of a faculty member on research topics that have a strong relevance to technological application in the work place. Whenever possible, these topics have a strong relevance to technological application in the work place. Whenever possible, these topics will be chosen to allow the student to be involved in faculty collaborations with industry or other technology work places. May be repeated for a maximum of 9 units.

**PHYS 799 PHYSICS MASTERS INTERNSHIP (1-6)**
Students will gain practical experience by working onsite at an industry, government or nonprofit agency organization in an internship position for a total minimum duration of 450 hours. May be repeated for a maximum of 12 units. S/U grading.

**PHYS 896 MASTER’S RESEARCH PRACTICUM (1-6)**
Students will carry out a research project in physics, astronomy or an interdisciplinary area related to these disciplines, under the supervision of a faculty member. Requirements for successful completion of the course consist of one or more of the following: (i) an oral or poster presentation at a conference (ii) a departmental seminar on the project (iii) a project report. Graded S/U. Prerequisite: PHYS 795.

**PHYS 897 PHYSICS THESIS (6)**
Students will undertake research in applied physics towards a masters thesis under the guidance of a faculty member. Thesis research will be structured so that student will need to collaborate actively and function as a team. Research topics will be chosen that have a strong relevance to technological application in the work place. Whenever possible, these topics will be chosen to allow the student to be involved in faculty collaborations with industry or other technology work places. Prerequisite: PHYS 795.

**PHYS 898 PHYSICS THESIS (3)**
Students will undertake research in applied physics towards a masters thesis under the guidance of a faculty member. Thesis research will be structured so that student will need to collaborate actively and function as a team. Research topics will be chosen that have a strong relevance to technological application in the work place. Whenever possible, these topics will be chosen to allow the student to be involved in faculty collaborations with industry or other technology work places. Taken over two semesters for a total of 6 units. Prerequisite: PHYS 795.

**PHYS 899 THESIS CONTINUUM (1)**
Continuation of thesis research.