M.S. in Applied Physics and Computer Science

The Master of Science in Applied Physics and Computer Science addresses the need for graduate education in applied physics and computer science. This degree is for both part-time and full-time graduate students who desire excellence in instruction, state of the art equipment and software, and a faculty with an intense involvement in the application of physics and computers to solve exciting and significant problems.

The department has amassed a strong record of research and publications in six areas: solid state (lasers, semiconductors and superconductors), nuclear physics, dynamical systems, artificial intelligence, instrumentation and advanced computer systems and new computer-based technologies for primary and secondary education. Much of this research has resulted in significant scientific collaborations with the two national laboratories here, the NASA Langley Research Center and the Thomas Jefferson National Accelerator Facility.

The department has five major teaching-research labs: the Hunter Creech Computer Lab, the Superconductivity and Data Acquisition Lab, the Photonics and Laser Lab, the Digital Systems Lab and the Information Science Lab. In addition, it has two general-purpose laboratories and a large common area for student-faculty collaborations and study.

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Master of Science in Applied Physics and Computer Science

The Master of Science in Applied Physics and Computer Science is built around a core of physics and computer science courses that are the foundation of the three areas of concentration: computer science, computer systems engineering and instrumentation, and applied physics. Students may elect a thesis option or a non-thesis option.

The CNU master's program offers students with a bachelor's degree a significant step in their maturing as scientists. The department offers many opportunities to its graduate students because of its location in the heart of high-tech Hampton Roads and its ties with area national labs and newly developing companies. They include:

- Participation in funded research at both the Thomas Jefferson National Accelerator Facility and the NASA Langley Research Center—each within a 15-minute drive of the campus.
- Research in solid state materials, digital signal processing, high speed data acquisition, artificial intelligence, the design of smart sensors, application-specific integrated circuits, modeling and simulation and pattern recognition.
- Solving the problems of industry at the Applied Research Center (ARC)—a new state-of-the-art research consortium for four area universities.
- Working in well-equipped laboratories both on campus and at the ARC.
- Creating papers and presentations for national conferences and publications.
- Team-based learning in small classes taught at the cutting edge of their disciplines.

Five-Year Combined B.S./M.S. Programs

The department also has programs leading to a B.S. and M.S. in Applied Physics and Computer Science after five years of study. For undergraduate students putting in an extra year to obtain the M.S., lifetime earnings and the potential for increased opportunities and job satisfaction can increase significantly. These programs are very flexible and students will still receive the B.S. in their degree program once they complete the requirements, even if they don't complete the M.S. program. Interested students should talk to their advisor early in their program since course sequencing is critical to success. To formally enroll in the program requires a GPA of 3.0 or better. Application to these programs should be made by February 1st of the junior year. The ***Application for Admission to 5 Year Graduate Study Program*** is distributed by the Graduate Program Coordinator. Detailed information on Admission and Program Requirements is found on pages 90-91 in this catalog, and is also available in the Physics, Computer Science & Engineering departmental office and online at ***www.pcs.cnu.edu*****.**

Admission Requirements for Degree-Seeking Students

1. A baccalaureate degree from a regionally accredited college or university with a minimum grade point average of 3.00 on a 4.00 scale.
2. An official transcript from the baccalaureate institution and official transcripts for all graduate work taken at other institutions.
3. Three letters of recommendation from people who can attest that the applicant is likely to be able to be successful in graduate level academic work. All recommendations must arrive in unopened envelopes with the reference's signature across the envelope flap.
4. Scores from the Graduate Record Examination (GRE) General Test taken within five years prior to the date of admission. A GRE score of at least 950 for Verbal and Quantitative sections combined is required and a score at or above 1000 is highly desirable. GRE scores are used as one of several indicators of the applicant's ability to succeed in graduate studies. For those applicants already holding a master's degree, the GRE may be waived by permission of the Director of Graduate Studies. A letter to the Director of Graduate Studies requesting a waiver is required.
5. International applicants must supply their TOEFL scores and the documentation as stated on page 101 of this catalog.

The Master of Science in Applied Physics and Computer Science is designed to serve students with a baccalaureate degree in applied physics, computer science, electrical and/or computer engineering or mathematics. Students with degrees in other areas are encouraged to apply. Departmental graduate advisors will establish the background courses needed for such students. This program is also designed to serve students who want advanced study in the electronic or optical properties of materials, computer science, computer systems engineering, or computer controlled instrumentation.

Applicants who have completed interesting research or design projects as undergraduates or as a part of their work are invited to submit descriptions of such projects as support for their application.

Academic Policy for Non-Degree Students

Students seeking non-degree admission status must have a grade point average of at least 3.0 on a 4.0 scale. Non-degree students are limited to 12 hours of graduate study. Up to 12 credits of graduate study may be applied to the graduate degree should a non-degree student apply and be accepted to degree-seeking status. Should a non-degree student desire additional courses beyond the 12-credit limit, he or she may petition the Graduate Program Coordinator for a waiver of this limit. Before enrolling in any graduate course a non-degree student must obtain consent of the instructor. The instructor will determine whether the student has the academic background prerequisites for the specific course.

Academic Prerequisites

See each concentration for the specific requirements. An accelerated schedule of undergraduate prerequisites can be arranged for applicants whose qualifications do not entirely satisfy the prerequisites for graduate study. Good computer programming skills are critical to a student's success in many of the courses, especially those courses with the CPSC prefix.

Goals of the Program

The program's overall goal is to provide its graduates with the scientific background and technical tools to:

1. Advance an experimental technique, extend the application of a theory or produce new data or observations.
2. Design, build and evaluate a system of measurement, instrumentation, computers and/or software.
3. Present logically and clearly the results of their own scientific investigation.
4. Understand and critically evaluate other scientists' work.

Curriculum

The student chooses either the 30-hour program which requires four core courses, plus four concentration courses and a thesis that includes a design course **or** the 36-hour program which requires four core courses, four concentration courses and four electives.

The special feature of the coursework in the master's degree program is its emphasis on applications, laboratory experience and extensive use of computer software and hardware. All of the courses make extensive use of computers or require significant laboratory experimentation. The thesis preparation seminars for the concentrations, Computer Systems Design (CPSC 619), Instrumentation Systems Design (PHYS 629), Design of Solid State Systems and Sensors (PHYS 639) or Design of Integrated Modeling and Simulation Environments (PHYS 649), tie these elements securely together and are an integral part of the thesis.

A formal plan of graduate study is prepared with the student's advisor. The general requirements listed below are guides and serve as models for students' planning for each of the concentrations.

Thesis Proposal/Comprehensive Oral Examination (Thesis Option)

The culminating requirement for the design course is completion of the thesis proposal. Students not completing the thesis proposal by the end of the design course will receive a grade of ***U***. **Students will have two chances to pass the thesis proposal.** If the student is not successful the second time, the student will receive a ***F*** for the design course and will be suspended from the graduate program.

Comprehensive Examination (Non-Thesis Option)

A written comprehensive examination is required, covering the concentration courses. A student not passing the comprehensive examination may request a re-examination within six months of the failure. Only one additional examination is permitted after the failure of the original comprehensive examination.

Memorandum of Understanding

Christopher Newport University has a memorandum of understanding with Longwood College for a dual degree program leading to a B.S. in Physics from Longwood College and a M.S. in Applied Physics and Computer Science from CNU. For more information contact the Program Coordinator at (757-594-7065) or **dhibler@pcs.cnu.edu**.

Graduate Certificate Programs

In addition to the M.S. degree, the department offers three graduate certificate programs. A student can receive a certificate in networked systems, software development and design, or applied artificial intelligence. Each program consists of three courses. All courses are offered in the evening. For more information contact the Physics, Computer Science, and Engineering Department at 757-594-7065 or at **phone@pcs.cnu.edu**.

Graduation Requirements

Thesis Option

- Successful completion of 30 hours of the M.S. in Applied Physics and Computer Science degree program course work; those students in the 5 year program must earn a minimum of 21 hours while in graduate status;
- An overall graduate grade point average of 3.00 in all CNU courses submitted for graduate credit with no more than two grades of ***C;***
- Registration and timely petition for candidacy prior to the final semester;
- Successful completion of the thesis proposal/comprehensive oral examination;
- Successful defense of thesis and presentation of the appropriate number of approved copies to the Office of Graduate Studies by the published deadline;
- Presentation of an electronic copy of the thesis in a suitable format to the department for archive purposes only.

Non-Thesis Option

- Successful completion of 36 hours of the M.S. in Applied Physics and Computer Science degree program course work; those students in the 5 year program must earn a minimum of 27 hours while in graduate status;
- An overall graduate grade point average of 3.00 in all CNU courses submitted for graduate credit with no more than two grades of ***C;***
- Registration and timely petition for candidacy prior to the final semester;
- Successful completion of the comprehensive examination.

Graduate Assistantships

Screening of applicants wishing to be considered for graduate assistantships will begin on May 1 for the following fall semester. See page 128 of the catalog for specific terms, criteria and procedures. Applications are available on the department's web site: ***http://www.pcs.cnu.edu***

For further information:

Contact the APCS Graduate Program Coordinator at **(757) 594-7065 or dhibler@pcs.cnu.edu or** ***http://www.pcs.cnu.edu***

COMPUTER SCIENCE CONCENTRATION

Academic Prerequisites

All applicants should have completed a three-semester sequence in mathematics including at least two semesters of calculus and programming including data structures. It is assumed that these courses are at least at the level of the following texts: Anton, *Calculus*; Headington and Riley, *Data Abstraction and Structures Using C++*; Aho, Hopcroft and Ullman, *Data Structures*; Mano, *Computer Engineering*. Students who do not have all prerequisites may, in some cases, be allowed to take a graduate independent study course to develop the necessary background for further graduate work.

Computer Science Concentration
Program of Study 30-36 Credits

Core Courses (12 credits)

Select any four courses from the following list:

CPSC 501 Software System Design and Implementation (3)
CPSC 502 Communications I (Computer Networks) (3)
CPSC 510 Artificial Intelligence I (3)
CPSC 521 Computer Architecture (3)
CPSC 550 Distributed Operating Systems (3)

Concentration Courses (12 credits)

Select any four courses meeting the following requirements:

1. All courses must be from the M.S. in Applied Physics and Computer Science program.
2. At least two of the courses must be 600 level courses.
3. Completion of a second course in at least one of the following sequences.

Each sequence prepares a student for a possible thesis in a given area.

<u>Artificial Intelligence Emphasis</u>
CPSC 510 Artificial Intelligence I (3) (Core Course)
CPSC 642 Artificial Intelligence II (3)

<u>Communications Emphasis</u>
CPSC 502 Communications I (3) (Core Course)
CPSC 611 Communications II (3)

<u>Software Engineering Emphasis</u>
CPSC 501 Software System Design and Implementation (3) (Core Course)
CPSC 525 Object Oriented Programming and Design (3)

Design Course (Thesis Preparation) and Thesis (6 credits)

CPSC 619 Computer Systems Design (3)
Students in the design courses are required to attend all theses proposals and defenses that occur during the course.
PCSE 699 Thesis Research (3)
Can be taken only upon successful completion of CPSC 619 design course. Thesis may be taken in one-credit increments.

OR

Non-Thesis Option (12 credits)

12 credit hours of electives from the M.S. in Applied Physics and Computer program

Total **30 credits** (Thesis) **OR** **36 credits** (Non-Thesis)

COMPUTER SYSTEMS ENGINEERING AND INSTRUMENTATION CONCENTRATION

Academic Prerequisites

All applicants should have completed a two-semester sequence in physics, including mechanics and at least two labs; a five-semester sequence in mathematics including calculus, matrix methods, and differential equations; programming including data structures; a course in computer organization and architecture; and a course with a lab in circuit analysis. It is assumed that these courses are at least at the level of the following texts: Serway, *Classical and Modern Physics*; Anton, *Calculus*; Williams, *Linear Algebra with Applications*; Boyce and DiPrima, *Ordinary Differential Equations*; Headington and Riley, *Data Abstraction and Structures Using C++*; Aho, Hopcroft and Ullman, *Data Structures*; Mano, *Computer Engineering*; Hayt and Kemmerly, *Circuit Theory*.

Computer Systems Engineering and Instrumentation Concentration Program of Study 30-36 Credits

Core Courses (12 credits)

PHYS 521	Computer Architecture (3)
CPSC 501	Software System Design and Implementation (3)
CPSC 502	Communications I (Computer Networks) (3)
CPSC/PHYS	Any course listed in the Applied Physics core

Concentration Courses (12 credits)

Select any four courses from the following list: (at least two must be 600 level)

PHYS 503	Data Acquisition and Instrumentation (3)
PHYS 522	Microprocessor-based Systems (3)
PHYS 621	Digital Signal Processing (3)
CPSC 525	Object Oriented Programming and Design (3)
CPSC 550	Distributed Operating Systems (3)
CPSC 611	Communications II (3)
CPSC 621	Parallel Processing (3)

Design Course (Thesis Preparation) and Thesis (6 credits)

PHYS 629	Instrumentation Systems Design (3) **OR**
CPSC 619	Computer Systems Design (3) Students in the design courses are required to attend all theses proposals and defenses that occur during the course.
AND	
PCSE 699	Thesis Research (3) Can be taken only upon successful completion of PHYS 629 or CPSC 619 design course. Thesis may be taken in one-credit increments.

OR

Non-Thesis Option (12 credits)

12 credit hours of electives from the M.S. in Applied Physics and Computer program

Total **30 credits** (Thesis) **OR** **36 credits** (Non-thesis)

APPLIED PHYSICS CONCENTRATION

Special Features of the Concentration

The Applied Physics curriculum presents the foundation theories of the physical world: mechanics, electromagnetism, thermodynamics, quantum mechanics, optics, and solid state. Students use these models in two computational courses and in their theses where they construct simulations of physical systems, analyze physical systems or design smart sensors, and then display the results of these efforts by using state-of-the-art techniques in computer graphics. This emphasis on fundamental concepts and on computational techniques of modeling and simulation is complemented by the experimental procedures that undergird current practice in data acquisition. As a result, students experience the entire range of effective problem-solving practices: data acquisition and data storage, and data analysis based on the fundamental physical models and graphical display of the results of the analysis.

For students with special interests and with established backgrounds in physics or engineering, the curriculum offers a versatility that allows students, in concert with their faculty advisers, to tailor graduate programs to suit their own professional goals by combining CNU courses with the offerings at the Virginia Consortium of Engineering and Science Universities (VCES).

Academic Prerequisites

All applicants should have completed a three-semester sequence in physics including modern physics and at least two labs; a five-semester sequence in mathematics including calculus, matrix methods and differential equations; programming including data structures; and a course with a lab in circuit analysis. It is assumed that these courses are at least at the level of the following texts: Serway, *Classical and Modern Physics*; Anton, *Calculus*; Williams, *Linear Algebra with Applicatio*ns; Boyce and DiPrima, *Ordinary Differential Equations*; Headington and Riley, *Data Abstraction and Structures Using C++*; Aho, Hopcroft and Ullman, *Data Structures*; Hayt and Kemmerly, *Circuit Theory.*

Applied Physics Concentration
Program of Study 30-36 Credits

Core Courses (12 credits)

PHYS 501 Models of Dynamical Systems (3)
PHYS 503 Data Acquisition and Instrumentation (3)
PHYS 504 Electromagnetic Theory (3)
PHYS 541 Modeling and Simulation (3)

Concentration Courses (12 credits)

Select any four courses from the following list:

PHYS 502 Quantum Physics (3)
PHYS 506 Thermodynamics and Statistical Physics (3)
PHYS 531 Optical Physics (3)
PHYS 634 Solid State Materials and Devices (3)
MATH 580 Advanced Numerical Analysis (3)

Design Course (Thesis Preparation) and Thesis (6 credits)

PHYS 639 Design of Solid State Systems and Sensors (3) **OR**
PHYS 649 Design of Integrated Modeling and Simulation Environments (3)
Students in these courses are required to attend all theses proposals and defenses that occur during the course.

AND

PCSE 699 Thesis Research (3)
Can be taken only upon successful completion of PHYS 639 or PHYS 649 design course. Thesis may be taken in one-credit increments.

OR

Non-Thesis Option (12 credits)

12 credit hours of electives from the M.S. in Applied Physics and Computer program

Total **30 credits** (Thesis) **OR** **36 credits** (Non-thesis)

Five-Year BS/MS Program in Applied Physics and Computer Science

This five-year program leads to both a Bachelor of Science and a Master of Science in Applied Physics and Computer Science. The Master of Science curriculum has concentrations in Computer Science, Computer Systems Engineering and Instrumentation, and Applied Physics that correspond to the undergraduate majors of Computer Science, Computer Engineering, and Applied Physics. By putting in an extra year to obtain the M.S. degree, a student's lifetime earnings and the potential for diverse opportunities and job satisfaction increase significantly.

Admission and Program Requirements

Admission

Criteria for student admission into a five-year program:

a) Undergraduate cumulative GPA of 3.0 or higher.
b) GPA in the student's major of at least 3.0.
c) Submit one of the following exam scores:
   i) A minimum SAT Score of 1100; **OR**
   ii) ACT Score of a composite score of 24, with the ACT math score no less than 22, and an English plus Reading score no less than 46; **OR**
   iii) A Graduate Record Examination (GRE) General Test Score of at least 950 for Verbal and Quantitative sections combined is required and a score at or above 1000 is highly desirable. GRE scores are used as one of several indicators of the applicant's ability to succeed in graduate studies.
d) Two letters of recommendation. One must be from a faculty member in the major who has taught or mentored the student in a major course or research project.
e) A Program of Study for the five-year program approved by the student's advisor.
f) Students apply for admission to a five-year program by February 1st of the junior year.

Program Requirements

a) To continue in the five-year program a student must maintain a 3.0 GPA, and remain in good standing by earning a grade of ***B-*** or better in any graduate course taken while in the undergraduate status.
b) If an undergraduate student in a five-year program earns a single grade of ***F*** or two grades of ***C+*** or lower in a graduate level course(s), that student will not be allowed to continue in the five-year program and the offer of admission to the graduate program will be rescinded.
c) Upon completion of the normal requirements in their respective undergraduate programs, a baccalaureate degree will be awarded to the student.

Graduate Course Hours

Graduate credit hours taken as an five-year B.S./M.S. **undergraduate** are subject to the following requirements:

a) A maximum of nine hours of credit will be allowed while classified as an undergraduate.
b) All courses must be approved by the student's advisor.
c) The student will be held to the same standards in these classes as any other graduate student.
d) To continue to take graduate courses as an undergraduate, a student must complete each graduate course with a grade of ***B-*** or better.
e) These graduate credit hours will count towards the 120 hours required for an undergraduate degree. They will not directly count toward the M.S. degree.
f) Graduate cross-listed courses will count toward the student's major requirements in exactly the same way that the corresponding undergraduate cross-listed courses would count. If a graduate course, which is not cross-listed, is used to satisfy a requirement of the undergraduate major then the student must get the course substitution approved by the department chair to substitute the graduate course for a required course in the major. (Ref: *Authorization for Course Substitution* form)
g) Students in the five-year program who have taken graduate courses (up to 9 credit hours) as an undergraduate will be required to take additional graduate hours (21 credit hours for thesis and 27 for the non-thesis) for the M.S. in Applied Physics and Computer Science as a graduate student. The number of graduate credit hours must total at least 30 (thesis) or 36 (non-thesis) overall.

Suggested Course Schedule for Five-Year Program in Applied Physics and Computer Science

FRESHMAN YEAR

Fall		Spring	
CPSC 125 Introduction to Computer Science	3	CPSC 150/150L Computers & Programming I w/Lab	4
MATH 140 Calculus & Analytic Geometry	4	MATH 240 Intermediate Calculus	4
ENGL 101	3	ENGL 102	3
HIST 111B	3	HIST 112G	3
Foreign Lang.	3	Foreign Lang.	3
Credit hours	16	Credit hours	17

SOPHOMORE YEAR

Fall		Spring	
CPSC 250/250L Computers & Programming II w/Lab	4	CPSC 270 Data & File Structures	3
MATH 125 Elementary Statistics	3	ENGR 213 Discrete Structures for Computer App.	3
PHYS 201/201L	4	PHYS 202/202L General Physics w/Lab	4
Hum/SS	3	Hum/SS	3
		COMM 201 Public Speaking	3
Credit hours	14	Credit hours	16

JUNIOR YEAR

Fall		Spring	
CPSC 260 Programming Language Concepts	3	CPSC 330 Computer Organization	3
CPEN 214 Digital Logic Design	3	MATH 235 or 260	3
Science with Lab	4	Science	3
Hum/SS	3	Hum/SS	3
LSPE	2	CPEN 371W Computer Ethics WI	1
		Elective	3
Credit hours	15	Credit hours	16

SENIOR YEAR

Fall		Spring	
CPSC 410 Operating Systems	3	CPSC 550 Distributed Operating Systems	3
CPSC 501 Models of Dynamical Systems	3	CPSC 420 Algorithms	3
CPSC Elective	3	Elective	3
CPSC 525 Object Oriented Program. & Design	3	Elective	3
Elective	3	Elective	3
Credit hours	15	Credit hours	15

SUMMER

CPSC 502 Communications I	3
Credit hours	3

FIFTH YEAR

Fall		Spring	
CPSC 510 Artificial Intelligence I	3	CPSC 560 Introduction to Compilers	3
CPSC 611 Communications II	3	CPSC 642 Artificial Intelligence II	3
CPSC 619 Computer Systems Design	3	PCSE 699 Thesis Research	3
Credit hours	9	Credit hours	9

This is for reference only and does not supersede the current CNU Undergraduate or Graduate Catalog.

M.S.IN APPLIED PHYSICS AND COMPUTER SCIENCE COURSES OF INSTRUCTION

PHYSICS

PHYS 501. Models of Dynamical Systems (3-3-0)
Prerequisites: Math through differential equations and graduate standing in the department or permission of the instructor. (Fall)
The classical models of physical phenomena, the modern perspective on their analytic and qualitative solutions and the insights that numerical analysis of the models gives to expected behaviors of dynamical systems. Computer analysis and graphical representation of solutions for regular and chaotic dynamical systems.

PHYS 502. Quantum Physics (3-3-0)
Prerequisites: PHYS 501 and graduate standing within the department or permission of instructor. (Even Spring)
Study of the formulation of quantum physics and the use of computers to analyze quantum mechanical systems. Topics include the postulates of quantum physics, the Shroedinger equation, indeterminacy, the Heisenberg representation, angular momentum, internal degrees of freedom, the hydrogen atom, perturbation theory, quantization of the EM field and radiative transitions.

PHYS 503. Data Acquisition and Instrumentation (3-3-0)
Prerequisites: Graduate standing within the department or permission of instructor. (Even Fall)
Data reduction and error analysis. Computer-controlled data acquisition systems in the laboratory. The use of a case study to develop a measurement system. Noise in electronic systems. Introduction to signal processing. Students are required to complete a project that includes an implementation of a measurement system and data reduction of the results.

PHYS 504. Electromagnetic Theory (3-3-0)
Prerequisites: PHYS 304 or MATH 350; graduate standing within the department or permission of instructor. (Spring)
Review of electrostatics and magnetostatics. Maxwell's equations and time varying fields: wave propagation and polarization, waveguides and cavities and radiating systems. Computer programs for the solution of problems will be emphasized.

PHYS 506. Thermodynamics and Statistical Physics (3-3-0)
Prerequisites: Graduate standing within the department or permission of instructor. (Odd Spring)
Review of thermodynamics followed by advanced topics in thermodynamics: first-order phase transitions, maximum work theorem, Legendre transformations, critical phenomena and irreversible thermodynamics. Statistical mechanics: entropy representation, microcanonical, canonical, grand canonical formalisms, quantum fluids and fluctuations. Use of the computer in the analysis and presentation of technical problems.

PHYS 521. Computer Architecture (3-3-0)
Prerequisites: Graduate standing within the department or permission of instructor. (Spring)
Advanced issues and techniques in computer architecture and design. Instruction set design and performance impact. Architectural simulation using VERILOG. Pipelining. Computer arithmetic and vector processors. Advanced memory and cache design. I/O interfaces for high performance. Students may not take both PHYS 521 and 523.

PHYS 522. Microprocessor-based Systems (3-3-0)
Prerequisites: Graduate standing in the department or permission of the instructor. (Fall)
Focus on microprocessor-based computer architectures. Hardware topics include studies of several microprocessor architectures, memory, peripheral interfaces and buses. Software issues include I/O and interrupt handling and microprocessor development systems. Students may not take both PHYS 522 and 524.

PHYS 523. Computer Architecture, Advanced Topics (1-1-0)
Prerequisites: ENGR 414 or equivalent.
A one-credit course in advanced computer architecture for students with a solid undergraduate background in the topic. Students may not take both PHYS 521 and 523.

PHYS 524. Microprocessor-based Systems, Advanced Topics (1-1-0)
Prerequisites: PHYS 422 or equivalent.
A one-credit course in advanced microprocessor-based systems for students with a solid undergraduate background in the topic. Students may not take both PHYS 522 and 524.

PHYS 531. Optical Physics (3-3-0)
Prerequisites: Graduate standing in the department or permission of the instructor.
This course lays the foundation of modern optical science. It presents an overview of the properties of light and its interaction with matter and describes basic principles for control and detection of light beams. Provides an introduction to optical spectroscopy. The use of computer software for optical analysis is emphasized.

PHYS 541. Modeling and Simulation (3-3-0)
Prerequisites: PHYS 501, PHYS 502, MATH 580, CPSC 501, C or FORTRAN 90.
The modeling and simulation of physical systems. Applying software methodologies to the solution of physi

ical problems. Lectures typically involve a short review of a physics topic such as Keplerian motion, followed by an extensive discussion on the modeling and/or simulation of the problem. A large component of the course is a project. Students are able to "design" their own project, drawing from any area in the complete spectrum of physics curriculum. The project might entail modeling physical systems (ex: mechanics, optics, fluids, waveguides, atmospheric propagation or nonlinear system). Or, the student may choose to write a stimulation (ex: interplanetary spaceflight, orbital adjustment and insertion or powered flight). Substantive, additional work in the form of more advanced assignments and projects are required to distinguish this class from the cross-listed class.

PHYS 595. Advanced Topics in Physics (Credit varies)
Course topics are selected on the basis of faculty and student interests.

PHYS 599. Independent Study. 1- 6 Credits.
Qualified students may enrich their program through directed reading or independent research under faculty supervision and for University credit. Goals, prerequisites, stages, and grading are agreed upon in writing by the faculty member and the student and are submitted for approval prior to enrollment. See page 113 for specific instructions and procedures.

PHYS 621. Digital Signal Processing (3-3-0)
Prerequisites: PHYS 503, PHYS 522. (Odd Fall)
This course covers the principles of digital signal processing beginning with the sampling process on through digital filter design. Advanced topics include approximation effects, inverse filtering and hardware implementation structures. The course correlates theoretical aspects presented in the classroom with practical experimentation and design in a laboratory setting using commercial DSP hardware.

PHYS 629. Instrumentation Systems Design (3-3-0)
Prerequisites: PHYS 521, PHYS 522, completion of 12-15 hrs of program requirements & have chosen a thesis advisor.
This advanced instrumentation systems course is directed at understanding a comprehensive systems problem and formulating a design approach based on sound computer engineering principles. This course is a precursor to the student's thesis work in computer systems engineering and instrumentation concentration. Students select computer system research areas and formulate problem solving approaches under instructor supervision. Background research, trade-off studies and alternative implementations are explored. Each student presents a thesis proposal and is examined orally on topics related to his or her proposal. During this thesis proposal/oral comprehensive exam, students must demonstrate a basic knowledge in areas related to their proposed thesis to receive a passing grade. Students in this course are required to attend all thesis proposal presentations and all thesis defense presentations that occur during the course.

PHYS 631. Physics of Solids (3-3-0)
Prerequisites: PHYS 502 and PHYS 506 or permission of instructor.
Introduction to the physics of solids at the graduate level. Quantum ideas are emphasized to provide a better understanding of the properties of solids. Topics include crystal structure, electrons in a periodic potential, Fermi surface and band theory, lattice dynamics, phonons, semiconductors and magnetism.

PHYS 632. Lasers and Photonics (3-3-0)
Prerequisites: PHYS 631.
This course provides a survey of fundamental optical properties of matter and how they are employed in modern optical devices. The course focuses on laser physics and the varied use of lasers in meteorology. Includes a discussion of optical fibers for use in communications and sensors.

PHYS 634. Solid State Materials and Devices (3-3-0)
Introduction to theory of the solid state. Application of the theory to describe the behavior of solid state materials such as superconductors and optical elements that form the building blocks of devices. Overview of applications of these devices. Laboratory experimentation.

PHYS 639. Design of Solid State Systems & Sensors (3-3-0) *Prerequisite: Completion of 12-15 hours of program requirements and have chosen a thesis advisor.*
A design course to integrate knowledge acquired in the solid state program into a research/design effort. Each student presents a thesis proposal and is examined orally on topics related to his or her proposal. During this thesis proposal/oral comprehensive exam students must demonstrate a basic knowledge in areas related to their proposed thesis to receive a passing grade. Students in this course are required to attend all theses proposals and all defenses of thesis that occur during the course.

PHYS 649. Design of Integrated Modeling and Simulation Environments (3-3-0)
Prerequisite: PHYS 631, completion of 12-15 hours of program requirements and have chosen a thesis advisor.
Conceptualize, design, develop and test an integrated computational environment suitable for the modeling and simulation of systems and the appropriate presentation of the results. Each student presents a thesis proposal and is examined orally on topics related to his or her proposal. During this thesis proposal presentation students must demonstrate a basic knowledge in areas related to their proposed thesis to receive a passing grade. Students in this course are required to attend all thesis defense presentations which occur during the course.

PCSE 699. Thesis Research (3 Credits)
Prerequisite: Successful completion of CPSC 619, or PHYS 629, or PHYS 639, or PHYS 649.
Students in this course are required to attend all thesis proposals and defenses that occur during the course.

COMPUTER SCIENCE

CPSC 501. Software System Design & Implementation (3-3-0) *Prerequisites: Graduate standing or permission of the instructor. (Fall)*
The management, specification, design, implementation and documentation of complex software systems. A paper or class presentation based on independent reading of research papers concerning new developments in software engineering are required. Students are expected to learn to use software systems such as CASE tools.

CPSC 502. Communications I (3-3-0)
Prerequisites: Graduate standing and ability to program in C or C++, or permission of the instructor. (Spring)
A comprehensive view of data communications with an emphasis on computer networks. Baseband and broadband local area networks, OSI model, logical link protocols, media with an emphasis on fiber-based interfaces, topology and routing/flow control. TCP/IP protocols and socket-based application development are emphasized.

CPSC 510. Artificial Intelligence I (3-3-0)
Prerequisites: Graduate standing within the department. (Fall)
The purpose of this course is to introduce students to the basic elements of artificial intelligence with an emphasis on applications such as neural nets and heuristic search.

CPSC 521. Computer Architecture (3-3-0)
Prerequisites: Graduate standing within the department or permission of instructor. (Spring)
Advanced issues and techniques in computer architecture and design. Instruction set design and performance impact. Architectural simulation using VERILOG. Pipelining. Computer arithmetic and vector processors. Advanced memory and cache design. I/O interfaces for high performance.

CPSC 525. Object Oriented Programming & Design (3-3-0)
Prerequisites: Graduate standing or permission of the instructor. (Spring)
Basic object-oriented design and applications. This course introduces object-oriented design methods and provides guidance in the effective implementation of object oriented programs. Substantive, additional work in the form of more advanced assignments and projects are required to distinguish this class from the cross-listed course.

CPSC 550. Distributed Operating Systems (3-3-0)
Prerequisites: Graduate standing within the department. (Spring)
A study of operating systems with emphasis on distributed systems and intra-system communications. Substantive, additional work in the form of more advanced assignments and projects are required to distinguish this class from the cross-listed course.

CPSC 560. Introduction to Compilers (3-3-0)
(Even Spring)
A study of the problems of translating procedure oriented languages; lexicographic analysis, syntax checking, code generation and optimization, error detection and diagnostics. Substantive, additional work in the form of more advanced assignments and projects are required to distinguish this class from the cross-listed course.

CPSC 570. Theoretical Computer Science (3-3-0)
Prerequisites: Graduate standing within the department. (Fall)
Presentation of basic results relating to formal models of computation. Emphasis is placed on developing skills in understanding rigorous definitions in computing and in determining their logical consequences. Substantive, additional work in the form of more advanced assignments and projects are required to distinguish this class from the cross-listed course.

CPSC 585. Principles & Applications of Multimedia (3-3-0) *Prerequisites: Graduate standing with the department. (Fall)*
The purpose of this course is to learn the principles and techniques of multimedia, focusing on digital images and audio in print and online form. Technical topics include the nature of sound and images and their digital representation and multimedia relevant web protocols. The course will also address copyright issues, graphic design and human interface principles. A semester project is required.

CPSC 595. Advanced Topics in Computer Science (Credit varies)
Course topics are selected on the basis of faculty and student interests.

CPSC 599. Independent Study. 1-6 Credits.
Qualified students may enrich their program through directed reading or independent research under faculty supervision and for University credit. Goals, prerequisites, stages, and grading are agreed upon in writing by the faculty member and the student and are submitted for approval prior to enrollment. See page 113 for specific instructions and procedures.

CPSC 611. Communications II (3-3-0)
Prerequisite: CPSC 502. (Even Fall)
Analysis of communication systems through the application of queuing theory results and the modeling and simulation of these systems by state-of-the-art network simulation tools. Client/server network software strategies with an emphasis on RPC.

CPSC 619. Computer Systems Design (3-3-0)
Prerequisites: Completion of 12-15 hours of program requirements and have chosen a thesis advisor.
A design course to integrate knowledge acquired in the program into a research/design effort and to serve as a structure for beginning the research/design effort. Each student presents a thesis proposal and is examined orally on topics related to his or her proposal. During this thesis proposal/oral comprehensive exam, students must demonstrate a basic knowledge in areas related to their proposed thesis to receive a passing grade. Students in this course are required to attend all thesis proposal presentations and all thesis defense presentations that occur during the course.

CPSC 621. Parallel Processing (3-3-0)
Prerequisite: CPSC 521 or PHYS 521. (Odd Fall)
Advanced topics in concurrent processor design. Memory and I/O structures for high performance and parallel architectures. Comparison of vector processing machines. SIMD architectures and algorithms. MIMD architectural options. Centralized vs. distributed memory. Shared memory vs. message passing. Algorithms for different MIMD machines. Parallel programming.

CPSC 642. Artificial Intelligence II (3-3-0)
Prerequisites: CPSC 510, or permission of the instructor. (Odd Spring)
Topics in artificial intelligence. Content will vary. Possible topics include advanced neural nets, qualitative reasoning and natural language processing.

CPSC 681. Principles and Applications of Image Processing (3-3-0)
Prerequisites: CPSC 585 and CPSC 510, or permission of the instructor.
The purpose of this course is to learn the principles and techniques of digital image processing and computer vision. Technical topics include: image fundamental, image enhancement in the spatial and frequence domains, restoration, color image processing, wavelets, image compression, morphology, segmentation, image description, and the fundamentals of object recognition. The course will also address image processing in Java and image processing library in C++. A semester proposal is required.

MATHEMATICS

MATH 580. Advanced Numerical Analysis (3-3-0)
The course covers a range of topics in numerical analysis concentrating on an introduction to finite elements and their applications. Use of a software package and research journal readings are required.