Computer Engineering, Ph.D.

Degree Offered
• Doctor of Philosophy, Computer Engineering (Ph.D.)

Nature of the Program
The Doctor of Philosophy program should be considered by those with superior academic achievement and who desire to pursue a career of research or teaching. Students interested in the Ph.D. program in computer engineering should see our web page at http://www.csee.wvu.edu (http://www.csee.wvu.edu/) for information. If additional information is needed, contact the graduate coordinator of electrical and computer engineering.

Program Educational Objectives & Outcomes
The educational objective of the Ph.D. program in Computer Engineering is to produce graduates who have the knowledge, skills, and attitudes that will ensure success in professional positions in business, industry, research, government service, or in further graduate or professional study.

Specific outcomes of the program are:
1. Achieve a depth of knowledge in core computer engineering subjects, as demonstrated by completion of core Ph.D. courses and examination on those subjects through the Qualifying Examination process.
2. Achieve a breadth of advanced knowledge to support research, as demonstrated by completion of doctoral level coursework and graduate seminar participation.
3. Achieve an ability to carry out independent research, as demonstrated by successful completion and defense of a dissertation.

Admissions
All applicants must provide the items below to be considered for admission:
• A minimum cumulative grade point average of 3.0 or equivalent, based on a 4.0 system.
• Three letters of reference.
• Statement of purpose.
• International applicants must submit proof of English language proficiency.
• All graduate degree programs require the GRE general test, with a suggested score of either the 80th percentile on the quantitative part or 80th percentile total (verbal + quantitative + analytical).
• All graduate degree programs require an appropriate bachelors or master’s degree for entry. Students lacking some foundation courses appropriate to a particular degree program may be assigned some remedial coursework as a condition of admission.

Students who hold a M.S. degree in Electrical Engineering or Computer Engineering (or equivalent degree) will be considered for admission with regular status into the Ph.D. program. Students who hold a Masters degree in the sciences or engineering, excluding M.S.E.E. or M.S.E., will be considered for admission with provisional status and will likely have coursework deficiencies to remove. All other students must apply for admission into a master’s program as the first stage in attaining the Ph.D.

FOUNDATION ASSESSMENT
Prior to the first week of classes, new Ph.D. students must meet with the graduate coordinator to select classes. This interview determines if the student needs remedial work in order to pursue a graduate degree. Students with deficiencies may be required to take courses as prerequisites for graduate courses. Deficiencies are usually noted as a condition for admission. However, they may also be specified during the interview or later.

During the second semester, students must form their Advisory and Examining Committee (AEC) and write a plan of study. The AEC may also identify additional deficiencies to be removed, but this is rare since deficiencies should have been identified earlier in the student’s career.

Major Code: 3021

Curriculum in Doctor of Philosophy –Computer Engineering
A candidate for the Ph.D. degree with a major in computer engineering must comply with the rules and regulations as outlined in the WVU Graduate Catalog and the specific requirements of the Statler College and the Lane Department of Computer Science and Electrical Engineering.
Program Requirements

The doctor of philosophy degree with a major in computer engineering is administered through the college's interdisciplinary Ph.D. program. The research work for the doctoral dissertation must show a high degree of originality on the part of the student and must constitute an original contribution to the art and science of computer engineering.

All Ph.D. degree candidates are required to perform research and follow a planned program of study. The student’s research advisor, in conjunction with the student’s Advising and Examining Committee (AEC) will be responsible for determining the plan of study appropriate to the student’s needs. The underlying principle of the planned program is to provide the students with the necessary support to complete their degree and prepare them for their career.

Research work for the doctoral dissertation must represent a significant contribution to engineering or computer science. It may entail a fundamental investigation into a specialized area.

Curriculum Requirements

A minimum cumulative GPA of 3.0 is required

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<thead>
<tr>
<th>Course Requirements</th>
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<tbody>
<tr>
<td>A minimum of six credit hours of 600 or higher level courses</td>
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<tr>
<td>A maximum of six credit hours may be in directed study (CPE 795)</td>
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<tr>
<td>Select from the following based on degree path:</td>
<td>18</td>
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<tr>
<td>Any BIOM, CE, CHE, CHEM, CPE, CS, EE, IENG, IH&amp;S, MAE, MATH, MINE, PNGE, PHYS, SAFM, SENG, or STAT courses 500-799</td>
<td>24</td>
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<table>
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<tr>
<th>Examinations</th>
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<tbody>
<tr>
<td>Qualifying Exam</td>
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<tr>
<td>Candidacy Exam</td>
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<tr>
<td>Final Exam</td>
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<tr>
<td>Total Hours</td>
<td>42</td>
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* Students who do not hold a baccalaureate degree in computer engineering are required to take a set of undergraduate computer engineering courses above and beyond the minimum coursework requirements. Doctoral students who do not have an M.S.C.S. or M.S.E.E. degree must either earn this degree, or complete coursework as required for the master’s degree with thesis option. It is not necessary to actually write a thesis. A minimum of twenty-four hours of coursework is required. Up to twelve hours may be transferred from work done at another institution. A minimum of forty-two hours of coursework and thirty hours of independent research beyond a bachelor’s degree, or eighteen hours of coursework and twenty-four hours of independent research beyond an M.S. degree are required.

Examinations

QUALIFYING EXAM

All students must take and pass a written qualifying examination. Normally, the qualifying examination is given no later than one semester after completion of eighteen credit hours toward the doctoral degree. This examination is designed to assess the basic competency of students in the computer engineering field to determine whether or not they have sufficient knowledge to undertake independent research.

The Lane Department of Computer Science and Electrical Engineering is organized in the following five Areas of Concentration. All Ph.D. degree programs use these Areas to provide organizational structure to the educational process as delineated under specific Ph.D. requirements. The significance of these Areas will be of particular importance in preparation for the Qualifying Exam as each area has designated Ph.D. Qualifier Core Courses as follows:

**1. Electronics and Photonics Area**

<table>
<thead>
<tr>
<th>EE 550</th>
<th>Advanced Semiconductor Electronics</th>
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<tbody>
<tr>
<td>EE 551</td>
<td>Linear Integrated Circuits</td>
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<tr>
<td>EE 650</td>
<td>Optoelectronics</td>
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**2. Signals and Systems Area**

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<tr>
<th>EE 513</th>
<th>Stochastic Systems Theory</th>
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<tbody>
<tr>
<td>EE 515</td>
<td>Linear Control Systems</td>
</tr>
<tr>
<td>EE 533</td>
<td>Computer Applications in Power System Analysis</td>
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**3. Computer Systems**
Ph.D. students must make the first attempt to pass the qualifying exam within fourteen months of their enrollment if they already have a M.S. degree from the Lane Department of CSEE or within twenty-six months otherwise. The Ph.D. qualifying process consists of completion of a research project and oral examination. The project is intended to demonstrate the student's ability to assemble and analyze the relevant literature for a given research problem and to make preliminary steps towards his/her own contribution.

The oral exam will include:

1. Presentation by the student of his/her research project
2. Questions about the work, its context, and relevant literature
3. Questions about course work, focusing specifically on the three core courses for which the student has earned credit

The possible outcomes of the first year exam are: “Pass” which means the student is qualified to begin work towards the candidacy exam; “Pass with Recommended Coursework” which means the student is qualified to begin work towards a candidacy exam but certain courses must be taken; or “Fail”. Any student failing the qualifying exam on the initial attempt will have one additional attempt within six months. Failure of the exam on the second attempt will disqualify the student from further doctoral studies in the LCSEE program.

CANDIDACY EXAMINATION

In order to be admitted to candidacy, the student must pass a candidacy exam, which is designed to evaluate the student’s overall ability to engage in high-level research.

When all requirements are completed, the qualifying and candidacy examinations are passed, and the research proposal is successfully defended, the student is formally admitted to candidacy for the Ph.D. degree. For full-time students, admission to candidacy must normally occur within three years of entering the Ph.D. program.

FINAL EXAMINATION

At the completion of the dissertation research, candidates must prepare a dissertation and pass the final oral examination (defense) administered by their AEC.

In order to complete the Ph.D. requirements, a student must pass a final oral examination on the results embodied in the dissertation. This examination is open to the public and, in order to evaluate critically the student's competency, may include testing on material in related fields, as deemed necessary by the AEC. All requirements for the degree must be completed within five years after the student has been admitted to candidacy.

Suggested Plan of Study

It is important for students to take courses in the order specified as much as possible; all prerequisites and concurrent requirements must be observed. A typical doctoral degree program that completes degree requirements in three years is as follows. A typical Ph.D. program requires four to five years beyond the baccalaureate degree, although scholarly achievements are more important than length of program.

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<thead>
<tr>
<th>Semester</th>
<th>Course</th>
<th>Hours</th>
<th>Course</th>
<th>Hours</th>
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<tbody>
<tr>
<td>Fall</td>
<td>CPE 670</td>
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<td>Spring</td>
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<td>CS 550</td>
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<tr>
<td>Second</td>
<td>CPE 797</td>
<td>6</td>
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**First Year**

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<th>Course</th>
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<td>CPE 797</td>
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<th>Course</th>
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**Second Year**

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<th>Course</th>
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<td>CPE 797</td>
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<tr>
<th>Course</th>
<th>Hours</th>
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Total credit hours: 54

Major Learning Outcomes

COMPUTER ENGINEERING

It is our goal that in the first five years after graduation our students will:

1. Achieve success and proficiency in the Computer Engineering profession.
2. Be recognized as leaders.
3. Contribute to the well-being of society.

COURSES

CPE 520. Application of Neural Networks. 3 Hours.
PR: Consent. Theories, principles, techniques, and procedures used in design implementation of supervised and unsupervised neural networks. Algorithms and computer programming for software realization with engineering applications.

CPE 521. Applied Fuzzy Logic. 3 Hours.
PR: Consent. Theory and applications of fuzzy logic, fuzzy fundamentals, fuzzy rules, decision-making systems, control systems, pattern recognition systems, and advanced topics. Algorithms and computer programming for software realization with engineering applications.

CPE 536. Computer Data Forensics. 3 Hours.
PR: CPE 310 and CPE 435 or Consent. Provides students with a comprehensive overview of collecting, investigating, preserving, and presenting evidence of cybercrime; introduces topics of forensic data examination of computers and other digital storage devices.

CPE 538. Intro Computer Security Management. 3 Hours.
Develops management tools to build and maintain a secure enterprise. Includes policies, procedures, and the various management and auditing processes that are needed in a networked enterprise.

CPE 553. Advanced Networking Concepts. 3 Hours.
PR: Graduate standing. Design and analysis of network protocols; includes the TCP/IP protocol suite, wireless network protocols, mobility management protocols and ad-hoc network protocols; hands-on network programming using TCP/UDP sockets and discrete event simulations.

CPE 568. Computer Network Forensics. 3 Hours.
PR: CS 450 and CS 453 or consent. Introduction to threat assessment in modern networked computer systems. Techniques, methodologies and technologies for preventing, detecting, recovering from and collecting evidence of intrusions, with the intent of prosecuting the offending parties.

CPE 591. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

CPE 595. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

CPE 620. Deep Learning. 3 Hours.
PR: CPE 520. Review of neural network architectures; introduction to advanced deep neural network architectures that use many layers and large databases; application of deep learning to dimensionality reduction, latent feature extraction, and manifold representation; coupled deep neural networks for cross-modality object verification; use of multiple neural networks for data fusion; applications of deep learning in biometrics, computer vision, and data mining.

CPE 643. Fault Tolerant Computing. 3 Hours.

CPE 664. Sensor Actuator Networks. 3 Hours.
PR: Graduate standing in CS, CPE, EE or SENG. Introduces students to the state of the art in wireless sensor actuator networks. Provides hands on training in programming these networks.

CPE 670. Switching Circuit Theory 1. 3 Hours.
PR: CPE 271 or equivalent. Course presumes an understanding of the elements of Boolean or switching algebra. Study of both combinational and sequential switching circuits with emphasis on sequential networks. Advanced manual design and computer-aided design techniques for single and multiple output combinational circuits. Analysis and design of sequential circuits. Detection and prevention of undesired transient outputs. (3 hr. rec.).
CPE 684. Advanced Real-Time Systems. 3 Hours.
PR: CS 415 and CPE 484 or consent. Project-based course focused on analysis and design of real-time systems using the unified modeling language. Object-oriented development process based on design patterns and frameworks is described.

CPE 691. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

CPE 693. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

CPE 694. Seminar. 1-6 Hours.
Special seminars arranged for advanced graduate students.

CPE 695. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

CPE 697. Research. 1-9 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper, equivalent scholarly project, or dissertation. (Grading may be S/U.)

CPE 699. Graduate Colloquium. 1-6 Hours.
PR: Consent. For graduate students not seeking coursework credit but who wish to meet residency requirements, use the University's facilities, and participate in its academic and cultural programs. Note: Graduate students who are not actively involved in coursework or research are entitled, through enrollment in their department's 699/799 Graduate Colloquium to consult with graduate faculty, participate in both formal and informal academic activities sponsored by their program, and retain all of the rights and privileges of duly enrolled students. Grading is S/U; colloquium credit may not be counted against credit requirements for masters programs. Registration for one credit of 699/799 graduate colloquium satisfies the University requirement of registration in the semester in which graduation occurs.

CPE 790. Teaching Practicum. 1-3 Hours.
PR: Consent. Supervised practice in college teaching of computer engineering. Note: This course is intended to insure that graduate assistants are adequately prepared and supervised when they are given college teaching responsibility. It will also present a mechanism for students not on assistantships to gain teaching experience. (Grading will be S/U.)

CPE 791. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

CPE 792. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

CPE 793. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

CPE 795. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

CPE 796. Graduate Seminar. 1-3 Hours.
PR: Consent. Each graduate student will present at least one seminar to the assembled faculty and graduate student body of his or her program.

CPE 797. Research. 1-9 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper, or equivalent scholarly project, or a dissertation. (Grading may be S/U.)