Electrical Engineering

Degrees Offered

- Masters of Science, Electrical Engineering (M.S.E.E.)
- Doctor of Philosophy, Electrical Engineering (Ph.D.)

Nature of the Program

The Masters of Science in Electrical Engineering (M.S.E.E.) degree program is intended for students who have an undergraduate degree in Electrical Engineering, Computer Engineering, or a closely related discipline, and wish to broaden their depth of understanding in one or more areas of the field. Program graduates will be qualified to pursue careers in industry, government, or further academic study. 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.

Masters Program Educational Objectives & Outcomes

The objective of the Master of Science in Electrical Engineering (M.S.E.E.) degree program 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 that will be achieved by graduates of the program are:

1. Achieve a depth of proficiency in a specific field of Electrical Engineering by completing major courses in one of four areas: electronics and photonics; systems and signals; computer systems; or software and knowledge engineering.
2. Achieve a breadth of understanding of Electrical Engineering by completing minor coursework requirements in another area, and by participation in graduate seminar requirements.
3. Demonstrate professionalism and communication skills through completion of coursework, project or thesis defense.

Doctoral Program Educational Objectives & Outcomes

The objective of the Ph.D. Program in Electrical Engineering degree program 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 that will be achieved by graduates of the program are:

1. Achieve a depth of understanding in Electrical Engineering, as demonstrated by completion of core Ph.D. courses and examination on that material through the Qualifying Examination process.
2. Achieve a breadth of understanding of the Electrical Engineering discipline, as demonstrated by completion of remaining doctoral coursework and participation in graduate seminar.
3. Demonstrate the ability to conduct independent research by completion and defense of a dissertation.

Admissions

All Masters and Ph.D. programs require applicants to provide the items below to be considered for admission. Specific programs may have additional requirements. Exception: These requirements do not apply to nontraditional students in the Certificate of Software Engineering program and M.S.S.E. program (see certificate program and M.S.S.E. program for more information):

- A minimum cumulative grade point average of 3.0 or equivalent, based on a 4.0 system.
- Three letters of reference.
- International students must demonstrate proficiency in communicating in English (a minimum TOEFL Score of 550, or iBT Score of 79, or IELTS Score of 6.5). (Students who have completed a recent four-year bachelor’s degree in the USA need not submit these scores.)
- 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.
- See: Certificate in Software Engineering; Master of Science in Software Engineering for alternative admission requirements to those programs for working professionals.

MASTERS ADMISSIONS

Students admitted into a program are designated as regular, provisional, or non-degree status. Regular status is given to students who are granted unconditional admissions. Provisional status is given to students who have deficiencies to make up such as incomplete credentials or other reasons as identified by the graduate coordinator. In all cases, the student’s letter of admission will state what must be done to attain regular status, and students
Electrical Engineering

must sign and date this letter no later than the first registration. Non-degree status is granted case-by-case by the graduate coordinator. Basically, a non-degree student is one who may take courses but sometimes with no plan of study or any guarantee for attaining provisional status.

DOCTORAL ADMISSIONS

As a first step, students must satisfy provisions under the “Admission Requirements for All Programs” and must submit a statement of purpose. Students who hold an M.S.E.E. or M.S.E. (or equivalent) degree will be considered for admission with regular status into the Ph.D. program. Students who hold a master’s 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.

REMOVING DEFICIENCIES

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.

REGULAR, PROVISIONAL, AND NON-DEGREE ADMISSION

Students admitted into a program are designated as regular status or provisional. The department also admits students to non-degree status in the College of Engineering and Mineral Resources, but these students are not admitted to any specific program. Regular status is given to students who are qualified for unconditional admission to a specific program. Provisional status is given to students who have deficiencies to make up such as incomplete credentials or other reasons as identified by the graduate coordinator. In all cases, the student’s letter of admission will state what must be done to attain regular status.

Provisional students must complete the requirements for transfer to regular status by the end of the semester in which they complete eighteen credit hours. Usually provisional students are not considered for graduate assistantships or tuition waivers.

Non-degree status is granted upon request to students meeting the minimum admission requirements. A non-degree student is one who wishes to take courses without seeking a formal degree. Non-degree students require permission of the instructor to take courses that are restricted to specific majors. There is no guarantee of eventual acceptance into a degree program, and in no case may more than twelve hours be transferred to a degree program.

Non-degree students may not be offered graduate assistantships or tuition waivers.

Curriculum in Master of Science in Electrical Engineering Masters

A candidate for the M.S. degree in electrical 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

All M.S. 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.

Curriculum Requirements

A minimum cumulative GPA of 3.0 is required

<table>
<thead>
<tr>
<th>Course Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>No more than 9 credit hours may be at the 400 level.</td>
</tr>
<tr>
<td>EE 796 Graduate Seminar 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area of Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete one Area of Concentration:</td>
</tr>
<tr>
<td>One Core course</td>
</tr>
<tr>
<td>Two Elective courses</td>
</tr>
<tr>
<td>Complete one additional core course from a second area of concentration. 3</td>
</tr>
<tr>
<td>Choose 12 additional credit hours from the courses listed in any EE area of concentration 12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Complete 1 of the following options: 7-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 796 Graduate Seminar (1 hour)</td>
</tr>
<tr>
<td>EE 697 Research (6 hours)</td>
</tr>
</tbody>
</table>
Thesis
Final Oral or Written Examination

Problem Report Option - 9 hours
Complete a minimum 6 additional hours of coursework, at least 3 hours of which must be from the completed area of concentration.
EE 697 Research (3 hours)
Formal written report or professional report/paper
Final Oral or Written Examination

Coursework Option - 9 hours
Complete a minimum of 9 additional hours of coursework, at least 6 hours of which must be from the completed area of concentration.
Final Oral or Written Examination

Total Hours 32-34

* Students who do not hold a baccalaureate degree in electrical engineering are required to take a set of undergraduate electrical engineering courses above and beyond the minimum coursework requirements.

Areas of Concentration

ELECTRONIC AND PHOTONICS

Core Courses
EE 550 Advanced Semiconductor Electronics 3
EE 551 Linear Integrated Circuits 3

Elective Courses
EE 435 Introduction to Power Electronics 3
EE 437 Fiber Optics Communications 3
EE 455 Introduction to Microfabrication 3
EE 457 Fundamentals of Photonics 3
EE 528 Biomedical Microdevices 3
EE 650 Optoelectronics 3
PHYS 771 Introduction to Solid State Physics 3
PHYS 772 Semiconductor Physics 3
PHYS 773 Collective Phenomena in Solids 3
CHE 466 Electronic Materials Processing 3

SIGNALS AND SYSTEMS

Core Courses
EE 513 Stochastic Systems Theory 3
EE 515 Linear Control Systems 3

Elective Courses
EE 461 Introduction to Communications Systems 3
EE 465 Introduction to Digital Image Processing 3
EE 517 Optimal Control 3
EE 531 Advanced Electrical Machinery 3
EE 533 Computer Applications in Power System Analysis 3
EE 535 Power System Control and Stability 3
EE 561 Communication Theory 3
EE 562 Wireless Communication System 3
EE 565 Advanced Image Processing 3
EE 567 Coding Theory 3
EE 568 Information Theory 3
EE 569 Digital Video Processing 3
EE 613 Detection and Estimation Theory 3
EE 713 Large-Scale System Modeling 3
EE 731 Real Time Control of Power System 3
EE 733 Protection of Power Systems 3
EE 735 HVDC Transmission 3

COMPUTER SYSTEMS

Core Courses
CPE 553 Advanced Networking Concepts 3
CPE 670 Switching Circuit Theory 1 3

Elective Courses
CPE 435 Computer Incident Response 3
CPE 520 Application of Neural Networks 3
CPE 521 Applied Fuzzy Logic 3
CPE 536 Computer Data Forensics 3
CPE 538 Intro Computer Security Management 3
CPE 664 Sensor Actuator Networks 3
CS 453 Data and Computer Communications 3
CS 539 Computer Forensics and the Law 3
CS 572 Advanced Artificial Intelligence Techniques 3
CS 665 Computer System Security 3
CS 676 Machine Learning 3
CS 677 Pattern Recognition 3
CS 678 Computer Vision 3
CS 555 Advanced Computer Systems Architecture 3
CS 556 Distributed and Pervasive Compt 3
CS 568 Computer Network Forensics 3
CPE 684 Advanced Real-Time Systems 3
EE 565 Advanced Image Processing 3
EE 569 Digital Video Processing 3

SOFTWARE/KNOWLEDGE ENGINEERING

Core Courses
CPE 684 Advanced Real-Time Systems 3
CS 573 Advanced Data Mining 3
CS 630 Empirical Methods in Software Engineering and Computer Science 3
CS 677 Pattern Recognition 3

Elective Courses
BIOM 693 Special Topics (Advanced Biometrics) 3
CS 533 Developing Portable Software 3
CS 558 Multimedia Systems 3
CS 572 Advanced Artificial Intelligence Techniques 3
CS 665 Computer System Security 3
CS 674 Computational Photography 3
CS 676 Machine Learning 3
CS 757 Distributed Systems and Algorithms 3
EE 565 Advanced Image Processing 3
SENG 550 Object Oriented Design 3

Final Examination

M.S. students following the thesis or problem report option must prepare a written research proposal. The proposal must be approved by the student's AEC at least one semester prior to the final oral examination.

All students, regardless of option, are required to pass a final oral or written examination, administered by their AEC, covering the thesis or problem report and/or related course material.
All master’s students must defend their thesis or problem report at an oral exam, attended by all members of the committee.

A student who fails the research defense may repeat the defense at most once, at a time determined by the AEC but not necessarily during the same semester.

**Suggested Plan of Study**

The plan below illustrates the Thesis Option. 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 M.S.E.E degree program that completes degree requirements in one and half years is as follows. Those students who lack course prerequisites may require more than three semesters of full-time study to complete the degree. Students with research assistantships may also require more than three semesters to complete the degree.

**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Hours</th>
<th>Spring</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field of Study 1 Core Course</td>
<td>3</td>
<td>Field of Study 1 Elective Course</td>
<td>3</td>
</tr>
<tr>
<td>Field of Study 1 Elective Course</td>
<td>3</td>
<td>Field of Study 2 Core Course</td>
<td>3</td>
</tr>
<tr>
<td>Elective Course</td>
<td>3</td>
<td>3 Elective Course</td>
<td>3</td>
</tr>
<tr>
<td>EE 796</td>
<td>1</td>
<td>EE 796</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field of Study 3 Core Course</td>
<td>3</td>
</tr>
<tr>
<td>Elective Course</td>
<td>3</td>
</tr>
<tr>
<td>EE 697</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

Total credit hours: 32

**AREA OF EMPHASIS IN CYBERSECURITY**

A 3.0 GPA is required in AOE coursework.

**Required Courses**

| CPE 536   | Computer Data Forensics | 3 |
| CPE 568   | Computer Network Forensics | 3 |
| CS 539    | Computer Forensics and the Law | 3 |

Select one of the following:

| CPE 538   | Intro Computer Security Management | 3 |
| CS 569    | Cybersecurity and Big Data Analytics | |

Total Hours 12

**Curriculum in Doctor of Philosophy – Electrical Engineering Requirements**

A candidate for the Ph.D. degree with a major in electrical 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 electrical 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 electrical 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. A minimum of twenty-four credit hours of research (EE 797 [http://catalog.wvu.edu/graduate/collegeofengineeringandmineralresources/thelanedepartmentofcomputerscienceandelectricalengineering/computer_engineering/]) is required.
Curriculum Requirements

A minimum cumulative GPA of 3.0 is required

Course Requirements

A minimum of six credit hours of 600 or higher level courses

A maximum of six credit hours may be in directed study (EE 795)

Research

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 797</td>
<td>Research</td>
</tr>
</tbody>
</table>

Select from the following based on degree path:

- Any BIOM, CE, CHE, CHEM, CPE, CS, EE, IENG, IH&S, MAE, MATH, MINE, PNGE, PHYS, SAFM, SENG, or STAT courses 500-799

Examinations

<table>
<thead>
<tr>
<th>Examinations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualifying Exam</td>
</tr>
<tr>
<td>Candidacy Exam</td>
</tr>
<tr>
<td>Final Exam</td>
</tr>
</tbody>
</table>

Total Hours: 42

* Students who do not hold a baccalaureate degree in electrical engineering are required to take a set of undergraduate electrical engineering courses above and beyond the minimum coursework requirements.

Doctoral students who do not have an 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 electrical 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>Course</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 550</td>
<td>Advanced Semiconductor Electronics</td>
</tr>
<tr>
<td>EE 551</td>
<td>Linear Integrated Circuits</td>
</tr>
<tr>
<td>EE 650</td>
<td>Optoelectronics</td>
</tr>
</tbody>
</table>

2. Signals and Systems Area

<table>
<thead>
<tr>
<th>Course</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 513</td>
<td>Stochastic Systems Theory</td>
</tr>
<tr>
<td>EE 515</td>
<td>Linear Control Systems</td>
</tr>
<tr>
<td>EE 533</td>
<td>Computer Applications in Power System Analysis</td>
</tr>
</tbody>
</table>

3. Computer Systems

<table>
<thead>
<tr>
<th>Course</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPE 670</td>
<td>Switching Circuit Theory 1</td>
</tr>
<tr>
<td>CS 550</td>
<td>Theory of Operating Systems</td>
</tr>
</tbody>
</table>

4. Software/Knowledge Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPE 684</td>
<td>Advanced Real-Time Systems</td>
</tr>
<tr>
<td>CS 573</td>
<td>Advanced Data Mining</td>
</tr>
<tr>
<td>CS 591Q</td>
<td>Pattern Recognition</td>
</tr>
</tbody>
</table>

5. Theory of Computing

<table>
<thead>
<tr>
<th>Course</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 510</td>
<td>Formal Specification of Language</td>
</tr>
<tr>
<td>CS 520</td>
<td>Advanced Analysis of Algorithms</td>
</tr>
<tr>
<td>CS 525</td>
<td>Computational Complexity</td>
</tr>
</tbody>
</table>
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 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.

<table>
<thead>
<tr>
<th>First Year</th>
<th>Hours</th>
<th>Hours</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course</td>
<td>3</td>
<td>Course</td>
<td>3</td>
</tr>
<tr>
<td>Course</td>
<td>3</td>
<td>Course</td>
<td>3</td>
</tr>
<tr>
<td>EE 797</td>
<td>3</td>
<td>EE 797</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Second Year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE 797</td>
<td>9</td>
<td>EE 797</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Third Year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course</td>
<td>3</td>
<td>Course</td>
<td>3</td>
</tr>
<tr>
<td>EE 797</td>
<td>6</td>
<td>EE 797</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

Total credit hours: 54

**Major Learning Outcomes**

**ELECTRICAL ENGINEERING**

It is our goal that in the first five years after graduation our students will:
2. Be recognized as leaders.
3. Contribute to the well-being of society.