

ENGINEERING SCIENCE

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Programs Offered

Bachelor of Science in Engineering Science
(Specialization in Electronics and Communications)

Master of Science in Computer and Engineering Science
(Specialization in Bioengineering, Communications
and Photonics or Computer Hardware and Software
Systems)

As defined in *Webster's Unabridged Dictionary*, "Engineering is the science by which the properties of matter and the sources of energy in nature are made useful to [humankind]." The study of engineering science, with focus in electronics and communications, deals with the processing of information and energy in electrical and magnetic forms involving conceptualization and formulation of the ideas, design to manufacturing to application of many diverse electrical, electronic, and magnetic devices and systems.

The focus of the Bachelor of Science in Engineering Science (BSES) curriculum is electronics and communication. The program

has been designed to prepare students for an exciting career in designing and manufacturing of electronic systems, communications systems and networks, microprocessors and computers, microwave and lightwave communications, and integrated circuits. The graduates of the proposed program will be well grounded in the rigorous scientific and theoretical foundations of the discipline. This will prepare them not only to have a successful career in the industry in the region and beyond, but also to enter and be successful in any advanced level graduate program of their choosing. The technical and liberal arts components of the curriculum provide= students with the opportunity for gaining self-development, technical competence, and awareness of economic and ethical responsibilities.

The Master of Science in Computer and Engineering Science (MS-CES) curriculum is designed to further the working skills and practical knowledge of engineers, computer scientists, and similar professionals. The firm base in mathematics, computer science, and physics is augmented with a selection of engineering course options, which prepares the students for tackling real-world problems. These options include such areas as advanced analog and digital electronics, embedded systems, communications, networking, and photonics.

Careers in Engineering Science

The BSES program has been designed to prepare students for an exciting career in industries or to pursue graduate degrees. The graduates will find opportunities in the industry in areas such as:

- Designing and manufacturing of electronic systems;
- Communications systems;
- Networking;
- Computer engineering;
- Telecommunications;
- Optical fiber communications;
- Integrated circuits;
- Research and development in the areas above; and/or
- Sales, marketing, and management in the areas above.

Some examples of the corresponding job titles are electronics engineer, computer engineer, hardware designer, systems engineer, communications engineer, communications analyst, telecommunication engineer, network engineer, network analyst, sales engineer, applications engineer, and field engineer.

Graduate degrees can be pursued in any one of the many fields such as electronics, communications, networking, computer engineering, and computer science.

Bachelor of Science in Engineering Science (Emphasis in Electronics and Communications)

Consistent with the mission of the University, the mission of the Bachelor of Science in Engineering Science program is “to prepare students to be learned men and women who are capable of pursuing fulfilling careers in a changing world,” and “to fulfill the undergraduate technical education needs of the community, business, and industry of the North Bay region.” A broader mission is to enable graduating engineers to acquire knowledge and experiences to prepare them to pursue lifelong learning, advanced study, and leadership roles in business and community settings.

The B.S. in engineering science at Sonoma State University is a focused and innovative program in which the curriculum has been designed to provide students with a basic education in engineering science, based on a strong foundation of liberal arts.

The curriculum includes 51 units of General Education courses; a 35-unit core in mathematics, computer science, and basic sciences (9 units overlap with GE units); a 49-unit core in engineering sciences which includes electrical, computer, electronics, and communications engineering subjects such as circuits, analog/digital electronics, electromagnetic fields, microprocessors, analog and digital communications, and networking; and 6 units of engineering science electives which provides senior-level choices for more depth in students’ areas of interest. Theoretical and practical learning experiences are an important part of all course work. The senior year also gives students the opportunity to consolidate their educational experience with a capstone design project. The curriculum develops students’ abilities to formulate problems, analyze alternatives, make decisions, and solve problems. Internship and co-op experiences will be encouraged to provide the students a real-world experience and to enhance students’ communication and interpersonal skills.

Program Educational Objectives

- Educate and prepare students to be successful in the profession of electrical engineering, particularly in the fields of electronics and communications;
- Educate students to successfully pursue graduate degrees; and
- Provide a strong foundation to the students for lifelong learning and to be responsible citizens.

Program Outcomes

The students will attain:

- An ability to apply knowledge of mathematics, science, and engineering;
- An ability to design and conduct experiments, as well as to analyze and interpret data;
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;

- An ability to function on multidisciplinary teams;
- An ability to identify, formulate, and solve engineering problems;
- An understanding of professional and ethical responsibility;
- An ability to communicate effectively;
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context; and
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practices.

Degree Requirements	Units
#GE courses	51
Major requirement	49
Support courses (basic sciences, computer science, and mathematics)	35
Technical electives	6
Total units needed for graduation	132

**A list of recommended GE courses is posted at the department's website and is available in the department office.*

**9 units overlap with GE units.*

Engineering Science

ES 110 Introduction to Engineering & Lab Experience	2
ES 210 Digital Circuits & Logic Design	4
ES 220 Electric Circuits	3
ES 221 Electric Circuits Laboratory	1
ES 230 Electronics I	3
ES 231 Electronics I Lab	1
ES 310 Microprocessors & System Design	4
ES 314 Adv. Program., Modeling and Simulation	4
ES 330 Electronics II	3
ES 400 Linear Systems Theory	3
ES 440 Analog & Digital Communications I	3
ES 441 Analog & Digital Communications II	3
ES 443 Introduction to Optical Fiber Communication	3
ES 465 Introduction to Networking	3
ES 430 Electromagnetic Theory & Applications	3
Approved Technical Elective I	3
Approved Technical Elective II	3
ES 492 Senior Design Project Planning	2
ES 493 Senior Design Project	3
ES 497 Engineering Science Colloquium	1

Subtotal 55

Current List of Technical Electives

ES 480 Artificial Intelligence (3)
ES 432 Physical Electronics (3)
ES 445 Photonics (3)

Computer Science

CS 115 Programming I	4
Subtotal	4

Physics

PHYS 114 Introduction to Physics I	4
PHYS 116 Introductory Lab Experience	1
PHYS 214 Introduction to Physics II	4

Subtotal 9

Mathematics

MATH 142E Discrete Mathematics for Engineering	2
MATH 161 Calculus I	4
MATH 211 Calculus II	4
MATH 241 Calculus III	4
MATH 261 Calculus IV	4
MATH 345 Probability Theory	4

Subtotal 22

General Education

(Excluding math, physics, and CS courses)

ENGL 101 Expository Writing & Analytical Reading	3
Remaining GE courses	39

Subtotal 42

GPA Requirements

Please refer to this catalog and the department office for various general academic regulations and specific requirements for undergraduate students, such as grade point average requirement, course repeat policy, continuation in the program, etc.

Minor in Mathematics

The course ES 400 Linear Systems Theory is crosslisted with MATH 430. As such, the BSES curriculum includes 25 units of mathematics including 6 units in upper-division (MATH 345 and MATH 430) required to minor in mathematics. Therefore, a student satisfying BSES degree requirement is automatically completing a minor in mathematics.

Minor in Electrical Engineering (EE)

A pathway to minor in EE is currently being approved to provide an opportunity to students interested in gaining ability and training in the field of electrical engineering. Students interested in receiving a minor in electrical engineering require 10 to 43 units depending upon the student's major field of study. A list of requirements for a minor in EE by students majoring in chemistry, computer science, mathematics, and physics disciplines is posted at the department's website and is available in the department office.

Sample Four-year Program for Bachelor of Science in Engineering Science

SEMESTER 1:: 15 Units

ES 110 Introduction to Engineering & Lab Experience	2
CS 115 Programming I	4
MATH 142E Discrete Mathematics for Engineering	2
MATH 161 Calculus I	4
ENGL 101 Expository Writing & Analytical Reading	3

SEMESTER 2:: 15 Units

PHYS 114 Introduction to Physics I	4
PHYS 116 Introductory Lab Experience	1
MATH 211 Calculus II	4
GE	6

SEMESTER 3:: 18 Units

PHYS 214 Introduction to Physics II	4
MATH 241 Calculus III	4
ES 220 Electric Circuits	3
ES 221 Electric Circuits Lab	1
GE	6

SEMESTER 4:: 18 Units

ES 210 Digital Circuits & Logic Design (w/lab)	4
ES 230 Electronics I	3
ES 231 Electronics I Laboratory	1
MATH 261 Calculus IV	4
GE	6

SEMESTER 5:: 17 Units

ES 314 Adv. Program., Modeling and Simulation	4
ES 330 Electronics II (w/lab)	3
MATH 345 Probability Theory	4
ES 400 Linear Systems Theory	3
GE	3

SEMESTER 6:: 16 Units

ES 310 Microprocessors and System Design	4
ES 440 Analog and Digital Communications I	3
ES 430 Electromagnetic Theory & Applications	3
GE	6

SEMESTER 7:: 18 Units

ES 441 Analog and Digital Communications II	3
ES 443 Introduction to Optical Fiber Communications	3
ES 465 Introduction to Networking (w/lab)	3
ES 492 Senior Design Project Planning	2
ES 497 Eng. Science Colloquium	1
GE	6

SEMESTER 8:: 15 Units

ES 493 Senior Design Project	3
Approved Technical Elective I	3
Approved Technical Elective II	3
GE	6

TOTAL UNITS:: 132**Master of Science in Computer and Engineering Science**

(Specialization in bioengineering communications and photonics or computer hardware and software systems)

The Master of Science degree in Computer and Engineering Science (MS-CES) at Sonoma State University is a multidisciplinary degree built on a strong foundation of physics, mathematics, computer science, and/or electrical sciences. The MS-CES faculty is composed of professors from Sonoma State University whose interests traverse the fields of science and engineering, as well as professionals from the local community who have cutting-edge expertise in the various engineering disciplines of interest and are qualified to be adjunct faculty at SSU.

A link with local industry in the form of an Engineering Science Advisory Board (ESAB) is an integral part of the program. Such an advisory board is critical to ensure that the program meets local community needs. The ESAB provides the program with valuable input regarding the new scientific and technological developments and educational needs of the industry. It also facilitates internship opportunities for students, joint student research/project development and supervision, faculty-scientists/engineers joint project opportunities, and equipment and financial support from the industries. Through this link of academic learning and practical application, students obtain a solid education indispensable for working in a professional environment. The MS-CES is a self-supported program that is underwritten by local industry as well as by student tuition revenue. Therefore, as of this writing, tuition fees for this program are \$500 per unit for all students, resident and non-resident. The MS-CES is a 30-33 unit program, not including any prerequisite work.

Professional Science Master's (PSM)

The Professional Science Master's (PSM) degree is a unique professional degree grounded in science and/or mathematics and designed to prepare students for a variety of career options. The degree combines advanced coursework in science and/or math with an appropriate array of professional skill-development activities to produce graduates highly valued by employers and fully prepared to progress toward leadership roles. A petition to offer this program is currently under approval.

Program Educational Objectives

- Educate and prepare students to be independent investigators;

- Educate students to be leaders in their professions; and
- Educate students to be socially responsible engineers, committed to community service.

Program Outcomes

The students of this program will acquire:

- Knowledge of the theory of high-performance computing, communications, and/or networking;
- Critical thinking ability and analytical and simulation tools to do system performance evaluation;
- Ability to model and analyze scientific and engineering problems;
- Ability to apply theory to design and to implement efficient computing and/or communications systems;
- Ability to integrate knowledge from multiple interrelated disciplines to formulate, design, and/or implement interdisciplinary projects;
- Ability to investigate and to formulate research problems and/or design projects independently; and
- Ability for effective written and oral communication skills.

Internship Opportunities and Financial Aid

The industries in the region provide opportunities to students to work as interns on-site and to enrich their academic experience at SSU with valuable hands-on practical experience. Students are also eligible to apply for financial aid in the form of low interest loans through the SSU Financial Aid Office and for part-time employment on campus as student assistants.

Admission to the Program

For admission, the applicant must have:

1. A baccalaureate degree in a scientific or technical discipline from a U.S. institution accredited by an appropriate accreditation body, or an equivalent baccalaureate degree from a foreign institution of high reputation;
2. Attained grade point average of at least 3.00 (A=4.00) in the last 60 semester (90 quarter) units attempted;
3. Applicants whose native language is not English and who have not spent at least three years of school at the secondary level (or beyond) where English is the principal language of instruction must present a minimum score of 212 on the computerized Test of English as a Foreign Language (550 on the paper form or 79-80 on Internet version);
4. Demonstrated competency in writing by one of the Written English Proficiency Test criteria for MS-CES students given below. Generally, this requirement must be met before entering the program. One of the criteria is demonstrating competency in writing through an essay. Therefore, if the applicant plans to use this criteria, the essay should be submitted with the application for admission; and

5. Completed the following SSU courses or equivalent at the undergraduate level with a GPA of 3.00 or higher:
 - 3 semesters of calculus (MATH 161, 211, 241);
 - 2 semesters of calculus-based physics with laboratory (PHYS 114, 116 and 214);
 - 1 semester of Probability Theory (MATH 345);
 - 1 semester of analog and digital electronics (ES 230 and 231);
 - 1 semester of Programming in an approved high-level procedural language (CS 115);
 - 1 semester of Advanced Programming, Modeling, and Simulation (ES 314); and
 - 2 semesters of digital systems, and Microprocessors and System Design (ES 210 and 310, or CS 252 and 351).

In addition, students interested in bioengineering track are required to take CES 490 course to satisfy the prerequisite requirement of a biology background.

Note: Occasionally, the department offers compressed prerequisite courses to enable students to satisfy the prerequisite requirements in an expeditious manner.

Conditional Admission

The applicants whose GPA is less than 3.00 but greater than 2.50, or who lack not more than 18 units of prerequisite work (generally, 6 courses), may be accepted conditionally and must complete a program of study specified by the graduate coordinator at the time of admission before being given full admission.

Written English Proficiency Test Requirement

All students are required to demonstrate competency in written English. A student can satisfy the Written English Proficiency Test (WEPT) requirement by meeting any one of the following five criteria:

1. A student who has obtained his/her bachelor's degree from a CSU institution will be deemed to have satisfied WEPT requirement.
2. A student who has obtained a bachelor's degree and a master's degree from an accredited institution(s) with English as the medium of instruction for both the degree programs will be deemed to have satisfied WEPT requirement.
3. A student who scores at least 3.5 in the analytical writing portion of the GRE test will be deemed to have satisfied the WEPT requirement.
4. A student who takes and passes the campus WEPT test.
5. A student who writes and submits an article of at least 500 words in length to demonstrate his/her writing proficiency in English. It will be evaluated by the MS-CES curriculum committee for (i) competent analysis of complex ideas, (ii) development and support of main points with relevant reasons and/or examples, (iii) organization of ideas, (iv) ease in con-

veying meaning with reasonable clarity, and (v) demonstration of satisfactory control of sentence structure and language (including spelling, punctuation, and proper use of grammar). If accepted by the curriculum committee, the student will be deemed to have satisfied the WEPT requirement.

Program of Study

The program offers three tracks or areas of specialization:

- **Track 1: Communications & Photonics** - This area of specialization provides students with expertise in the areas of (i) analog and digital electronics, (ii) semiconductor and photonics components and devices, (iii) communications techniques (wireless, wireline, and optical fiber media), (iv) local and wide area networking, and (v) broadband access technology.
- **Track 2: Computer Hardware & Software Systems** - This area of specialization is intended to deepen students' ability to analyze and design computer systems. This specialization includes topics such as embedded systems, digital data compression, software engineering, and computer networks.
- **Track 3: Bioengineering** - This area of specialization prepares students to apply engineering principles in the areas of communications, photonics and computer hardware and software systems to develop solutions for health-related products and techniques that improve the quality of life. This specialization includes topics such as computational techniques for biomolecules, biomedical instrumentation, biophotonics, and medical image processing.

A student chooses one of the three tracks at the time of admission but can change it during their course of study. However, that may mean taking additional courses to meet the requirements of the new track. A student's program of study consists of the following four components: a common core, a track core, culminating experience, and technical electives. Details of these components are as follows.

Common Core

All students in the program must take three core courses (9 units). These courses are designed to give students the fundamentals necessary to master advanced-level academic work. These core courses are:

- CES 400 Linear Systems Theory
- CES 440 Data Communications
- CES 432 Physics of Semiconductor Devices or CES 530 Analog and Digital Microelectronics

If any of the above core courses were part of a student's undergraduate program, the student must take a 500-level course in its place approved by the student's faculty advisor. Furthermore, only two 400-level courses can be used to satisfy degree requirements. A petition must be filed with the department for any exceptions.

Track Core

A student must take 12 units of courses from the list of courses for the chosen track. The lists of the courses for each track, which will be revised periodically, are given below.

Communications and Photonics Track Courses

- CES 430 Photonics
- CES 500 Queuing and Transform Theory
- CES 532 Advanced Semiconductor and Photonics Devices
- CES 540 Digital Data Transmission
- CES 542 Digital Signal Processing
- CES 543 Optical Fiber Communications
- CES 544 Wireless Communications
- CES 546 Data Compression
- CES 547 Digital Switching: Techniques and Architectures
- CES 550 Integrated Digital Networks
- CES 552 Network Architecture and Protocols
- CES 554 Broadband Access Technology
- CES 558 Multicasting on the Internet
- CES 590 Selected Topics in Communications and Photonics

Computer Hardware and Software Systems

- CES 500 Queuing and Transform Theory
- CES 510 Intelligent Systems Design
- CES 512 Theory of Software Systems
- CES 514 Data Mining
- CES 516 High Performance Computing
- CES 520 Embedded Systems
- CES 522 VLSI Design
- CES 524 Advanced Computer Architecture
- CES 530 Analog and Digital Microelectronics
- CES 546 Data Compression
- CES 592 Selected Topics in Hardware and Software Systems

Bioengineering Track Courses

Group 1:

Take at least three but not more than four courses from Group 1

- CES 561 Computational Techniques for Biomolecules
- CES 562 Biomedical Instrumentation
- CES 563 Biophotonics
- CES 564 Medical Image Processing
- CES 592B Selected Topics in Bioengineering

Group 2:

Take at least one and not more than two courses from Group 2

- CES 512 Theory of Software Systems
- CES 514 Data Mining
- CES 516 High Performance Computing
- CES 546 Data Compression

The courses are selected with the approval of the student's faculty advisor to ensure that they form a cohesive plan of study in the desired subject area.

Culminating Experience through Thesis/Design Project/Lab and Technical Report Experience

All students are required to complete a culminating experience which may take one of the following three forms:

- Research and Thesis (Plan A)
- Design Project (Plan B)
- Lab and Technical Report Experience (Plan C)

A supervisory committee is appointed for the students who choose Plan A or Plan B. A supervisory committee consists of three faculty members. One of the three members can be an adjunct faculty. A student interested in choosing Plan A or B chooses a faculty member to be his/her thesis/project supervisor. Subsequently, the faculty supervisor becomes chairman of the student's supervisory committee. In consultation with the faculty supervisor, two other members of the committee are selected. For a student choosing Plan C, an advisor is appointed by the Program Director to guide the student through this plan.

Under Plan A, a student chooses to do thesis research and write a thesis under the guidance of the faculty supervisor and members of the supervisory committee.

Under Plan B, a student chooses to prepare a design project focused on the design of devices, instruments, or systems. As in the case of Plan A, the project is mentored by the student's faculty supervisor and members of the supervisory committee.

Upon approval by the student's supervisory committee, the thesis research or design project may be carried out at the student's company's site (if the student is working) under the supervision of an approved senior scientist/engineer of the company. However, a SSU faculty supervisor must oversee the research/project and regularly examine the student's progress. While not a requirement for graduation, it is expected that the results of the research/project will be presented in an appropriate technical conference and/or published in a relevant professional journal.

Plan C, Lab and Technical Report Experience (LTR Experience), provides students with the opportunity to take more courses to develop a deeper knowledge in their areas of interest instead of carrying out research or design projects, gives extensive exposure of the state-of-the-art equipment in various laboratories, and develops technical report writing skills.

Internship Requirement

As a part of culminating experience, each MS-CES student is required to do an internship in an industry, university, laboratory, utility company, government organization, etc. The objective of the internship must be to gain hands-on training in dealing with and solving real world engineering problems within the scope of the student's plan of study. The internship must be completed within one year. The number of hours worked as an intern should be at least 100, preferably much more. The supervisory committee's and graduate coordinator's approval must be obtained before starting the internship. After completion of the internship, a report of the work done and achievements certified by the intern-supervisor must be submitted to the supervisory committee and department for its acceptance.

Students with industrial experience can petition for a waiver of the internship requirement. However, the petition may be considered by the student's supervisory committee and the graduate coordinator of the MS-CES program only if the student can support the petition with proper supporting evidence that he/she fulfills this requirement based on his/her past industrial experience.

Degree Requirements

A student must complete 30 to 33 units to graduate depending upon the culminating experience plan chosen as given below:

<i>Plan A</i>	<i>(Thesis, 30 units)</i>
Common Core	9 units
Track Core	12 units
Electives	3 units
Thesis	6 units
<i>Plan B</i>	<i>(Project, 30 units)</i>
Common Core	9 units
Track Core	12 units
Electives	6 units
Design Project	3 units
<i>Plan C</i>	<i>(LTR Experience, 33 units)</i>
Common Core	9 units
Track Core	12 units
Electives	9 units
CES 593	3 units

The purpose of technical elective courses is to provide a student with greater depth and/or breadth in his/her area(s) of interest. A technical elective course can be from any of the three lists of the track courses and must be at 500-level.

GPA Requirements

Please refer to this catalog and the department office for various general academic regulations and specific requirements for graduate students such as grade point average requirement, course repeat policy, continuation in the program, etc.

Laboratories

The program has the following eight state-of-the art laboratories in various areas of interest located in the Cerent Engineering Sciences Complex in Salazar Hall.

- AFC Access Technologies Laboratory
- Agilent Technologies Communications Laboratory
- Rolf Illsley Photonics Laboratory
- William Keck Microanalysis Laboratory
- Networking Laboratory
- Human-Computer Interaction and Systems Laboratory
- Software Engineering Laboratory
- Electronics Laboratory

These labs provide excellent facilities to our students and faculty for hands-on experience, research, project development, implementation, and testing. Many of these labs are sponsored by the high-tech industries in the North Bay region of the San Francisco area.