ENGINEERING SCIENCE

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Bachelor of Science in Engineering Science / Sample Four-Year Programs for Bachelor of Science in Enginerring Science / Master of Science in Computer and Engineering Science / Engineering Science Courses

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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 Communications and Photonics or Computer Hardware and Software Systems)

As defined in the 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 applications of many diverse electrical, electronic, and magnetic devices and systems.

The 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.

The focus of the BSES curriculum is Electronics and Communication. However, it 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 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 the students with the opportunity for gaining self-development, technical competence, and awareness of economic and ethical responsibilities.

Bachelor of Science in Engineering Science*

(Emphasis in Electronics and Communications)

* For the start date of the program, please see the program Web site www.sononma.edu/scitech/msces

Consistent with the mission of the University, the mission of the BS-ES 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, leadership roles in business and community.

The B.S. in Engineering Science (ES) 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 (1) 51 units of General Education courses, (2) a 40-unit core in mathematics and sciences (9 units overlap with GE units), (3) a 41-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, networking, and (4) a 6-unit 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 coursework. 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 enhance students' communication and interpersonal skills.

LEARNING OBJECTIVES

- Students will receive a broad education, which will enable them to understand the impact of engineering solutions in global, local, social, and professional contexts.
- Students will acquire the ability to apply fundamental knowledge of mathematics, science, and engineering to analyze and solve practical problems in the field of electronics and communications. This will include formulation of new ideas and projects, feasibility study, planning, design, implementation, and performance and cost trade-offs.
- Students will acquire expertise to design and conduct scientific and engineering experiments, analyze data and interpret results.
- Students will develop abilities necessary for analysis, modeling, simulation, design, testing, and manufacturing of electronics and communications equipment.
- Students will develop critical thinking abilities and abilities to handle multidisciplinary problems in an effective manner.
- Students will develop an ability to communicate effectively.
- Students will develop a solid understanding of professionalism and ethics to enable them to be cognizant of societal issues and their role as future professional engineers working for the general benefit of society.

Degree Requirements

	Units
GE Courses	51
Major requirement	41
Support courses (Science and Mathematics*)	40
Technical Electives	6
*9 units may overlap with GE units	
Total units needed for graduation	**129**

ENGINEERING SCIENCE:

ES 110: Introduction to Engineering & Lab Experience	1
ES 210: Digital Circuit & Logic Design (or CS 250 and CS 251)	3+1
ES 220: Electric Circuits	3

ES 221: Electric Circuits Laboratory	1
ES 230: Electronics I (PHYS 230)	3
ES 231: Electronics I Lab (PHYS 231)	1
ES 310: Microprocessors & System Design	3+1
ES 330: Electronics II	2+1
ES 400: Linear Systems Theory (MATH 430)	3
ES 440: Analog & Digital Communications I	2+1
ES 441: Analog & Digital Communications II	2+1
ES 443: Introduction to Optical Fiber Communication	3
ES 465: Introduction to Networking (CS 465 or CES 440)	2+1
ES 430: Electromagnetic Theory & Applications (PHYS 430)	3
Approved Technical Elective I	3
Approved Technical Elective II	3
ES 493: Senior Design Project	3
Subtotal	**47**

CURRENT LIST OF TECHNICAL ELECTIVES:

CS 355: DBMS Design	3
CS 450: Operating Systems	3
PHYS 340: Light and Optics	3
PHYS 413: Microprocessor Applications	3
PHYS 413L: Microprocessor Applications Laboratory	1
ES 480: Artificial Intelligence (CS 480)	3
ES 432: Physical Electronics (PHYS 475)	3
ES 445: Photonics (PHYS 445)	3

COMPUTER SCIENCE:

CS 110: Introduction to UNIX	1
CS 115: Programming I	4
CS 215: Programming II	3
CS 315: Data Structures	3
Subtotal	**11**

PHYSICS:

PHYS 114: Introduction to Physics I	4
PHYS 214: Introduction to Physics II	4
PHYS 325: Introduction to Mathematical Physics (or MATH 241: Cal III)	3
Subtotal	**8 or 11**

MATHEMATICS:

MATH 142: Discrete Structures I	3
MATH 161: Calculus I	4
MATH 211: Calculus II	4
MATH 241: Calculus III (or PHYS 325)	4
MATH 261: Calculus IV	4
MATH 345: Probability Theory	3
Subtotal	**18 or 22**

GENERAL EDUCATION:

(excluding Math, Physics and CS courses)

ENGL 101: Expository Writing & Analytical Reading	3
Remaining GE courses	39
Subtotal	**42**

Sample Four-Year BSES Program-1

Semester 1	**Units**
ES 110: Introduction to Engineering & Lab Experience	1
CS 110: Introduction to UNIX	1

CS 115: Programming I	4
PHYS 114: Introduction to Physics I	4
MATH 161: Calculus 1	4
ENGL 101: Expository Writing & Analytical Reading	3
Total	**17**

Semester 2

CS 215: Programming II	3
MATH 211: Calculus II	4
PHYS 214: Introduction to Physics II	4
GE	6
Total	**17**

Semester 3

ES 220: Electric Circuits	3
ES 221: Electric Circuits Laboratory	1
MATH 142: Discrete Structures I	3
MATH 261: Calculus IV	4
MATH 345: Probability Theory	3
GE	3
Total	**17**

Semester 4

ES 210: Digital Circuits & Logic Design (w/lab)(or CS 250 & CS 251)	3+1
ES 230: Electronic I	3
ES 231: Electronics I Laboratory	1
MATH 241: Calculus III/PHYS 325: Mathematical Physics	4 or 3
GE	6
Total	**17**

Semester 5

ES 310: Microprocessors & System Design (w/lab)	3+1
ES 440: Analog & Digital Communications I (w/lab)	2+1
ES 330: Electronics II (w/lab)	2+1
ES 400: Linear Systems Theory (MATH 430)	3
GE	3
Total	**16**

Semester 6

ES 441: Analog & Digital Communications II(w/lab)	2+1
ES 430: Electromagnetic Theory & Applications	3
CS 315: Data Structures	3
GE	6
Total	**15**

Semester 7

ES 443: Introduction to Optical Fiber Communications	3
Approved Technical Elective I	3
ES 465: Introduction to Networking (w/lab)(CS 465 or CES 440)	2+1
GE	6
Total	**15**

Semester 8	
ES 493: Senior Design Project	3
Approved Technical Elective II	3
GE	9
Total	**15**

Sample Four-year BSES Program-2

Semester 1	**Units**
ES 110: Introduction to Engineering & Lab Experience	1
CS 110: Introduction to UNIX	1
CS 115: Programming I	4
MATH 161: Calculus I	4
MATH 142: Discrete Structures I	3
ENGL 101: Expository Writing & Analytical Reading	3
Total	**16**

Semester 2	
CS 215: Programming II	3
MATH 211: Calculus II	4
PHYS 114: Introduction to Physics I	4
GE	6
Total	**17**

Semester 3	
PHYS 214: Introduction to Physics II	4
MATH 261: Calculus IV	4
MATH 345: Probability Theory	3
GE	6
Total	**17**

Semester 4	
ES 210: Electric Circuits	3
ES 221: Electric Circuits Laboratory	1
MATH 241: Calculus III/PHYS 325: Mathematical Physics	4 or 3
GE	9
Total	**16**

Semester 5	
ES 210: Digital Circuits & Logic Design (w/lab)(or CS 250 and CS 251)	3+1
ES 230: Electronics I	3
ES 231: Electronics I Laboratory	1
ES 400: Linear Systems Theory (MATH 430)	3
GE	6
Total	**17**

Semester 6	
ES 310: Microprocessors & System Design (w/lab)	3+1
ES 440: Analog & Digital Communications I (w/lab)	2+1
ES 330: Electronics II (w/lab)	2+1
CS 315: Data Structures	3
GE	3
Total	**16**

Semester 7	
ES 441: Analog & Digital Communications II (w/lab)	2+1
ES 430: Electromagnetic Theory & Applications	3
ES 443: Introduction to Optical Fiber Communications	3
ES 465: Introduction to Networking (w/lab) (CS 465 or CES 440)	2+1
GE	3
Total	**15**

Semester 8	
ES 493: Senior Design Project	3
Approved Technical Elective I	3
Approved Technical Elective II	3
GE	6
Total	**15**

Master of Science in Computer and Engineering Science

(Specialization in 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. Specifically, this program emphasizes the application of these fields to the design, analysis and synthesis of engineering problem solutions. 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 in SSU.

A linkage with local industry in the form of an Industrial Advisory Board (IAB) is an integral part of the program. Such an advisory board is critical to ensure the program meets local community needs. The IAB 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, equipment and financial support from the industries. Through this linkage 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 student tuition revenue. Therefore, as of this writing, tuition fee for this program is $500 per unit for all students, resident and non-resident. The MS-CES is a 30-unit program, not including any prerequisite work.

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 a regional accrediting association, or an equivalent baccalaureate degree from a foreign institution of high reputation.
2. Attained grade point average of at least 3.0 (A=4.00) in the last 60 semester (90 quarter) units attempted.
3. Earned a minimum score of 550 on the Test of English as a Foreign Language (TOEFL). This requirement applies only to applicants who have not spent at least three years of school at the secondary level (or beyond) where English is the principal language of instruction.
4. Demonstrate competency in writing by one of the WEPT (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 this requirement is to be met by writing an essay, it should be submitted with the application for admission.
5. Completed the following SSU courses or equivalent at the undergraduate level with a GPA of 3.0 or higher:
    - 3 semesters of Calculus (MATH 161, 211, 241)
    - 2 semesters of Calculus-based Physics (PHYS 114 and 214)

- 1 semester of Probability Theory (MATH 345)
- 1 semester of Analog and Digital Electronics (PHYS 230 and 231)
- 2 semesters of Programming in an approved high level Procedural Language (CS 115 and 215)
- 1 semester of Data Structures (CS 315)
- 2 semesters of Computer Design and/or Architecture (CS 250, 251 and 351)

In addition, it is highly desirable, though not required, that students have knowledge of Operating Systems (CS 450).

Note: When possible, the Program offers a highly intense and compressed 4-unit course as CES 490 which covers the major concepts of data structures, assembly language programming and computer design and architecture. Students can take this course, when offered, to satisfy the Prerequisite requirements of CS 315, 250, 251, and 351. Please contact MS-CES office about this offering.

CONDITIONAL ADMISSION

The applicants whose GPA is less than 3.0 but greater than 2.5, 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 (WEPT) REQUIREMENT

All students are required to demonstrate competency in written English known as WEPT requirement. A student can satisfy 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 can take and pass the campus WEPT test
5. A student may write and submit 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 conveying 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.

INTERNSHIP OPPORTUNITIES AND FINANCIAL AID

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

PROGRAM OF STUDY

The Program offers **two tracks** or **areas of specialization**:

- **Track 1: Communications & Photonics** - This area of specialization provides students with the 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.

A student chooses one of the two tracks at the time of admission but can change it in the midstream. However, that may mean taking additional courses to meet the requirements of the new track. A students program of study consists of the following four components: common core, 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 400-level core course was 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.

TRACK CORE

A student must take 12 units of courses from the list of courses for the chosen track. The lists of 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 & 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 & 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 & Software Systems

The courses are selected with the approval of the student's faculty advisor to ensure 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 choosing Plan A or Plan B. A supervisory committee consists of three faculty members. One of the three members could be an adjunct faculty. A student interested in choosing Plan A or Plan B chooses a faculty member to be his/her thesis/project supervisor who becomes chairman of his/her supervisory committee. In consultation with the faculty supervisor, then, two other members of the committee are selected. The committee must be approved by the director of the program. As a faculty member, director of the program may also serve on a student's supervisory committee as the chair or a member. 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 may choose to research and write a 6 unit thesis which is mentored by the student's faculty supervisor and supervised by his/her supervisory committee.

Under Plan B, a student may decide to prepare a design project for 3 units. Projects should focus on the design of devices, instruments or systems. As in the case of Plan A, project is mentored by the student's faculty supervisor and supervised by his/her 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 a senior scientist/engineer. 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 for taking 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 survey and report writing skills.

TECHNICAL ELECTIVES

A student must take 3 to 9 units of technical electives approved by his/her faculty advisor depending upon the culminating experience plan chosen as given below:

Plan A	**(Thesis, 30 units)**
Common Core	9 units
Track Core	12 units
Electives	3 units
Thesis	6 units

Plan B	**(Project, 30 units)**
Common Core	9 units
Track Core	12 units
Electives	6 units
Design Project	3 units

Plan C	**(LTR Experience, 33 units)**
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 two lists of the track courses and must be at 500-level.

LEARNING OBJECTIVES

The curriculum of the MS-CES Program has been designed to meet the following learning objectives:

1. Developing knowledge in multiple interrelated disciplines.
2. Learning mathematical tools to model and analyze scientific and engineering problems.
3. Learning theory of high performance computing, communications and/or networking.
4. Developing critical thinking ability and the learning of analytical and simulation tools to do system performance evaluation.
5. Developing ability to apply theory to design and implement efficient computing and/or communications systems.
6. Developing ability to integrate knowledge from multiple interrelated disciplines to formulate, design and/or implement interdisciplinary projects.
7. Ability to investigate and formulate research problems and/or design projects.
8. Ability to learn and research independently.
9. Developing written and oral communication skills.

A student's plan of study is designed such that all the nine learning objectives are covered by the courses selected. This is ensured by the student's faculty advisor.

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 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.

Engineering Science Courses

ES 110: Introduction to Engineering & Laboratory Experience (1)

Lecture, 0.5 hr., Laboratory, 1.5 hrs. This course is designed to introduce principles of engineering to the students and expose them to the electronics and computer lab environment. The students are given the opportunity to design and built some simple analog and digital circuits and make measurements using various types of lab equipment.

ES 210: Digital Circuit & Logic Design (4)

Lecture, 3 hrs., Laboratory, 3 hrs. Logic gates; combinatorial logic and analysis and design of combinatorial circuits; electronic circuits for various logic gates. Flip-flops, registers, and counters; sequential circuits and state machines. Various logic families and comparison of their electrical characteristics such as fan-out, rise and fall times, delay, etc. Concepts of machine, assembly and high-level languages and relationship between them, basic principles of computer design. Laboratory work will include designing, building and testing of digital circuits, logic and sequential circuits.
Prerequisite: MATH 142, Co-requisite: ES 230; or consent of instructor.

ES 220: Electric Circuits (3)

Lecture, 3 hrs., Laboratory, 0 hrs. Review of Kirchhoff's laws, circuit design, node and mesh analysis, etc.; Thevenin's theorem, Norton's theorem, steady state and transient analysis, transfer function. AC power and three-phase circuits, Y-Delta equivalents. Multi-port networks, two-port networks with energy storage, ideal transformers. Amplifiers and frequency response, filters.
Prerequisites: MATH 211 and PHYS 214; or consent of instructor.

ES 221: Electric Circuits Laboratory (1)

Lecture 0 hrs., Laboratory, 3 hrs. Laboratory work on material treated in ES 220 emphasizing elementary design principles.

ES 310: Microprocessors & System Design (4)

Lecture, 3 hrs. , Laboratory, 3 hrs. Hardware architecture of a microprocessor and its programming and instruction design; memory hierarchy and I/O interfaces; comparison of various microprocessor architectures and capabilities; system design using microprocessors. Laboratory work.
Prerequisites: ES 210 and ES 230; or consent of instructor.

ES 330: Electronics II (3)

Lecture, 2 hrs., Laboratory, 3 hrs. Analysis and design of high frequency amplifiers; high frequency models of transistors; operational amplifiers and applications; feedback amplifiers; oscillators, modulators, bandpass amplifiers, and demodulators for communications. Laboratory work.
Prerequisite: ES 230 or consent of instructor.

ES 440: Analog & Digital Communications I (3)

Lecture, 2 hrs., Laboratory, 3 hrs. Mathematical modeling of signals; time and frequency domain concepts; spectral density; components of a communications system; analog signal transmission. AM, FM and PM modulation and demodulation techniques; noise and bandwidth; link analysis. Laboratory work.
Prerequisite: ES 230, Corequisite: ES 400; or consent of instructor.

ES 441: Analog & Digital Communications II (3)

Lecture, 2 hrs., Laboratory, 3 hrs. Digital signals and their transmission; PCM, log-PCM, ADPCM, and DM and other low bit rate coders. Digital data transmission; data encoding; clock recovery and BER; data modulation techniques; ASK, FSK, PSK, and QAM. Link budgets for satellite, cellular, and cable systems; the effects of noise and bandwidth. Laboratory work.
Prerequisite: ES 440 or consent of the instructor.

ES 443: Introduction to Optical Fiber Communications (3)

Lecture: 3 hrs; Laboratory: 0 hrs. Principles of light wave propagation, and propagation in an optical fiber; fiber characteristics; O/E and E/O conversions; coupling; WDM; modulation techniques for efficient information transmission; system design.
Prerequisite: ES 441 or consent of the instructor.

ES 493: Senior Design Project (3)

This is a capstone course. A major project designed to bring the knowledge gained from various courses together to analyze, design, and implement an electronic ad/or communications system in an efficient and economic manner.
Prerequisite: consent of the instructor.

Master of Computer and Engineering Science (CES) Courses

CES 400: Linear Systems Theory (3)

Lecture, 3 hrs. Analysis of linear time-invariant systems; correlation; convolution; impulse response; complex variables; Fourier series and transform; sampling; filtering; modulation; stability and causality; feedback and control systems; Laplace and Z-transform; fast Fourier transforms.
Prerequisite: MATH 241 or consent of instructor.

CES 430: Photonics (3)

Lecture, 3 hrs. Lasers, diode lasers, and LED's; fiber optics; optical radiation detectors.
Prerequisites: A course in modern Physics (such as PHYS 314) and electromagnetism (such as PHYS 430).

CES 432: Physics of Semiconductor Devices (3)

Lecture, 3 hrs. Semiconductor materials, crystal structure, and growth; energy bands and charge carriers; conductivity and mobility; metal-semiconductor and p-n junctions; p-n junction diodes; bipolar junction transistors; field-effect transistors; CCD's; photonic devices; and integrated circuits. Projects in photolithography; conductivity and contact resistance measurements; I-V and C-V characteristics of diodes; characterization of transistors may be assigned.
Prerequisite: PHYS 314 or consent of instructor.

CES 440: Data Communications (3)

Lecture, 2 hrs, Laboratory, 3 hrs. The ISO reference model; theoretical basis for data communications; data transmission theory and practice; telephone systems; protocols; networks; internetworks with examples.
Prerequisites: CS 215, MATH 345 and PHYS 214 and 216, or consent of instructor.

CES 490: Selected Topics in CES (1-3)

Special topics to introduce new emerging fields, provide foundation for advanced graduate level courses or augment other courses in computer and engineering science. Prerequisite: consent of instructor.

CES 494: Directed Readings (1-3)

Independent study under a faculty. The proposal must be approved by the graduate advisor if the course is to apply towards degree requirements. Prerequisite: consent of instructor.

CES 500: Queuing and Transform Theory (3)

Lecture, 3 hrs. Review of probability theory, fundamentals of transform theory, Fourier and Z-transforms. Markovian and discrete time queuing systems, single and multi server queues, queuing networks and their applications. The course may require significant lab and/or project activity.
Prerequisites: MATH 345 and 261 or consent of instructor.

CES 510: Intelligent Systems Design (3)

Lecture, 3 hrs. Introduction to adaptive systems: neural networks, genetic algorithms (GAs), fuzzy logic, simulated annealing, tabu search, etc. Specific topics include perceptions, backpropagation, Hopfield nets, neural network theory, simple Gas, parallel Gas, cellular Gas, schema theory, mathematical models of simple Gas, and using Gas to evolve neural networks. Prerequisites: CS 315 and CES 400, or consent of instructor.

CES 512: Theory of Software Systems (3)

Lecture, 3 hrs. Review of data structures and basic algorithms for sorting and string processing. Basics of logic, formal systems, grammars, and automata. Applications to some of the following areas: design of language processing tools (editor, translator etc.), software specification, testing and verification, non-numerical problem solving. The course may require significant lab and/or project activity.
Prerequisite: CS 315 or consent of nstructor.

CES 514: Data Mining (3)

Lecture, 3 hrs. Introduction to data models, data warehousing, association-rule mining, searching the Web, Web Mining: Clustering. AI techniques (neural networks, decision trees), applications, and case studies. The course may require significant lab and/or project activity.
Prerequisite: CS 315 or consent of instructor.

CES 516: High-Performance Computing (3)

Lecture, 3 hrs. Algorithmic tools and techniques for problems hard to solve on a standard uniprocessor model, such as problems involving large data sets or real-time constraints; development of computational models to analyze the requirements and solutions and special hardware-based solutions; case studies to illustrate the developed models, tools, and techniques. The course may require significant lab and/or project activity.
Prerequisite: CS315 or consent of instructor.

CES 520: Embedded Systems (3)

Lecture, 3 hrs. Three major topics covered in this course are: controlling specialized I/O devices with particular attention to bit patterns and priority interrupts; waveshapes and measurement tools, both hardware and software; and real-time operating systems.
Prerequisites: PHYS 230-231 and CS 351, or consent of instructor.

CES 522: VLSI Design (3)

Lecture, 3 hrs. IC technology review; hardware description languages and describing hardware using one of the languages, modern VLSI design flow; circuit partitioning; clustering. Floorplanning; placement; global routing; area-efficient design; area-time tradeoffs The course may require significant lab and/or project activity.
Prerequisite: CES 530 or consent of instructor.

CES 524: Advanced Computer Architecture (3)

Lecture, 3 hrs. Concept of advanced computing architectures, pipelining; multiprocessing and multiprogramming, Single and multi-stage interconnection networks, applications/ algorithms for parallel computers; local and system bus architectures; CPU and computer system performance analysis. The course may require significant lab and/or project activity.
Prerequisites: CS 351 and CS 450, or consent of instructor.

CES 530: Analog and Digital Microelectronics (3)

Lecture, 3 hrs. Introduction to analog/digital integrated circuits; bipolar and MOS transistor models; analysis and design of monolithic operational amplifiers; frequency response; non-linear circuits and CMOS, and Bipolar Logic Circuits. The course requires lab and/or project activity.
Prerequisites: PHYS 230-231 and CES 432, or consent of instructor.

CES 532: Advanced Photonics Devices (3)

Lecture, 3 hrs. Optical resonators, interaction of photons with materials, LED's, laser diodes, optical amplifiers, optical noise, photoconductors, electro-optic modulators, photonic switches, nonlinear optical materials, and devices. The course requires lab and/or project activity.
Prerequisite: CES 430 or equivalent.

CES 540: Digital Data Transmission (3)

Characteristics of base-band and bandpass channels, optimum signaling sets, and receivers for digital communications; effect of noise and intersymbol interference on probability of error; channel capacity; introduction to phase-locked loop analysis for timing and carrier synchronization.
Prerequisites: CES 400 and 440, or consent of instructor.

CES 542: Digital Signal Processing (3)

Lecture, 3 hrs. Time/frequency analysis of discrete-time signals and systems. Fast implementations of the DFT and its relatives. IIR and FIR digital filter design, implementation, and quantization error analysis. Decimation, interpolation, and multirate processing.
Prerequisite: CES 400 or consent of instructor.

CES 543:Optical Fiber Communications (3)

Lecture, 3 hrs. Lightwave fundamentals; optical fiber as transmission media; losses and bandwidth; fiber cables. Optical sources, detectors. Optical components such as switches, access couplers, wavelength multiplexers and demultiplexers. Analog and digital transmission techniques; line coding techniques; optic heterodyne receivers; thermal and shot noise; bit error rates; optical transmission system design. Optical T-carrier systems and SONET; future directions. The course may require significant lab and/or project activity.
Prerequisites: PHYS 230-231 and CES 440 or consent of instructor.

CES 544: Wireless Communications (3)

Lecture, 3 hrs. Introduction to mobile/wireless communication systems; cellular communication; data transmission and signaling; noise and interference; analog and digital techniques; multiple-access architecture. The course requires lab and/or project activity.
Prerequisites: PHYS 230-231 and CES 440, or consent of instructor.

CES 546: Data Compression (3)

Lecture, 3 hrs. Information theory, models, lossless compression (statistical, dictionary, static, dynamic, huffman, arithmetic, context-modeling), lossy compression (scalar quantization, vector quantization, differential encoding, subband, transform, predictive), compression standards (JPEG, MPEG).
Prerequisites: MATH 345 and CS 315, or consent of instructor.

CES 547: Digital Switching: Techniques and Architectures (3)

Lecture, 3 hrs. Review of switching techniques; synchronous and asynchronous transfer modes (i.e., STM and ATM); various switch architectures. Multirate and multipoint-to-multipoint switching; ATM switching, signaling and call set-up; ATM switch-architectures and their performance evaluation; multicasting techniques. VLSI implementation considerations, future directions. The course may require significant lab and/or project activity. Prerequisites: MATH 345, PHYS 230-231, and CES 440, or consent of instructor.

CES 550: Integrated Digital Networks (3)

Lecture, 3 hrs. Information types and signals; definitions of services and integration; narrowband ISDN and frame relay protocols; broadband ISDN concept and protocol. Integrated environment and ATM; principles of SONET and ATM transmission; broadband ATM networking; future trends. The course may require significant lab and/or project activity.
Prerequisite: CES 440 or consent of instructor.

CES 552: Network Architecture and Protocols (3)

Lecture, 3 hrs. ISO model, review of the physical and data link layers, network layer, and routing including for Internet; multicast routing; TCP and UDP protocols and their characteristics, performance and limitations; TCP/IP stack; applications such as FTP, e-mail and DNS, voice over IP. The course may require significant lab and/or project activity.
Prerequisite: CES 440 or consent of instructor.

CES 554: Broadband Access Technology (3)

Lecture, 3 hrs. Review of ISDN and B-ISDN Protocols; digital subscriber loops; digital modems. The xDSL technology; xDSL family of protocols; ADSL standardization, its architecture, operation, implementation and management; ATM; TCP/IP; Ethernet transmissions using ADSL; optical access. The course may require significant lab and/or project activity.
Prerequisite: CES 440 or consent of instructor.

CES 558: Multicasting on the Internet (3)

Lecture, 3 hrs. Multicasting fundamentals; multicast routing algorithms; IP multicast; architecture and operation of MOSPF, PIM, CBT, OCBT, HDVMRP, HPIM, BGMP; and Mbone protocols. Real-time Transport protocol and scalable reliable multicast, reliable multicast transport protocols. Multicasting in ATM networks; IP multicast over ATM; future directions. The course may require significant lab and/or project activity.
Prerequisite: CES 552 or consent of instructor.

CES 590: Selected Topics in Communications and Photonics (3)

Special topics to augment regularly scheduled graduate courses in communications and photonics will be presented.
Prerequisites depend on subject material.

CES 592: Selected Topics in Hardware and Software Systems (3)

Special topics to augment regularly scheduled graduate courses in hardware and software systems will be presented.
Prerequisites depend on subject material.

CES 593: Lab and Technical Report Experience (3)

Lecture, 1 hr., Laboratory, 6 hrs. In this course, students will learn to operate state-of-the art equipment in at least 6 laboratories, perform experiments, and write lab reports. In addition, students will write a technical report on a state-of-the art topic within the scope of the master's

program of at least 3000 words excluding figures and tables. (The course cannot be taken to meet 30-unit requirement under thesis or project option unless approved by the Program Director).
Prerequisite: Permission of student's advisor.

CES 594: Directed Readings (1-3)

Independent study under a faculty. The proposal must be approved by the graduate advisor if it is to apply towards degree requirements.
Prerequisite: consent of instructor.

CES 595: Design Project (1-3)

The project plan, timetable, necessary resources, and the expected outcome must be approved by a faculty project advisor and the program advisor at least one semester before taking the course.
Prerequisite: Admission of candidacy for the Master's degree and approval of the faculty advisor.

CES 596: Project Continuation (1-3)

Designed for students working on their Thesis or Design project but who have otherwise completed all graduate coursework toward their degree. This course cannot be applied toward the minimum number of units needed for completion of the master's degree.
Prerequisite: consent of faculty thesis/project advisor.

CES 597: Graduate Seminar (1)

Series of lectures presented by experts from academia and industries.

CES 598: Comprehensive Examination (1)

In this four-hour examination the students' overall understanding of important concepts of the core courses and the main subjects of each track will be tested. Prerequisites: Advancement to candidacy for the Master's degree and approval of the graduate advisor.

CES 599: Research and Thesis (1-6)

Prerequisites: Admission of candidacy for the Master's degree and approval of the thesis advisor.

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THE CALIFORNIA STATE UNIVERSITY