



COMPUTER ENGINEERING AT AUBURN UNIVERSITY

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ABSTRACT

The computer engineering program offered by the Electrical Engineering Department of Auburn University is described. Bachelors, masters, and Ph.D. degree programs in Electrical Engineering may be pursued with specialization in computer engineering. Auburn's computer engineering program is structured to emphasize computer system design and utilization including both hardware and software considerations.

A broad spectrum of courses is offered in computer engineering at both the undergraduate and the graduate level. Brief descriptions of the courses are given in the paper. Subjects covered in the courses range from traditional topics such as logic design, computer organization, and programming to various specialized topics. Computer architecture, computer graphics, coding theory, fault diagnosis, and fault-tolerant computing are but some of the specialized topics covered.

Research is a fundamental aspect of any graduate program. The computer engineering research activities at Auburn are described in the paper. Graduate students, undergraduate students, and faculty participate in a wide range of sponsored and unsponsored projects. Laboratory facilities available for support of the projects will also be discussed.

Another important aspect of the computer engineering program at Auburn is extension activities. Short course and conference activities oriented toward computer engineering are frequently offered by the faculty at various locations within the state of Alabama and are briefly discussed here.

INTRODUCTION

The Electrical Engineering Department of Auburn University offers the opportunity for students at both the undergraduate and graduate levels to pursue a course of study in computer engineering. This paper presents a description of the computer engineering program and facilities available at Auburn.

Computer engineering can be defined as that branch of engineering concerned with the organization, design, and utilization of digital processing systems as general purpose computers or as components of larger systems.¹ Perhaps the distinction between computer engineering and computer science can best be made by taking a closer look at each. The computer scientist is interested in programming, in numerical analysis, and in the abstract theories of computation and languages. Computer science programs are most often found in the college of arts and sciences. Also, the faculty of computer science programs frequently have backgrounds from mathematics, science, or perhaps business.^{1,2} On the other hand, the computer engineer is interested in the design and utilization of digital processing systems including both the hardware and software components. Such systems may be stand-alone systems such as a general-purpose computer or they may be a component of a larger system such as an air traffic control and landing system. Computer engineering programs are usually found in electrical engineering

departments within the engineering college and are staffed by faculty with engineering backgrounds.

Computer engineering at Auburn is an informal program, i.e., degrees in computer engineering are not offered, within the Electrical Engineering Department. Students at the undergraduate level may specialize in computer engineering by majoring in electrical engineering and by selecting computer engineering courses for their technical electives. Graduate students may study computer engineering by enrolling in the electrical engineering graduate program and choosing computer engineering courses for their plan of study. Both master's and doctoral degrees may be pursued. Students without an electrical engineering undergraduate degree may be eligible for the graduate computer engineering program.

Auburn's computer engineering program is staffed by four permanent faculty members, an adjunct faculty member, an electrical engineer, a research associate, and numerous graduate students. All of the full-time staff plus most of the graduate students have electrical engineering backgrounds. In addition, other EE faculty occasionally teach some of the undergraduate computer engineering courses.

The computer engineering program at Auburn encompasses a wide spectrum of activities to help fulfill the University's responsibility as a land-grant institution. More specifically, the program is involved in not only instruction but also in research and extension activities. A more detailed description of the program is presented in the remaining sections of this paper.

UNDERGRADUATE PROGRAM

All undergraduate students at Auburn who major in electrical engineering are required to take ten quarter-hours of coursework in the computer engineering area. The required courses are listed below by number and title. Figure 1 shows the pre-requisite structure of all computer engineering courses.

EE 322	Combinational Logic Circuits
EE 324	Sequential Logic Circuits
EE 425	Minicomputer Organization and Assembly Language Programming

The following electrical engineering courses are recommended as electives for those students interested in computer engineering.[†]

EE 429	Computer Projects Laboratory
EE 499	Special Projects
EE 520	Computer Graphics Systems
EE 521	Artificial Intelligence and Robotics
EE 522	Digital Subsystems
EE 523	Fault Diagnosis of Digital Systems
EE 524	Microcomputers
EE 526	Minicomputer Laboratory
EE 527	Systems Programming
EE 528	Compiler Development
EE 547	Digital Signal Processing

[†]Those courses with a 500 number may be taken for graduate credit.

Computer engineering electives may also be chosen from the following non-electrical engineering courses.

IE 204	Computer Programming
IE 384	Data Structures
IE 385	Computer Programming Systems I
IE 485	Computer Programming Systems II
IE 486	Fundamental Algorithms
MH 460	Introduction to Numerical Analysis
MH 461	Numerical Matrix Analysis

This program is in close agreement with the model curriculum currently being developed by the IEEE Computer Society's Education Committee.²

GRADUATE PROGRAM

Graduate students wishing to concentrate their programs in computer engineering may do so by enrolling in the electrical engineering graduate program and selecting courses according to their interest. The degrees that are offered are discussed below.

Master of Electrical Engineering (M.E.E.) - This degree is accredited by ECPD and is intended for students whose undergraduate degree is in electrical engineering from an ECPD accredited program. Thesis and non-thesis options are available on this degree program. The thesis option requires forty-five quarter-hours of graduate course work including thesis. Forty-five hours are also required for the non-thesis degree which is designed primarily for students who have had a significant amount of engineering experience prior to entering graduate school.

Master of Science (M.S.) - This is a non-accredited degree intended for students with an undergraduate degree in a subject other than electrical engineering or from a program not accredited by ECPD. Forty-five hours of course work including a thesis is required.

Doctor of Philosophy (Ph.D.) - Requirements include at least eighty quarter-hours of graduate course work beyond the bachelor's degree, reading knowledge in two foreign languages or the equivalent, and a dissertation.

The following graduate-level courses are offered for those students pursuing computer engineering.

EE 621	Switching Theory I
EE 622	Switching Theory II
EE 623	Coding Theory
EE 626	Computer Architecture I
EE 627	Computer Architecture II
EE 640	Digital Computer Systems
EE 642	Fault-Tolerant Computing
EE 643	Software Development
EE 644	Theory of Compilers
EE 646	Artificial Intelligence and Pattern Recognition
EE 647	Digital Filter Theory

The prerequisite structure for these courses is shown in Figure 1.

Currently, fifteen students are enrolled in computer engineering studies. Many of these students receive financial support while pursuing their degrees. Sources of support include teaching assistantships, research assistantships, General Motors Institute, U.S. Air Force Institute of Technology, and graduate fellowships. The research assistantship funds are provided from research contracts with various agencies as discussed in the next section.

Individual and special projects courses are an important and popular extension to the list of fixed topic courses. By enrolling in such courses, advanced students have an opportunity to obtain varying amounts of credit for work on a project of special interest to them. The results from these courses often include a program or a piece of hardware that is useful or needed for a particular instructional or research purpose. Students working on special project courses sometimes continue to do further work on their project after entering graduate school.

Perhaps the most difficult aspect of a computer engineering program is keeping the program current since computer technology is such a rapidly advancing field. Auburn's approach to maintaining a relevant program is multifaceted. In particular, close contact is maintained with government and industry through research and extension activities of the faculty and students. Other growth type activities include participation in professional societies, attending conferences and seminars, keeping abreast of the latest developments as published in professional and trade journals, and by contributing papers to conferences and journals.

RESEARCH PROGRAM

Auburn's computer engineering research program encompasses both sponsored and unsponsored projects. Currently funded projects include the following.

<u>Title</u>	<u>Sponsor</u>
Advanced Computer System Studies and Development	NASA-MSFC (NAS8-26930)
Design, Processing, and Test of LSI Arrays	NASA-MSFC (NAS8-31572)
Development of Techniques and Procedures for Advanced Tool Development Prototype Fabrication	U.S. Army Missile Command (DAAH01- 76C-0328)
Marine Air Traffic Control and Landing System	Naval Electronic Systems Command

Qualified students may receive research assistantships with stipends ranging from \$3,000 to \$5,000 per year.

The projects listed below are representative of the unsponsored projects that are carried on by students and faculty.

- A Logic Simulator for Use in Instruction
- A Language for Representation and Manipulation of Boolean Functions
- Computerized Graph Theoretic Methods for Finding Feedback and Reconvergent Fan-out in Logic Circuits

Memory Elements for Multiple-Valued Logic
 Microcomputer Control of a Building Environment
 Statistical Models for Software Reliability
 Computer Recognition and Generation of Speech
 A Simulation Language for Industrial Programmable Controllers

In order to provide a local forum for dissemination of the research efforts, a computer engineering seminar is held on a fairly regular basis. Auburn students and faculty present the results of their research to other students and faculty at the seminar.

FACILITIES

A wide range of computing facilities are available to computer science and engineering students at Auburn University.

IBM 370/155 - The University Computer Center operates a large scale computer system which batch processes student programs written in many different languages; i.e., FORTRAN IV, COBOL, ALGOL, PL/1, RPG, BAL and others. The system has 4 remote batch terminals and supports interactive timesharing.

HP2000 - The University in conjunction with the School of Engineering provides a timeshare system for all university students. The system is controlled by two mini-computers which operate 32 interactive terminals. Students write their programs on the terminals using the BASIC language.

H316 - The Electrical Engineering Department provides a software development facility which centers around an H316 minicomputer system. Student programs are written in FORTRAN and Assembly Language (DAP-16).

Logic Laboratory - A logic laboratory, in which the fundamental building blocks of digital computers are analyzed, is maintained by the Electrical Engineering Department. Students learn to build digital subsystems.

PDP 11 - The Electrical Engineering Department operates its own timesharing facility, a PDP 11/40 RSTS/E system. The system supports character terminals, graphics CRT's, microprocessors, and a graphics laboratory.

Hybrid Computer - The department maintains a large hybrid computer laboratory. Two EAI 580 computers and a MINIAC are available. Also a Raytheon 520 digital machine is interfaced to an EAI 231RV analog computer.

PEPE - A parallel element processing ensemble consisting of sixteen parallel processors under global control of an HP2114 and an HP2100 minicomputer is available in the Electrical Engineering Department for studies in advanced machine architecture and software development.

Microcomputers - A new microcomputer laboratory has been installed to support the computer engineering program. INTEL 4040, 8008, and 8080 machines are available, as well as DEC LSI-11 machines. These microcomputers are interfaced to the PDP 11. Fairchild F8 and Motorola M6800 installations are planned.

Graphics - Three storage tube graphics displays with a hard copy unit and a DEC GT42 (refreshed mode) graphics unit are provided for instruction in interactive computer graphics and in support of research.

EXTENSION ACTIVITIES

Auburn University has long recognized its responsibility in the field of extension services. For many years Auburn has faithfully extended its resources and services to the people of the State and region. The Electrical Engineering Department conducted its first intensive course in 1892 and has continued the fine tradition established at that time. The Department's extension short courses have been attended by educators, researchers, engineers and scientists from across the Nation. Courses range in complexity from fundamental review workshops to advanced theoretical design seminars. Electrical Engineering at Auburn is proud of its record in extension activities and intends to place even more emphasis on this important function in the future.

A list of available digital computing short courses follows:

1. Introduction to Digital Systems
2. BASIC Programming
3. FORTRAN Programming
4. Assembler Programming
5. Minicomputer Systems
6. Minicomputer Software
7. Microcomputers
8. Coding Theory
9. Computer Architecture
10. Real-Time Computer Systems
11. Software Engineering
12. Systems Software
13. Digital Systems Reliability and Fault Diagnosis
14. Digital Signal Processing

Courses are administered by the Engineering Extension Service at Auburn and are conducted throughout the State and region.

PROFESSIONAL ACTIVITIES

The professional activities of the faculty are an integral part of the overall computer engineering program at Auburn University. One of the faculty members organized the Alabama Chapter of the IEEE Computer Society. The IEEE Computer Society has a list of nationally known experts called the Distinguished Visitors List. These individuals are invited to speak throughout the country on their area of technical expertise. One of the members of the computer engineering faculty is a Distinguished Visitor. Another member of the computer engineering faculty is the Education Editor for Computer and a member of the IEEE Computer Society's Education Committee. Another faculty member is on the Board of Directors of Eta Kappa Nu, national electrical engineering honorary society.

CONCLUSION

The goal of Auburn University is threefold: instruction, research, and extension. The computer engineering program at Auburn stresses all three goals. The emphasis placed in this area in recent years by the Electrical Engineering Department demonstrates that Auburn University is firmly committed to providing a broad-based computer engineering program to help supply well educated engineering specialists as needed by the state and nation.

REFERENCES

1. C. L. Coates, Jr., et.al., "An Undergraduate Computer Engineering Option for Electrical Engineering," Proceedings of the IEEE, vol. 59, no. 6, June 1971, pp. 854-860.
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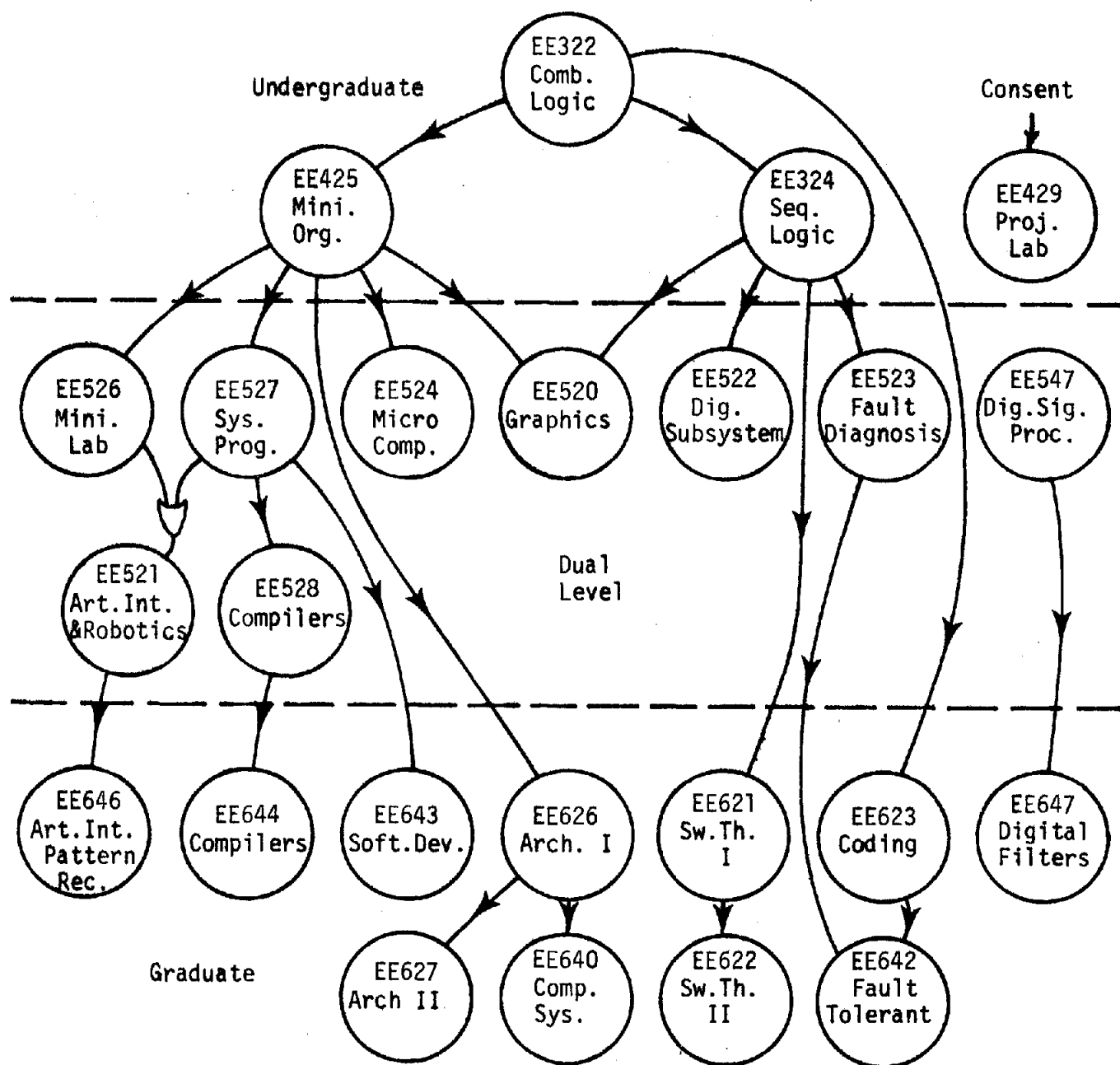


Figure 1