Currículo EC
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Capa Documento

Computer Engineering

Curricula 2016

Curriculum Guidelines for
Undergraduate Degree Programs
in Computer Engineering

A Report in the Computing Curricula Series

Joint Task Group on Computer Engineering Curricula

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Engenharia de Computação

Computer engineering is a discipline that embodies the science and technology of design, construction, implementation, and maintenance of software and hardware components of modern computing systems and computer-controlled equipment.

Princípios do Documento ACM/IEEE

10. This computer engineering report must strive to be international in scope. Despite the fact that curricular requirements differ from country to country, this report must be useful for computing educators throughout the world. Although educational practice in the United States may influence curriculum, the report should make every effort to ensure that the curriculum recommendations are sensitive to national and cultural differences so that they will be widely applicable throughout the world.

13. Integration of hardware-software systems is critical to the work of computer engineering. Since computer systems include integrated hardware and software components, this report should emphasize the development of a "whole computer" or a "complete computer" in the laboratory experiences that include exposure to hardware, operating systems, and software systems in the context of relevant applications.

Contexto

2.1 Background

Computer engineering is a discipline that embodies the science and technology of design, construction, implementation, and maintenance of software and hardware components of modern computing systems, computer-controlled equipment, and networks of intelligent devices. Traditionally, computer engineering is some combination of both electrical engineering (EE) and computer science (CS). It has evolved over the past four decades as a separate discipline, although intimately related to computer science and electrical engineering. Computer engineering is solidly grounded in the theories and principles of computing, mathematics, science, and engineering and it applies these theories and principles to solve technical problems through the design of computing hardware, software, networks, and processes.

Contexto

Technological advances and innovation continue to drive computer engineering. There is now a convergence of several established technologies (such as multimedia, computer, and networking technologies) resulting in widespread and ready access to information on an enormous scale. This convergence of technologies and the associated innovation lie at the heart of economic development and the future of many organizations, creating many opportunities and challenges for computer engineers. The situation bodes well for a successful career in computer engineering.

Caracterização do Engenheiro de Computação

2.3 Characteristics of computer engineering graduates

With the ubiquity of computers, computer-based systems, and networks in the world today, computer engineers must be versatile in the knowledge drawn from standard study areas in computer science and electrical engineering as well as the foundations in mathematics and sciences. The rapid pace of change in the computing field requires that computer engineers be lifelong learners to maintain their knowledge and skills within their chosen discipline.

Caracterização do Engenheiro de Computação

2.3.1 Distinctions

An important distinction should be made between computer engineers, electrical engineers, other computer professionals, and engineering technologists. While such distinctions are sometimes ambiguous, computer engineers generally should possess the following three characteristics:

- the ability to design computers, computer-based systems, and networks that include both hardware and software as well as their integration to solve novel engineering problems, subject to trade-offs involving a set of competing goals and constraints—in this context, "design" refers to a level of ability beyond "assembling" or "configuring" systems
- a breadth of knowledge in mathematics and engineering sciences, associated with the broader scope of engineering and beyond that narrowly required for the field
- acquisition and maintenance of a preparation for professional practice in engineering

Caracterização do Engenheiro de Computação

Other related disciplines can be described as follows.

- Electrical engineering spans a wide range of areas, including bioengineering, power engineering, electronics, telecommunications, and digital systems. Related to the field of computer engineering, electrical engineers concern themselves primarily with the physical aspects of electronics including circuits, signal analysis, and microelectronic devices.
- Computer scientists concern themselves primarily with the theoretical and algorithmic aspects of computing with a focus on the theoretical underpinnings of computing.
- Software engineers have a focus on the principles underlying the development and maintenance of correct (often large-scale) software throughout its lifecycle. Information systems specialists encompass the acquisition, deployment, and management of information resources for use in organizational processes.

Corpo de Conhecimento

Table 3.2: CE2016 Body of Knowledge
(CE Core Hours: 420)

Knowledge Areas and Knowledge Units			
CE-CAE	**Circuits and Electronics** [50 core hours]	**CE-CAL**	**Computing Algorithms** [30 core hours]
CE-CAE-1	History and overview [1]	CE-CAL-1	History and overview [1]
CE-CAE-2	Relevant tools, standards, and/or engineering constraints [3]	CE-CAL-2	Relevant tools, standards and/or engineering constraints [1]
CE-CAE-3	Electrical quantities and basic elements [4]	CE-CAL-3	Basic algorithmic analysis [4]
CE-CAE-4	Electrical circuits [11]	CE-CAL-4	Algorithmic strategies [6]
CE-CAE-5	Electronic materials, diodes, and bipolar transistors [7]	CE-CAL-5	Classic algorithms for common tasks [3]
CE-CAE-6	MOS transistor circuits, timing, and power [12]	CE-CAL-6	Analysis and design of application-specific algorithms [6]
CE-CAE-7	Storage cell architecture [3]	CE-CAL-7	Parallel algorithms and multi-threading [6]
CE-CAE-8	Interfacing logic families [3]	CE-CAL-8	Algorithmic complexity [3]
CE-CAE-9	Operational amplifiers [3]	CE-CAL-9	Scheduling algorithms
CE-CAE-10	Mixed-signal circuit design [3]	CE-CAL-10	Basic computability theory
CE-CAE-11	Design parameters and issues		
CE-CAE-12	Circuit modeling and simulation methods		

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CE-CAO	Computer Architecture and Organization [60 core hours]	CE-DIG	Digital Design [50 core hours]
CE-CAO-1	History and overview [1]	CE-DIG-1	History and overview [1]
CE-CAO-2	Relevant tools, standards and/or engineering constraints [1]	CE-DIG-2	Relevant tools, standards, and/or engineering constraints [2]
CE-CAO-3	Instruction set architecture [10]	CE-DIG-3	Number systems and data encoding [3]
CE-CAO-4	Measuring performance [3]	CE-DIG-4	Boolean algebra applications [3]
CE-CAO-5	Computer arithmetic [3]	CE-DIG-5	Basic logic circuits [6]
CE-CAO-6	Processor organization [10]	CE-DIG-6	Modular design of combinational circuits [8]
CE-CAO-7	Memory system organization and architectures [9]	CE-DIG-7	Modular design of sequential circuits [9]
CE-CAO-8	Input/Output interfacing and communication [7]	CE-DIG-8	Control and datapath design [9]
CE-CAO-9	Peripheral subsystems [7]	CE-DIG-9	Design with programmable logic [4]
CE-CAO-10	Multi/Many-core architectures [5]	CE-DIG-10	System design constraints [5]
CE-CAO-11	Distributed system architectures [4]	CE-DIG-11	Fault models, testing, and design for testability

Corpo de Conhecimento

CE-ESY	**Embedded Systems** [40 core hours]	**CE-NWK**	**Computer Networks** [20 core hours]
CE-ESY-1	History and overview [1]	CE-NWK-1	History and overview [1]
CE-ESY-2	Relevant tools, standards, and/or engineering constraints [2]	CE-NWK-2	Relevant tools, standards, and/or engineering constraints [1]
CE-ESY-3	Characteristics of embedded systems [2]	CE-NWK-3	Network architecture [4]
CE-ESY-4	Basic software techniques for embedded applications [3]	CE-NWK-4	Local and wide area networks [4]
CE-ESY-5	Parallel input and output [3]	CE-NWK-5	Wireless and mobile networks [2]
CE-ESY-6	Asynchronous and synchronous serial communication [6]	CE-NWK-6	Network protocols [3]
CE-ESY-7	Periodic interrupts, waveform generation, time measurement [3]	CE-NWK-7	Network applications [2]
CE-ESY-8	Data acquisition, control, sensors, actuators [4]	CE-NWK-8	Network management [3]
CE-ESY-9	Implementation strategies for complex embedded systems [7]	CE-NWK-9	Data communications
CE-ESY-10	Techniques for low-power operation [3]	CE-NWK-10	Performance evaluation
CE-ESY-11	Mobile and networked embedded systems [3]	CE-NWK-11	Wireless sensor networks
CE-ESY-12	Advanced input/output issues [3]		
CE-ESY-13	Computing platforms for embedded systems		

Corpo de Conhecimento

CE-PPP	Preparation for Professional Practice [20 core hours]	CE-SEC	Information Security [20 core hours]
CE-PPP-1	History and overview [1]	CE-SEC-1	History and overview [2]
CE-PPP-2	Relevant tools, standards, and/or engineering constraints [1]	CE-SEC-2	Relevant tools, standards, and/or engineering constraints [2]
CE-PPP-3	Effective communication strategies [2]	CE-SEC-3	Data security and integrity [1]
CE-PPP-4	Interdisciplinary team approaches [1]	CE-SEC-4	Vulnerabilities: technical and human factors [4]
CE-PPP-5	Philosophical frameworks and cultural issues [2]	CE-SEC-5	Resource protection models [1]
CE-PPP-6	Engineering solutions and societal effects [2]	CE-SEC-6	Secret and public key cryptography [3]
CE-PPP-7	Professional and ethical responsibilities [3]	CE-SEC-7	Message authentication codes [1]
CE-PPP-8	Intellectual property and legal issues [3]	CE-SEC-8	Network and web security [3]
CE-PPP-9	Contemporary issues [2]	CE-SEC-9	Authentication [1]
CE-PPP-10	Business and management issues [3]	CE-SEC-10	Trusted computing [1]
CE-PPP-11	Tradeoffs in professional practice	CE-SEC-11	Side-channel attacks [1]

Corpo de Conhecimento

CE-SGP	**Signal Processing** [30 core hours]	**CE-SPE**	**Systems and Project Engineering** [35 core hours]
CE-SGP-1	History and overview [1]	CE-SPE-1	History and overview [1]
CE-SGP-2	Relevant tools, standards, and/or engineering constraints [3]	CE-SPE-2	Relevant tools, standards and/or engineering constraints [3]
CE-SGP-3	Convolution [3]	CE-SPE-3	Project management principles [3]
CE-SGP-4	Transform analysis [5]	CE-SPE-4	User experience* [6]
CE-SGP-5	Frequency response [5]	CE-SPE-5	Risk, dependability, safety and fault tolerance [3]
CE-SGP-6	Sampling and aliasing [3]	CE-SPE-6	Hardware and software processes [3]
CE-SGP-7	Digital spectra and discrete transforms [6]	CE-SPE-7	Requirements analysis and elicitation [2]
CE-SGP-8	Finite and infinite impulse response filter design [4]	CE-SPE-8	System specifications [2]
CE-SGP-9	Window functions	CE-SPE-9	System architectural design and evaluation [4]
CE-SGP-10	Multimedia processing	CE-SPE-10	Concurrent hardware and software design [3]
CE-SGP-11	Control system theory and applications	CE-SPE-11	System integration, testing and validation [3]
		CE-SPE-12	Maintainability, sustainability, manufacturability [2]

Corpo de Conhecimento

CE-SRM	**Systems Resource Management**	**CE-SWD**	**Software Design**
	[20 core hours]		[45 core hours]
CE-SRM-1	History and overview [1]	CE-SWD-1	History and overview [1]
CE-SRM-2	Relevant tools, standards, and/or engineering constraints [1]	CE-SWD-2	Relevant tools, standards, and/or engineering constraints [3]
CE-SRM-3	Managing system resources [8]	CE-SWD-3	Programming constructs and paradigms [12]
CE-SRM-4	Real-time operating system design [4]	CE-SWD-4	Problem-solving strategies [5]
CE-SRM-5	Operating systems for mobile devices [3]	CE-SWD-5	Data structures [5]
CE-SRM-6	Support for concurrent processing [3]	CE-SWD-6	Recursion [3]
CE-SRM-7	System performance evaluation	CE-SWD-7	Object-oriented design [4]
CE-SRM-8	Support for virtualization	CE-SWD-8	Software testing and quality [5]
		CE-SWD-9	Data modeling [2]
		CE-SWD-10	Database systems [3]
		CE-SWD-11	Event-driven and concurrent programming [2]
		CE-SWD-12	Using application programming interfaces
		CE-SWD-13	Data mining
		CE-SWD-14	Data visualization

Corpo de Conhecimento

3.3.1 Related mathematics

Table 3.3 describes the mathematical component of the CE body of knowledge. The CE2016 steering committee recommends that a robust computer engineering program have at least four areas of capability that require at least 120 hours in mathematics to produce a competent CE professional for the 2020s. Clearly, programs typically include much more mathematics to achieve their goals. The four areas include analysis of continuous functions (calculus), discrete structures, linear algebra, and probability and statistics; these four areas emphasize what the steering committee considers essential to computer engineering.

Corpo de Conhecimento

3.3.2 Related science

The CE2016 steering committee has elected not to recommend specific science areas or the number of hours that a program should devote to science. However, it does recommend that students undertaking computer engineering as a program include as much natural science (e.g., biology or chemistry in addition to physics) as appropriate so that they obtain a command of the scientific bases for engineering. The reason for a science recommendation is that students in the engineering field should develop strong analytical thinking skills and learn empirical and experimental ways of learning. See Chapter 6 for a more detailed discussion on science for computer engineering.