Bachelor in Computer Science Engineering

Titles, contents and timetable

Escuela Técnica Superior de Ingeniería Informática

Universidad Rey Juan Carlos

Contents

Prologue

This document contains information about titles, contents and timetable of subjects taught in the Bachelor in Computer Science Engineering, offered at Rey Juan Carlos University, Escuela Técnica Superior de Ingeniería Informática. This information pretends to be helpful to international students interested in visiting our University.

Contents in this document referred to subjects taught during course 2021-2022. More information can be consulted in

`https://www.urjc.es/estudios/grado/628-ingenieria-informatica`.

1

First Course

1.1 First Semester

1.1.1 Physical Fundamentals of Computer Science

Physical foundations on design of devices for the construction of a computer system, fundamentals of electrical circuits, electromagnetism and semiconductors: diodes and bipolar and field-effect transistors.

6 ECTS credits.

1.1.2 Logic

Introduction to set Theory. Propositional logic (Syntax, Semantics and Gentzen Natural Deduction System). First order logic (Syntax, Semantics and Gentzen Natural Deduction System).

6 ECTS credits.

1.1.3 Statistics

Descriptive statistics: Description of data Basic concepts. Types of variables. Graphical summary of data. Numerical summary of data. Description of bivariate data. Summary of bivariate data. Covariance, correlation. Regression. Probability: random events, definition and interpretation of probability. Properties. Conditional probability. Independence of events. Total Probability and Bayes theorem. Random variables. Definition of random variable. Types of variables. Mass function and density function. Distribution function. Mean and variance. Special distributions. Statistical Inference: Introduction. Sampling. Central Limit Theorem. Estimation for means, proportions and variances. Hypothesis tests

6 ECTS credits.

1.1.4 Introduction to Programming

Simple types, control structures, modularization and recursion. Programming concepts. Problems, algorithms and programs. Programming paradigms and languages. Systematic application development. Basic elements of Pascal. History of Pascal. Basic data types. Basic elements of Pascal. Programmer-defined data types. Compatibility between types. Program documentation. Structured instructions. Composite instructions. Selection instructions. Iteration instructions. Subprograms. Syntactic structure of subprograms. Design aspects. Parameter subprograms. Validity and scope. Methodological aspects. Introduction to recursion. Basic concepts. Linear recursion. Multiple recursion. Mutual recursion. Complex data structures: Arrays. Array type: description and operations. One-dimensional arrays. Two-dimensional arrays. String type. Algorithms with arrays. Records and files. Record type: description and operations. File type: description and operations. File types. Manipulation of files and directories.

6 ECTS credits.

1.1.5 Discrete Math and Linear Algebra

Discrete Math: Fundaments. Modular arithmetic. Introduction to combinatorics. Graph Theory. Linear Algebra: Matrices and systems of linear equations. Vector spaces. Linear maps. Matrix diagonalization.

6 ECTS credits.

1.2 Second Semester

1.2.1 Calculus

The real line. Complex numbers. Functions: Overview. Limits and continuity. Derivatives. Derivative computation. Taylor polynomial. Study and graphical representation

of functions. Primitive computation. Definite integrals. Fundamental Theorem of Calculus. Areas calculation. Sequences of numbers. Series of numbers.

6 ECTS credits.

1.2.2 Computer Fundamentals

Introduction to computers. Binary system of numerical representation. Introduction to the languages of hardware description. Boolean algebra. Specification and synthesis of combinational circuits. Combinational modules basic. Finite state machines. Memory elements. Basic sequential modules. Structure of a basic computer.

6 ECTS credits.

1.2.3 Computer Science and Society

History of the scientific, industrial and technological revolutions in their context through the Enlightenment and the 19th and the 20th centuries; the Information and Knowledge Society, the Digitization of information and the evolution of hardware; the study of Free Software and Free culture versus concentration of power; economic, social and political transformations caused by information technology and the critical analysis of the process of the globalization process; the Internet and the transformation of human subjectivity; the analysis of the public space, private space and virtual space, social networks, cyber security, artificial intelligence, transhumanism and post humanism. Debates in moral philosophy â€“ethics and technology- and the reflection on the ends of science and technology are analysed.

6 ECTS credits.

1.2.4 Data Structures

Introduction. Abstract Data Types. List. Stack. Queue. Set. Tree. Graph.

6 ECTS credits.

1.2.5 Basic Legal Principles, Professional Deontology and Equality

Ethics, engineering and human being. Ethical and social responsibility. Basic legal principles. Introduction to Law. Basic legal principles of the Spanish legal system. Fundamental elements of Computer Law. Professional ethics and deontology of computers engineering. The importance of professional ethics. The profession of Software Engineer. Software licenses and business models.

6 ECTS credits.

2

Second Course

2.1 First Semester

2.1.1 Computer Structure

The Computer Structure course is the second in the sequence of courses focused on the study of the structure and architecture of computers. Its main objective is to further study the concepts presented in the Fundamentals of Computers course, as well as to introduce more advanced topics. In this course, the classical computer model, called "Von Neumann Model", is presented, describing its fundamental elements. A study of the design of the central processing unit will be carried out, with a emphasis on the assembler and machine language level. An analysis of performance measurements in computers will also be presented, some concepts of computer performance will be studied. and some concepts related to operating systems will be also covered.

6 ECTS credits.

2.1.2 Formal Languages and Automata Theory

Introduction. Formal languages. Grammars. Automata. The Chomsky hierarchy. Regular languages. Finite automata: deterministic finite automata, non deterministic finite automata, equivalence of finite automata and regular grammar. Regular expressions: definitions, equivalence of finite automata and regular expressions. Properties of regular languages: operations on regular languages, decision algorithms, Pumping lemma. Context-free languages. Pushdown Automata. Definitions. Equivalences. Properties of context-free languages. Operations. Pumping lemma for context-free languages. Decision Algorithms. Some Applications. Recursively enumerable languages. Turing Machines. Definitions. Computable functions. Equivalences. Some applications.

6 ECTS credits.

2.1.3 Databases

Database Foundations. Information Systems and Databases. File Systems versus Database Management Systems. Data Models Data model definition. Entity/Relationship model. Conceptual modelling. Relational model. Database Design. Database Logical Design. Normalization theory. Database Implementation. SQL: Definition, Manipulation and Control languages.

6 ECTS credits.

2.1.4 Object Oriented Programming

Introduction: Motivation. Basic concepts of OOP: Classes, objects and references. Methods and messages. Attributes. Constructors. Vectors. The Java language: history, basic syntax, programming environments. Object-oriented design principles. UML class diagrams. Simple design problems. Elements of Java. Classes and Interfaces. Packages. Instance and static attributes and methods. Final attributes. Classes. Utility Classes (Strings, Wrappers). JUnit. Inheritance and Polymorphism. Concept and mechanisms. Interfaces. Polymorphism. Object-oriented applications. Java APIs: collections, input/output, exceptions, introduction to graphical interfaces (Swing) and event-driven programming, generics."

6 ECTS credits.

2.2 Second Semester

2.2.1 Design and Analysis of Algorithms

Analysis of algorithms: Mathematical preliminaries; Computational complexity and asymptotic notation; Memory and runtime analysis of iterative and recursive algorithms. Algorithm design techniques: Introduction to recursion; Divide and conquer; Backtracking; Greedy algorithms.

6 ECTS credits.

2.2.2 Computer Organization and Architecture

The general aspects of the instruction set architecture in computers. The organization of the computer memory system. The interconnections between the functional units in the computer. The general features of the computer's peripheral devices. The organization of the input / output systems. The most advanced trends in computer architecture. This course has as a prerequisite to have taken the following subjects: Computer Fundamental. Introduction to Programming. Computer Structure.

6 ECTS credits.

2.2.3 Software Engineering

Introduction to Software Engineering. Concept of Software and Software Engineering. Software Engineering Workflows. Software Requirements. Concept of Requirement. Types of Requirements. Requirements Specification Documents. Requirements Elicitation. Information Gathering Techniques. Use Case Modelling. Specification of Use Cases. Requirements Analysis and Specification. Requirements in the Unified Process. Realization of Use Cases. Collaborations. Modelling of Analysis Classes. Documentation and Traceability of Requirements. Software Design. Modelling Design Classes. Design in the Unified Process. Design Principles. Design patterns. Principles of Software Modelling. The Unified Modelling Language. Structure of UML. Introduction to Software Processes. Introduction to Software Processes. Software Life Cycle. Introduction to Software Process Models. The Unified Software Development Process, Structure. Disciplines. Phases and Iterations.

6 ECTS credits.

2.2.4 Computer Networks

The Computer Networks course aims to provide basic and in-depth training in the technical aspects of computer communication to students of the degree in Computer Engineering, Software Engineering and Computer Engineering.

Computer networks involve concepts, protocols and technologies organized in a layered architecture that is explained during the course. In this way, students can understand the different concepts and protocols and how all the parts fit together.

The student must be able, at the end of the course, to properly design a computer network for a company, taking into account cost, performance and needs criteria. Also, you should be able to understand the technical description or documentation of a communications product, as well as articles from the specialized literature.

6 ECTS credits.

2.2.5 Operational and Statistical Management Methods

Introduction: The company and its purposes. Organization and structure of the company. The role of operations research in the companies. Mathematical Programming: Optimization models for management. Introduction to the solution methods. Postoptimization. Examples. Decision Theory: Introduction. Decision analysis. Multiobjective decision making. Examples. Project Management: Planning a project. Critical activities. Gantt chart. Cost balance and resource constraints. Other management methods. Quality management and design of experiments: X-R control charts. Design of experiments in quality control.

6 ECTS credits.

3

Third Course

3.1 First Semester

3.1.1 Declarative Programming

Functinoal Programming: The functional programming paradigm. Functional programming languages: Scala. Functional programming in the software industry. Algebraic data types. Recursive functions and data types. Curry-Howard correspondence. Higher-order functions. Scala's collections framework. Logic Programming: The logic programming paradigm: theoretical foundations, historical evolution, main features and applications. Prolog basics: general description, syntax (predicates, programs and queries), semantics (unification, resolution rule and resolution trees), some built-in predicates (arithmetic, input/output, terms' classification and inspection, etc), lists' manipulation, control predicates (cut). Some Prolog's more advanced topics: negation, collecting solutions predicates, higher-order predicates (mapping, filtering and folding).

6 ECTS credits.

3.1.2 Computer Security

Concepts and definitions. Risk management and incidents. Anatomy of an attack. IP network and protocol attack. Malware. Application and services attacks. Criptography. Network and protocol countermeasures. User, administrator and developer countermeasures. Present and future of Computer Security.

6 ECTS credits.

3.1.3 Human-Computer Interaction

Introduction to Human-Computer Interaction. Graphical elements of IUs. Design of User Interfaces. Usability. Accessibility. Evaluation of User Interfaces.

6 ECTS credits.

3.1.4 Advanced Data Structures

Introduction: Linear data structures, complexity, unitary tests and the Java Framework Collections. General Trees: General Trees, Binary Trees, interfaces and different implementations. Maps and Dictionaries. Ordered dictionaries: Binary Search Trees, AVL Trees, Red-Black Trees. Graphs. Index: B-Trees.

6 ECTS credits.

3.1.5 Operating Systems

This subject shows how operating systems work. Specifically, the student will understand the basic concepts of operating systems and will become familiar with their programming, understanding their principles and forms of application. The student will acquire knowledge related to the management of processes, memory and file system.

6 ECTS credits.

3.2 Second Semester

3.2.1 Artificial Intelligence

Introduction to Artificial Intelligence, Problem solving through search (Uninformed search, Heuristic search, Advanced heuristic search, Multiagent search, Constraint satisfaction problems), Knowledge Representation (Description logic, Ontologies and Web services, Reasoning with imprecision), Machine Learning (Supervised learning/Decision Trees, Neural Networks, Reinforcement learning /Q-learning).

6 ECTS credits.

3.2.2 Language Processors

Introduction to Language Processors. Lexical analysis. Sintax analysis. Sintax directed traslation.

6 ECTS credits.

3.2.3 Real-Time Embedded Systems

Embedded systems Introduction. Basic concepts of Embedded systems. AD, DA converters. Sensors and actuators. Microcontrollers. Embedded systems design. Basic interconnections methods. Embedded systems programming. Arduino basics Digital inputs and outputs Analog inputs and outputs Communication inter IC systems (wired and wireless comms) Internet of things. IoT basic concepts.

6 ECTS credits.

3.2.4 Distributed Systems

The main goal of this course is that the students learn to understand and to design and develop distributed computer systems. Nowadays there is rarely an application that is not based, at least in part, in distributed techniques. For instance, most applications in mobile devices are able to share data with distributed applications such as messengers, electronic mail, cloud file systems, etc. In the first part of the course we will present the objectives and desirable characteristics of distributed systems, the main architectural alternatives and the most important technologies currently used to develop and build them. In the second part, students will gain practical experience in designing, implementing, and debugging real distributed systems, with emphasis in Web applications. Prospective students should have a working knowledge of object oriented programming, relational databases and operating systems.

6 ECTS credits.

3.2.5 Software Engineering II

Software testing and quality. Introduction. Unit and integration testing. System Testing. Static Code Analysis. Software maintenance and evolution. Introduction. Software design. Refactoring. Test Driven Development Software Configuration Management. Introduction. Software Version Control. Continuous Integration. Continuous Delivery and Deployment. Project Management. Introduction. Project Management: People, Process and Product. Project Management Strategies and Project Teams. Project planning. Agile processes in project management Introduction. XP. Lean. Scrum. Kanban.

6 ECTS credits.

4

Fourth Course

4.1 First Semester

4.1.1 Advanced Computer Architectures

The subject Advanced Computer Architectures is an elective subject in the field of Computer Engineering. Computers, focused on the study of new trends in computer architecture and the development of programs on these new architectures.

Segmented and superscalar processors. Shared memory architectures. Distributed memory architectures. Accelerators.

6 ECTS credits.

4.1.2 Advanced Algorithms

This subject is only taught at Mostoles Campus.

Introduction. Specifications and algorithms. Basic and advanced algorithm design techniques. Combinatorial and optimization problems. Exact and approximate algorithms. Principles of experimentation with algorithms. Advanced aspects of greedy algorithms. Implementation decisions. Optimality proofs and counterexamples. Examples and applications. Heuristic and approximation algorithms. Definitions. Experimenting with optimality. Examples and applications. Advanced aspects of search-based design techniques. Application of backtracking to optimization problems. Technique of branch-and-bound. Experimenting with time efficiency. Examples and applications. Removal of redundant recursion. Analysis of redundancy. Techniques for removal of redundant recursion: tabulation, memorization. Dynamic programming. Development methodology. Examples and applications. Probabilistic algorithms. Definitions. Classes of probabilistic algorithms. Examples and applications.

6 ECTS credits.

4.1.3 Computer Graphics

Introduction. Computer graphics. Image formation.The graphics pipeline. Modelling and representation of 3D objects. Object representation techniques. Other representations. Geometric transformations. Concatenations of transformations. Geometric projections. Visualization. Clipping and culling Hidden surfaces Virtual camera model. Lighting. Phong lighting model Shading models. Increase of visual realism. Textures. Other effects OpenGL. Programming in Open GL. Programmable pipeline Programable shaders: GLSL Models: VAOs Textures.

6 ECTS credits.

4.1.4 Mobile Devices Laboratory

This subject is only taught at Mostoles Campus.

Introduction: Ubiquitous Computing. Principles and Concepts. Mobile Computing. Types of Mobile Devices. Review of technologies and systems. Development of mobile applications: environments and programming languages. Application development and interaction with mobile devices. Development of User Interfaces for Mobile Devices. Persistent storage. Project creation. File manifest and AVD. Layout creation. Activity and View. Main Widgets. Android storage concepts. File systems. Preferences and other storage. Databases with mobile device. Advanced programming. Multimedia content management. Game programming for mobile devices. Multimedia concepts. multimedia APIs. Audio and video processing. Recording of contents. Animation and game programming.

6 ECTS credits.

4.2 Second Semester

4.2.1 Computer Vision

Introduction to Computer Vision. Applications of Computer Vision Light and colour: their perception and representation. Physiology of human vision. Image capture: fundamentals of digital cameras. Optics and lens models. Characteristics of digital images. Pre-processing and filtering of digital images. Operations at pixel level. Histogram of an image. Applications of the histogram: contrast enhancement and equalisation. Operations at neighbourhood level. Spatial domain filtering: low-pass and high-pass filters. Mathematical morphology. Geometric operations on images. Filtering in the frequency domain: the Fourier transform. Detection and description of interest points in images. Interest points: concepts and properties. Most important point detectors: Harris, SIFT, BRIEF, ... Applications of interest points: visual words. Detection of simple geometric structures: Detection of lines: Hough transform. Detection of lines: RANSAC. Detection of circles: Hough transform for circles. Region detection: global and adaptive thresholding -Region detection: connected components. Region detection: MSER. Pattern classification: Concepts, properties and types of classifiers. Distance-based classifiers: Euclidean, Mahalanobis and knn. Bayesian classifier. Artificial neural networks. Support Vector Machines (SVM). Unsupervised classification: k-means. Dimensionality reduction techniques -Performance evaluation of classifiers.

6 ECTS credits.

4.2.2 Information Systems

Information systems, Business organisation, elements, classification, security; Information systems in organisations, OLAP, Business intelligence and Information System implementation.

6 ECTS credits.

4.2.3 Concurrent Programming

This subject is only taught at Mostoles Campus.

Introduction to concurrent programming, Conditional synchronisation, Mutual exclusion, Active waiting, Passive waiting, Semaphore, Introduction to concurrent programming in Java, Monitors, Locks, Cyclic barriers, Parallel models such as fork/join and map/reduce.

6 ECTS credits.

4.2.4 Knowledge-Based Systems

This subject is only taught at Vicalvaro Campus.

Introduction to knowledge-based and expert systems. Rule-based systems. Ontologies and Semantic Web. Uncertainty representation and reasoning. Bayesian networks. Fuzzy logic and fuzzy controllers.

6 ECTS credits.