Universidad de Alcalá

TEACHING GUIDE

Data Structures

Degree in
Information System Engineering (GISI)
Computer Engineering (GIC)
Computer Science Engineering (GII)

Universidad de Alcalá

Academic Year 2021/2022

1st Year - 1st Semester (GISI+GIC+GII)

Approved by the School Board on July 6, 2021

TEACHING GUIDE

Course Name:	**Data Structures**
Code:	**780009 (GISI+GIC+GII)**
Degree in:	**Information System Engineering (GISI)** **Computer Engineering (GIC)** **Computer Science Engineering (GII)**
Department and area:	**Ciencias de la Computación** **Computer Science**
Type:	**Compulsory (GISI+GIC+GII)**
ECTS Credits:	**6.0**
Year and semester:	**1st Year - 1st Semester (GISI+GIC+GII)**
Teachers:	Check the web page of the department
Tutoring schedule:	Consultar al comienzo de la asignatura
Language:	English

1. COURSE SUMMARY

The learning objective of this course is to study data structures conceptually along with their forms of representation and their implementations. The student will also learn to build specifications of Abstract Data Types (ADTs) and also to implement these specifications using an object-oriented programming language.

Requirements: Programming. Basic course/s on basic mathematics and/or discrete structures are also recommended.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following basic, generic and cross curricular skills:

en_CG8 - Knowledge of the basic subjects and technologies, which enable them to learn and develop new methods and technologies, as well as those that provide them with great versatility to adapt to new situations.

en_CG9 - Ability to solve problems with initiative, decision making, autonomy and creativity. Ability to know how to communicate and transmit the knowledge, skills and abilities of the profession of Computer Engineering Engineer.

en_CB1 - That students have demonstrated to possess and understand knowledge in an area of study that is based on general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that involve knowledge from the forefront of their field of study.

en_CB2 - That the students know how to apply their knowledge to their work or vocation in a professional manner and possess the competencies that are usually demonstrated through the elaboration and defense of arguments and the resolution of problems within their area of study.

en_CB3 - That students have the ability to gather and interpret relevant data (usually within their area of study) to make judgments that include a reflection on relevant social, scientific or ethical issues.

en_CB4 - That students can transmit information, ideas, problems and solutions to both a specialized and non-specialized public.

en_CB5 - That the students have developed those learning skills necessary to undertake further studies with a high degree of autonomy.

en_TRU1 - Capacity of analysis and synthesis.

en_TRU2 - Oral and written competencies.

en_TRU3 - Ability to manage information.

en_TRU4 - Autonomous learning skills.

en_TRU5 - Team work.

Specific Skills

This course contributes to acquire the following professional skills:

en_CI7 - Knowledge, design and efficient use of the types and structures of data most appropriate to the resolution of a problem.

en_CI8 - Ability to analyze, design, build and maintain applications in a robust, safe and efficient way, choosing the most appropriate programming paradigm and languages.

Learning Outcomes

The expected learning results, obtained from the specific competences included in the verified report of the Degree in Computer Engineering, are the following:

- RA1: Understand the concept of abstraction, abstract data type and data structure.
- RA2: Apply the techniques of abstraction and concealment as a means to solve complex problems.
- RA3: Explain and justify the need for data structures and their construction methods.
- RA4: Understand and apply the concept of complexity / efficiency in the context of data structures.
- RA5: Know the fundamental data structures (stacks, lists, queues, trees, ...) and use them to solve different problems.
- RA6: Implement in a high level language, comparing the different implementations, the fundamental data structures (stacks, lists, queues, trees, ...
- RA7: Understand the concept of recursion, identify the base case and the general case of a recursively defined problem and compare iterative and recursive solutions to elementary problems.
- RA8: Understand and implement the usual ordering and search algorithms.
- RA9: Know the common applications of data structures and identify the most appropriate to model specific problems.

3. CONTENTS

Contents Blocks	Total number of hours (*)
1. Fundamentals of Data Structures Basic concepts. Data structure. Abstract Data Types (ADTs). Specification of ADTs.	8 hours
2. Linear Data Structures Introduction. Specification of linear data structures: stacks, queues, lists. Vectors and sorting algorithms. Implementation. Applications.	20 hours
3. Non-linear Data Structures Introduction. Specification of non-linear data structures: dictionaries, hash tables, general trees, binary search trees, priority queues, heaps, AVL trees and graphs. Implementation. Applications.	28 hours

* Including tests and assessments.

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (56 hours on-site +2 exams hours)
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

The following learning methods are used:

- Theoretical lectures.
- Supervised practical classes: problem-solving in class.
- Supervised practical labs.
- Individual tutoring and mentoring.

In addition, depending on the nature of the work, the students may make use of the following study methods:

- Individual or collaborative elaboration of coursework.
- Exchange of information, problems, and doubts which arise during individual work.
- Use of the online learning platform and other virtual resources.

Classroom activities.	• In class: Presentation and discussion of core subject knowledge. Planning and theoretical solving and prol hypotheses. Oriented towards the teaching of subject-specific skills, especially those related to the fundamental con for the specification of Abstract Data Types and for the implementation of Data Structures. • In practical labs: Planning and development of practical exercises which allow problems to be solved and hypothes contributing to the development of analytical and critical reasoning skills as well as an understanding of probler These will serve as a basis for acquiring the skills and/or learning outcomes described in part 2 of this guide.
Independent work, non-contact activities.	• Analyzing and learning course contents, solving of problems, consulting the bibliography, individually preparing exams, and self-evaluation. Oriented primarily towards developing personal organization skills and planning work in of a team. • Tutorials: Individuals and group guidance throughout the learning process. Students may attend in person or online.
Materials and resources.	• Learning materials created by the learning staff for the classroom activities. • Reference bibliography of core and further reading on the subject. • Personal computers • Virtual Learning Platform and accompanying user guides. Development environments and accompanying user guides. Internet connection. Projectors.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Learning Assesment Guidelines, LAG, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Learning Assesment Guidelines as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

Ordinary Call

Continous Assessment:

The main assessment tools will be:

1. **Written exams** (PEI, PE2). Written exams of the learning contents, focused on both practical and theoretical aspects.
2. **Lab assignment** of the learning contents (PL). The assessment of the laboratory consists of practical assignments that the student must submit and present to the professor in laboratory sessions specifically designed for it. In addition, professors can collect evidence of the student's work throughout the laboratory sessions.

Assessment through final exam:

In the case of evaluation by means of a final exam, the evaluation elements to be used will be the following:

1. **Written exam:** Written exam of the learning contents, focused on both practical and theoretical aspects.
2. **Lab assignment** of the learning contents (PL). The assessment of the laboratory consists of practical assignments that the student must submit and present to the professor in laboratory sessions specifically designed for it.

Extraordinary Call

The same assessment tools as described in the final exam are used.

5.2. EVALUATION

EVALUATION CRITERIA

The assessment criteria measure the level in which the competences have been acquired by the student. For that purpose, the following are defined:

- CE1: Student knows and knows how to apply abstraction as a means to solve complex problems.
- CE2: Student understands why data structures are necessary and also the methods to build them.
- CE3: Student knows and knows how to apply the concept of complexity/efficiency within the context of data structures.
- CE4: Student knows the linear data structures and knows how to use them to solve problems.
- CE5: Student knows the non-linear data structures and knows how to use them to solve problems.
- CE6: Student can implement linear data structures (stacks, queues, lists) using a high-level programming language.
- CE7: Student can implement non-linear data structures (trees, binary search trees, AVL trees, hash tables, heaps) using a high-level programming language.
- CE8: Student understands the concept of recursion. Student can find the base case and the general case for a recursive problem.
- CE9: Student can compare the iterative solution and the recursive solution for elemental problems.
- CE10: Student knows and can implement common search algorithms and sorting algorithms.
- CE11: Student knows the standard applications of data structures, and he can select the most suitable data structures to model each specific problem.

GRADING TOOLS

The work of the student is graded in terms of the assessment criteria above, through the following tools:

1. **Ordinary call. Continuous assessment:**
    a. PEI1: Written exam of the learning contents of topics 1 and 2 (20%)
    b. PEI2: Written exam of the learning contents of topic 3 (40%)
    c. PL1: Lab assignment of the learning contents of topics 1 and 2 (20%)
    d.
    e. PL2: Lab assignment of the learning contents of topic 3 (20%)

   Exams (PEI1 and PEI2) take place in the classroom. The maximum duration is two and a half hours.
2. **Ordinary call. Final assessment:** writen exam (PEF) and two lab assignments (PL1,PL2). The date of the exam is established by the Polytechnic School, and its duration is three hours.
3. **Extraordinary call:** writen exam (PEE) and a lab assignment (PL). The date of the exam is established by the Polytechnic School, and its duration is three hours.

GRADING CRITERIA

In the **ordinary call-continuous assessment** the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
CG8, CG9, CI7, CI8	RA1, RA2, RA3, RA4, RA5, RA9	CE1, CE2, CE3, CE4, CE9, CE11	PEI1	20%
CG8, CG9, CI7, CI8	RA1, RA2, RA3, RA4, RA5, RA7,RA8	CE1, CE2, CE3, CE5, CE8, CE9, CE10, CE11	PEI2	40%
CG9, CI7, CI8	RA1, RA2, RA3, RA6, RA9	CE1, CE6, CE9, CE10, CE11	PL1	20%
CG9, CI7, CI8	RA1, RA2, RA3, RA6, RA7, RA8, RA9	CE1, CE7, CE8, CE9, CE10, CE11	PL2	20%

Failure to pass any of the exams/assignments does not imply that students do not pass the complete course. To pass the course students have to meet the following requirements:

- Take exams PEI1 and PEI2 and pass the evaluation of the competences related to both exams. Students acquire such competencies satisfactorily if the mark is equal or higher than 40% of the maximum possible mark.
- Pass the evaluation of the competences related lab assignments (PL1 and PL2). The student has to submit both assignments and get a mark equal or higher than 40% of the maximum possible mark.
- Obtain a final weighted mark equal to or greater to 5 out of 10.

In the **ordinary call-final assessment**, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the fi
CG8, CG9, CI7, CI8	RA1, RA2, RA3, RA4, RA5, RA7, RA8, RA9	CE1, CE2, CE3, CE4, CE5, CE8, CE9, CE10, CE11	PEF	60%
CG9, CI7, CI8	RA2, RA3, RA4, RA6, RA9	CE1, CE6, CE9, CE10, CE11	PL1	20%
CG9, CI7, CI8	RA2, RA3, RA4, RA6, RA7, RA8, RA9	CE1, CE7, CE8, CE9, CE10, CE11	PL2	20%

In the **Extraordinary call**, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to t
CG8, CG9, CI7, CI8	RA1, RA2, RA3, RA4, RA5, RA7, RA8, RA9	CE1, CE2, CE3, CE4, CE5, CE8, CE9, CE10, CE1	PEE	60%
CG9, CI7, CI8	RA2, RA3, RA4, RA6, RA7, RA8, RA9	CE1, CE6, CE7, CE8, CE9, CE10, CE11	PL	40%

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- A.V. AHO., J.E. HOPCROFT., J.D. ULLMAN. 1987. “Data Structures and Algorithms.” Addison-Wesley.
- C. SHAFFER. 2011 “Data Structures and Algorithm Analysis in C++”, 3ed. Dover Publications.
- B. STROUSTRUP. 1997. “The C++ programming language.” 3rd AddisonWesley.

6.2. Additional Bibliography

- ALLEN WEISS MARK. 1994. *Data Structures and Algorithms Analysis in C++*, The Benjamin/Cummings Publishing Company.
- BRASSARD,G., BRATLEY,P. 1995. *Fundamentals of Algorithmics*. Prentice Hall.
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- N. KARUMANCHI. 2011, *Data Structures and Algorithms Made Easy*, 2ed CareerMonk Publications.

Disclosure Note

The University of Alcalá guarantees to its students that, if due to health requirements the competent authorities do not allow the total or partial attendance of the teaching activities, the teaching plans will achieve their objectives through a teaching-learning and evaluation methodology in online format, which will return to the face-to-face mode as soon as these impediments cease.