1. OVERVIEW

Subject area	Programming with Linear Structures
Degree	Bachelor's Degree in Computer Engineering
School/Faculty	School of Architecture, Engineering and Design
Year	Second
ECTS	6
Type	Compulsory
Language(s)	Spanish
Delivery mode	On campus/Online
Semester	First
Year	2022-2023
Coordinating professor	Daniel Gómez Vergel

2. INTRODUCTION

This course covers a number of core chapters in Computer Science and Programming, including the implementation of dynamic data structures, the study of algorithms (with special attention to their efficiency) and the use of recursion. Its main aim is to give students a solid introduction to these fields, facilitating their subsequent academic and professional development, as well as to improve their practical problem-solving and data handling skills.

3. SKILLS AND LEARNING OUTCOMES

Basic skills (CB, by the acronym in Spanish):

- CB1: Students have demonstrated knowledge and understanding of a study area originating from general secondary school education, and are usually at the level where, with the support of more advanced textbooks, they may also demonstrate awareness of the latest developments in their field of study.
- CB2: Students can apply their knowledge to their work or vocation in a professional manner and possess the skills which are usually evident through the forming and defending of opinions and resolving problems within their study area.
- CB3: Students have the ability to gather and interpret relevant data (usually within their study area) to form opinions which include reflecting on relevant social, scientific or ethical matters.
- CB4: Students can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
- CB5: Students have developed the learning skills necessary to undertake further study in a much more independent manner.

General skills (CG, by their acronym in Spanish):

- CG8: Knowledge of the core topics and technologies, which enable the students to learn and develop new methods and technologies, as well as give them the versatility to adapt to new situations.

Transversal skills (CT, by the acronym in Spanish):

- CT2: Self-confidence: Ability to evaluate one's own results, performance and skills with the self-determination necessary to complete tasks and meet any objectives.
- CT7: Awareness of ethical values: Ability to think and act in line with universal principles based on the individual's value, contributing to his/her full development and involving commitment to certain social values.
- CT8: Information management: Ability to seek, choose, analyse and integrate information from diverse sources.
- CT9: Interpersonal relationship skills: Ability to maintain positive relationships with other people through assertive verbal and non-verbal communication. This means being able to express or communicate what you want, think or feel without discomforting, offending or harming the feelings of other people.
- CT11: Planning and time management: Ability to set objectives and choose the right means to fulfil them through efficient use of time and resources.
- CT15: Responsibility: Ability to fulfil commitments to themselves and others when undertaking a task and try to meet a range of objectives within the learning process. Ability to face and accept the consequences of actions taken freely.
- CT16: Decision-making: Ability to choose between different options or methods to effectively solve varied situations or problems.
- CT17: Teamwork: Ability to integrate and collaborate actively with other people, departments and/or organisations in order to reach common goals.

Specific skills (CE, by the acronym in Spanish):

- CE3: Ability to understand and master the basic concepts of discrete mathematics, logic, algorithmics and computational complexity and how they are used to solve engineering problems.
- CE12: Knowledge and application of the basic algorithmic procedures of computer technologies to solve problems, analysing the suitability and complexity of the proposed algorithms.
- CE13: Knowledge, design and efficient use of the most appropriate data types and structures to solve a problem.
- CE27: Ability to assess the computational complexity of a problem, know algorithmic strategies that can be used to solve it, and recommend, develop and implement the strategy that guarantees the best performance according to the established requirements.

Learning outcomes (RA, by the acronym in Spanish):

- Through these learning outcomes, the students will be able to:
  RA1: Understand the concept of Abstract Data Type (ADT) and the fundamental principles behind its design.
- RA2: Use various linear data structures and algorithms (describing and coding them) to solve practical programming problems.
- RA3: Analyse recursive problems and how they differ from purely iterative solutions.

The following table shows how the skills developed in the subject area match up with the intended learning outcomes:

Skills	Learning outcomes
CB1, CB2, CB3, CB4, CT2, CT11, CT16, CE13	RA1
CB3, CB4, CB5, CT8, CT9, CT10, CT11, CT15, CE12, CE13, CE27	RA2
CG8, CB3, CB4, CB5, CT7, CT10, CT11, CT15, CT16, CT17, CE3, CE27	RA3
CB3, CB4, CB5, CT8, CT16, CT17, CE3, CE13, CE27	RA4

4. CONTENTS

Unit 1 - Generic programming: This chapter summarises the fundamental concepts of class (basic unit of encapsulation) and its access modifiers, as a basic method of defining new types by the user. Generic classes/functions (class/function templates) are then considered, which allow the definition of classes/functions families that differ from each other in the type of data they manipulate.

Unit 2 - Advanced programming elements: In this second chapter, the structure of the virtual memory space allocated to a process will be analysed in detail, providing answers to many practical questions: How to protect our code from possible *user stack* corruptions? When to prefer the *free store* over the stack for storing variables? What impact does the fragmentation of *free store* have on the efficiency of our program? How to achieve a robust code that prevents recourse leakage?

Unit 3 - Dynamic arrays: In the following chapters, we will analyse in detail the implementation of various data structures, including vectors and dynamic lists. The vector, in particular, is especially efficient given the way the cache memory works on a computer, being the default recommended container type in the modern C++ language.

Unit 4 - Lists, stacks and queues: This chapter analyses the implementation of single and doubly linked lists, the latter using a sentinel node. The stack and queue structures can then be implemented directly as mere list adapters.

Unit 5 - Algorithms. Efficiency. Recursion: In this chapter, we will look at the problem of implementing algorithms which operate on data containers using iterators as intermediaries. This will lead to the discussion of concepts, such as the algorithmic complexity of such operations and the big O notation used to indicate it. Students will study the concept of recursion and how it is used in the implementation of search algorithms such as *Quick Sort.*

5. TEACHING/LEARNING METHODS

The types of teaching/learning methods are as follows:

1. Survey on aims and interests. This survey is used to establish the aims of the subject and gather the student's interests on the subject. We will then make reference to it throughout the year for the students to evaluate the achievement of the aims and interests. In the online delivery mode, an initial questionnaire will be carried out with the same objective. Throughout the year, reference will be made to this survey, and a final reflective questionnaire will be carried out for the students to check their learning progress of the subject.

2. Lectures, subjects of study and seminars. The "lectures" taught in the on-campus delivery mode are called subjects of study and seminars in the online delivery mode, and are conducted through readings on the topic, technical notes and webinars (which are recorded for students to access). In addition, students will be given a motivating introduction to each subject area, with multimedia presentations looking at specific topics of the subject, finally followed by forums.

3. Laboratory work: while the laboratories described in section 7 will mainly be used in the on-campus delivery mode, the online delivery mode will use the virtual desktop infrastructure, with the different methods and use cases explained in detail in section 7.

4. a) Group investigation (*jigsaw)* and/or b) group problem-solving. This learning method will be used for the development of both declarative and procedural knowledge. In method type a), a different topic will be assigned to each group to be investigated. Later, new groups will be formed with students who have all studied a different topic, and these new groups will be proposed comprehension and problem-solving activities. In method type b), a series of short questions and

problems will be proposed to be solved in groups. To develop these methods, students have different synchronous and asynchronous tools at their disposal in the online delivery mode, such as forums and group work chats which are only accessible to members of the group, as well as web conferences.

5. Designs, understood as practical proposals for solving specific problems (unlike the study of practical cases, it is not a question of delving deeper into the analysis and the real problems. Instead, it is based on this knowledge, and the aim is to provide new solutions in accordance with engineering standards). These learning methods will be used for the development of procedural knowledge. They will be used in all delivery modes and help to develop creative potential and technical skills in the field of engineering. To carry out these methods in e-learning, prepared teaching materials such as study topics, learning resources and individual and group activities are available on the Campus Virtual.

8. Fieldwork, conferences, visits to companies and institutions. These will be used for the development of conditional knowledge. In the on-campus delivery mode, all learning methods may be used, while only conferences can be used in the online delivery mode, as they will be available for remote access in real time (via streaming technologies) or recorded and broadcast afterwards.

6. LEARNING ACTIVITIES

The types of learning activities, plus the amount of time spent on each activity, are as follows:

On campus:

Learning activity (AF, by the acronym in Spanish)	Number of hours
TAF1: Lectures, reading on main topics and complementary materials, implementation of activities carried out independently and collectively (including participation in collaborative learning forums).	50 h
TAF2: Integrative group work, consisting of participation in debates and seminars, and group implementation of integrative activities, mainly in the classroom.	25 h
TAF3: Independent working.	50 h
TAF4: Tutorials, academic monitoring and assessment, both in the classroom and on the Campus Virtual.	25 h
TOTAL	**150h**

Online:

Learning activity (AF, by the acronym in Spanish)	Number of hours
TAF3: Independent working.	50 h
TAF6: Independent reading on complementary topics and materials and implementation of activities carried out independently. Subsequently, asynchronous group discussion on the Campus Virtual forum, and Webinars with the synchronous e-learning tools on the Campus Virtual.	50 h
TAF7: Integrative group work, consisting of participation in debates and seminars, and group implementation of integrative application activities. Carried out with the support of the Campus Virtual (the debates are held via forums, the seminars are online). In addition, each group will have asynchronous communication tools to prepare the group work (mainly forums), as well as synchronous communication tools (mainly virtual meeting tools).	25 h
TAF8: Tutorials, academic monitoring and assessment through the Campus Virtual. Some assessment tests (e.g. exams) will be carried out on-campus when necessary.	25 h
TOTAL	**150h**

7. ASSESSMENT

On campus

The assessment system for this subject includes the following items and weightings:

SE1. Exams and tests. These will be used for the assessment of declarative knowledge.	30%
SE2. Development of articles, reports or design briefs.	25%
SE3. Alternative assessment methods with mind maps, diaries, debates, portfolios, peer assessment, etc.	30%
SE6. Exercises, problems, case studies, designs, simulations and research will be used to assess the basic and general skills of the subject.	15%

The course's assessable tasks (modules), the assessment criteria for each of them and their weighting with regard to the final subject area grade are set out in the following table. The last column indicates the items of the assessment system associated with each module:

Assessable task (module)	Assessment criteria	Weigh	Assessme
Final Integrative Test	Analyse and solve theoretical and practical problems using the techniques learned over the	30%	SE1

	development of the subject area.		
Midterm tasks	Analyse and solve problems in which the techniques learnt up to this point will be used.	15%	SE3
Collaborative sessions	• Coordinate effectively with classmates. • Correctly apply the programming techniques developed in the lectures.	15%	SE6
Individual tasks	• Analyse and solve problems in which the techniques learnt up to this point will be used.	25%	SE2, SE3
Group challenges	• Analyse and solve large-scale problems. • Coordinate effectively with classmates. • Correctly express oneself orally or in writing.	15%	SE2

Online

The assessment system for this subject includes the following items and weightings:

SE8. Knowledge tests, exams, test.	60%
SE9. Development of articles, reports or design briefs.	15%

SE10. Alternative assessment methods with mind maps, diaries, debates, portfolios, peer assessment, etc.	10%
SE11. Conferences will be evaluated based on the students' participation in a discussion forum.	5%
SE12. To assess the basic and general skills corresponding to the subject, exercises, problems, practical case studies, designs, simulations and research will be used with their corresponding defence in an oral or written test.	10%

The course's assessable tasks (modules), the assessment criteria for each of them and their weighting with regard to the final subject area grade are set out in the following table. The last column indicates the items of the assessment system associated with each module:

Assessable task (module)	Assessment criteria	Weighting	Assessment
Final Integrative Test	Analyse and solve theoretical and practical problems using the techniques learned over the development of the subject area.	60%	SE8
Individual tasks	Analyse and solve problems in which the	20%	SE9, SE10

	techniques learnt up to this point will be used.		
Group project	• Coordinate effectively with classmates. • Analyse and solve large-scale problems.	15%	SE10, SE12
Active participation	• Participate in webinars and debate forums. • Deliver the application activities on time.	5%	SE11

7.1. Ordinary exam period

To pass the subject area in the ordinary exam period, you must:

1. Comply with the class attendance policy set by the School [criteria applicable only to the on-campus delivery mode].
2. Achieve a final grade of at least 5.0 out of 10 in the final integrative test.
3. Achieve a final weighted grade of at least 5.0 out of 10 for the subject area.
If students fail to meet one or more of the above-mentioned requirements, the final grade for the subject area will be:

- The final weighted grade if it is 4.0 out of 10 or less.
- 4.0 out of 10.0 if its final weighted grade is higher than 4.0 out of 10.

The grade in the Ordinary Exam Period will appear as NP (No grade reported) if the student has not carried out any of the assessable tasks for the subject area.

7.2. Extraordinary exam period (resits)

The Extraordinary Exam Period is in keeping with the Ordinary Exam Period, meaning that the same modules, weightings and requirements apply to both (see the previous points in **subsection 7.1**). However, there is no minimum attendance requirement for the on-campus delivery mode. The student must repeat the modules not passed, while maintaining the grades in those that were passed. The details of these substitute activities will be published on the Campus Virtual at the official start of the Extraordinary Exam Period.

Those students who do not comply with points 2 and/or 3 of **section 7.1** at the end of the Extraordinary Exam Period will receive a final grade for the subject area equal to:

- The final weighted grade in the Extraordinary Exam Period if it is 4.0 out of 10 or lower.
- 4 out of 10.0 if its final weighted grade in the Extraordinary Exam Period is higher than 4.0 out of 10.

The grade in the Extraordinary Exam Period will appear as NP (No grade reported) if the student has not carried out any of the assessable tasks for the subject area in this exam period.

8. TIMELINE

The predicted timetable for the learning units of year are as follows:

Unit	Weeks
1	1, 2 and 3
2	4, 5 and 6

3	7, 8 and 9
4	10, 11, 12, 13
5	14, 15 and 16
Revision	17
Final Integrative Test	18

This timetable may be subject to modifications for teaching and/or logistical reasons, which will be notified to the student in due time and course.

9. BIBLIOGRAPHY

The recommended bibliography is indicated below:

• Stroustrup, B., *The C++ Programming Language*. 4th Edition. Addison-Wesley Professional, 2013.
• Bryant R. E. and O'Hallaron D. R., *Computer Systems: A Programmer's Perspective*. Second edition. Addison-Wesley, 2010.
• Cormen T. H., et al., Introduction to Algorithms, 3rd Edition, MIT Press.
• Joyanes Aguilar L. et al., *Estructuras de datos en C++*. McGraw-Hill, 2007.

10. DIVERSITY AWARENESS UNIT

Students with special educational needs:

To ensure equal opportunities, curricular adaptations or adjustments for students with special educational needs will be outlined by the Diversity Awareness Unit (UAD, Spanish acronym).

As an essential requirement, students with special educational needs must obtain a report about the curricular adaptations/adjustments from the Diversity Awareness Unit by contacting unidad.diversidad@universidadeuropea.es at the beginning of each semester.

11. STUDENT SATISFACTION SURVEYS

Your opinion matters!
Universidad Europea encourages you to complete our satisfaction surveys to identify strengths and areas for improvement for staff, degrees and the learning process.
These surveys will be available in the survey area of your campus virtual or by email.
Your opinion is essential to improve the quality of the degree.
Many thanks for taking part.