



Universidad Nacional Mayor de San Marcos
School of Computer Science
Syllabus of Course
Academic Period 2018-II

1. **Code and Name:** CS341. Programming languages (Mandatory)
2. **Credits:** 4
3. **Hours of theory and Lab:** 2 HT; 2 HP; 2 HL; (15 weeks)
4. **Professor(s)**

Meetings after coordination with the professor

5. Bibliography

- [RH04] Peter Van Roy and Seif Haridi. *Concepts, Techniques, and Models of Computer Programming*. Cambridge, MA, USA: MIT Press, 2004. ISBN: 0262220695.
- [Seb12] Robert W. Sebesta. *Concepts of Programming Languages*. 10th. USA: Addison-Wesley Publishing Company, 2012. ISBN: 0131395319.
- [Web10] Adam Brooks Webber. *Modern Programming Languages: A Practical Introduction*. 2nd. Franklin, Beedle and Associates, Inc, 2010. ISBN: 978-1-59028-250-2.

6. Information about the course

- (a) **Brief description about the course** Los lenguajes de programación son el medio a través del cual los programadores describen con precisión los conceptos, formulan algoritmos y representan sus soluciones. Un científico de la computación trabajará con diferentes lenguajes, por separado o en conjunto. Los científicos de la computación deben entender los modelos de programación de los diferentes lenguajes, tomar decisiones de diseño basados en el lenguaje de programación y sus conceptos. El profesional a menudo necesitará aprender nuevos lenguajes y construcciones de programación y debe entender los fundamentos de como las características del lenguaje de programación están definidas, compuestas e implementadas. El uso eficaz de los lenguajes de programación y la apreciación de sus limitaciones, también requiere un conocimiento básico de traducción de lenguajes de programación y su análisis de ambientes estáticos y dinámicos, así como los componentes de tiempo de ejecución tales como la gestión de memoria, entre otros detalles de relevancia.

- (b) **Prerequisites:** CS2101. Theory of Computation. (4th Sem)

- (c) **Type of Course:** Mandatory

- (d) **Modality:** Face to face

7. Specific goals of the Course

- Capacitar a los estudiantes para entender los lenguajes de programación desde diferentes tipos de vista, según el modelo subyacente, los componentes fundamentales presentes en todo lenguaje de programación y como objetos formales dotados de una estructura y un significado según diversos enfoques.

8. Contribution to Outcomes

- a) An ability to apply knowledge of mathematics, science. (**Usage**)
- b) An ability to design and conduct experiments, as well as to analyze and interpret data. (**Usage**)
- i) An ability to use the techniques, skills, and modern computing tools necessary for computing practice. (**Usage**)
- j) Apply the mathematical basis, principles of algorithms and the theory of Computer Science in the modeling and design of computational systems in such a way as to demonstrate understanding of the equilibrium points involved in the chosen option. (**Usage**)

9. Competences (IEEE)

- C2.** Ability to have a critical and creative perspective in identifying and solving problems using computational thinking.
⇒ **Outcome a**
- CS1.** Model and design computer-based systems in a way that demonstrates comprehension of the tradeoff involved in design choices.⇒ **Outcome b**
- CS2.** Identify and analyze criteria and specifications appropriate to specific problems, and plan strategies for their solution.⇒ **Outcome i**
- CS3.** Analyze the extent to which a computer-based system meets the criteria defined for its current use and future development.⇒ **Outcome j**
- CS6.** Evaluate systems in terms of general quality attributes and possible tradeoffs presented within the given problem.⇒ **Outcome j**

10. List of topics

- 1.
2. Language Pragmatics
3. Type Systems
4. Object-Oriented Programming
5. Functional Programming
6. Event-Driven and Reactive Programming
7. Logic Programming

11. Methodology and Evaluation

Methodology:

Theory Sessions:

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

Lab Sessions:

In order to verify their competences, several activities including active learning and roleplay will be developed during lab sessions.

Oral Presentations:

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

Reading:

Throughout the course different readings are provided, which are evaluated. The average of the notes in the readings is considered as the mark of a qualified practice. The use of the UTEC Online virtual campus allows each student to access the course information, and interact outside the classroom with the teacher and with the other students.

Evaluation System:

12. Content

Unit 1: (18)	
Competences Expected: C2, CS1, CS2	
Learning Outcomes	Topics
<ul style="list-style-type: none"> • Reconocer el desarrollo histórico de los lenguajes de programación. [Familiarity] • Identificar los paradigmas que agrupan a la mayoría de lenguajes de programación existentes hoy en día. [Familiarity] • Explain how programs that process other programs treat the other programs as their input data [Familiarity] • Describe an abstract syntax tree for a small language [Familiarity] • Write a program to process some representation of code for some purpose, such as an interpreter, an expression optimizer, or a documentation generator [Usage] • Distinguish a language definition (what constructs mean) from a particular language implementation (compiler vs interpreter, run-time representation of data objects, etc) [Familiarity] • Reconocer como funciona un programa a nivel de computador. [Familiarity] 	<ul style="list-style-type: none"> • Historia de los Lenguajes de Programación • Programs that take (other) programs as input such as interpreters, compilers, type-checkers, documentation generators • Data structures to represent code for execution, translation, or transmission • Estructura de un programa: Léxico, Sintáctico y Semántico • BNF • Interpretation vs. compilation to native code vs. compilation to portable intermediate representation [Familiarity]
Readings : [Seb12], [Web10]	

Unit 2: Language Pragmatics (12)	
Competences Expected: C2, CS1, CS2	
Learning Outcomes	Topics
<ul style="list-style-type: none"> • Discuss the role of concepts such as orthogonality and well-chosen defaults in language design [Usage] • Use crisp and objective criteria for evaluating language-design decisions [Usage] • Give an example program whose result can differ under different rules for evaluation order, precedence, or associativity [Usage] • Show uses of delayed evaluation, such as user-defined control abstractions [Familiarity] • Discuss the need for allowing calls to external calls and system libraries and the consequences for language implementation [Familiarity] 	<ul style="list-style-type: none"> • Principles of language design such as orthogonality • Evaluation order, precedence and associativity • Eager vs. delayed evaluation • Defining control and iteration constructs • External calls and system libraries
Readings : [Seb12], [Web10], [RH04]	

Unit 3: Type Systems (18)	
Competences Expected: C2, CS1, CS2	
Learning Outcomes	Topics
<ul style="list-style-type: none"> • Define a type system precisely and compositionally [Usage] • For various foundational type constructors, identify the values they describe and the invariants they enforce [Familiarity] • Precisely specify the invariants preserved by a sound type system [Familiarity] • Prove type safety for a simple language in terms of preservation and progress theorems [Usage] • Implement a unification-based type-inference algorithm for a simple language [Usage] • Explain how static overloading and associated resolution algorithms influence the dynamic behavior of programs [Familiarity] 	<ul style="list-style-type: none"> • Compositional type constructors, such as product types (for aggregates), sum types (for unions), function types, quantified types, and recursive types • Type checking • Type safety as preservation plus progress • Type inference • Static overloading
Readings : [Seb12], [Web10], [RH04]	

Unit 4: Object-Oriented Programming (12)	
Competences Expected: CS2, CS3, CS6	
Learning Outcomes	Topics
<ul style="list-style-type: none"> • Design and implement a class [Usage] • Use subclassing to design simple class hierarchies that allow code to be reused for distinct subclasses [Usage] • Correctly reason about control flow in a program using dynamic dispatch [Usage] • Compare and contrast (1) the procedural/functional approach—defining a function for each operation with the function body providing a case for each data variant—and (2) the object-oriented approach—defining a class for each data variant with the class definition providing a method for each operation Understand both as defining a matrix of operations and variants [Assessment] • Explain the relationship between object-oriented inheritance (code-sharing and overriding) and subtyping (the idea of a subtype being usable in a context that expects the supertype) [Usage] • Use object-oriented encapsulation mechanisms such as interfaces and private members [Usage] • Define and use iterators and other operations on aggregates, including operations that take functions as arguments, in multiple programming languages, selecting the most natural idioms for each language [Usage] 	<ul style="list-style-type: none"> • Object-oriented design <ul style="list-style-type: none"> – Decomposition into objects carrying state and having behavior – Class-hierarchy design for modeling • Definition of classes: fields, methods, and constructors • Subclasses, inheritance, and method overriding • Dynamic dispatch: definition of method-call • Subtyping <ul style="list-style-type: none"> – Subtype polymorphism; implicit upcasts in typed languages – Notion of behavioral replacement: subtypes acting like supertypes – Relationship between subtyping and inheritance • Object-oriented idioms for encapsulation <ul style="list-style-type: none"> – Privacy and visibility of class members – Interfaces revealing only method signatures – Abstract base classes • Using collection classes, iterators, and other common library components
Readings : [Seb12], [Web10], [RH04]	

Unit 5: Functional Programming (18)	
Competences Expected: CS2, CS3, CS6	
Learning Outcomes	Topics
<ul style="list-style-type: none"> • Write basic algorithms that avoid assigning to mutable state or considering reference equality [Usage] • Write useful functions that take and return other functions [Usage] • Compare and contrast (1) the procedural/functional approach-defining a function for each operation with the function body providing a case for each data variant-and (2) the object-oriented approach-defining a class for each data variant with the class definition providing a method for each operation Understand both as defining a matrix of operations and variants [Assessment] • Correctly reason about variables and lexical scope in a program using function closures [Usage] • Use functional encapsulation mechanisms such as closures and modular interfaces [Usage] • Define and use iterators and other operations on aggregates, including operations that take functions as arguments, in multiple programming languages, selecting the most natural idioms for each language [Usage] 	<ul style="list-style-type: none"> • Effect-free programming <ul style="list-style-type: none"> – Function calls have no side effects, facilitating compositional reasoning – Variables are immutable, preventing unexpected changes to program data by other code – Data can be freely aliased or copied without introducing unintended effects from mutation • Processing structured data (e.g., trees) via functions with cases for each data variant <ul style="list-style-type: none"> – Associated language constructs such as discriminated unions and pattern-matching over them – Functions defined over compound data in terms of functions applied to the constituent pieces • First-class functions (taking, returning, and storing functions) • Function closures (functions using variables in the enclosing lexical environment) <ul style="list-style-type: none"> – Basic meaning and definition – creating closures at run-time by capturing the environment – Canonical idioms: call-backs, arguments to iterators, reusable code via function arguments – Using a closure to encapsulate data in its environment – Currying and partial application • Defining higher-order operations on aggregates, especially map, reduce/fold, and filter
Readings : [Seb12], [Web10], [RH04]	

Unit 6: Event-Driven and Reactive Programming (12)	
Competences Expected: CS2, CS3, CS6	
Learning Outcomes	Topics
<ul style="list-style-type: none"> • Write event handlers for use in reactive systems, such as GUIs [Usage] • Explain why an event-driven programming style is natural in domains where programs react to external events [Familiarity] • Describe an interactive system in terms of a model, a view, and a controller [Familiarity] 	<ul style="list-style-type: none"> • Events and event handlers • Canonical uses such as GUIs, mobile devices, robots, servers • Using a reactive framework <ul style="list-style-type: none"> – Defining event handlers/listeners – Main event loop not under event-handler-writer’s control • Externally-generated events and program-generated events • Separation of model, view, and controller
Readings : [Seb12]	

Unit 7: Logic Programming (12)	
Competences Expected: CS2, CS3, CS6	
Learning Outcomes	Topics
<ul style="list-style-type: none"> • Use a logic language to implement a conventional algorithm [Usage] • Use a logic language to implement an algorithm employing implicit search using clauses, relations, and cuts [Usage] 	<ul style="list-style-type: none"> • Causal representation of data structures and algorithms • Unification • Backtracking and search • Cuts
Readings : [Seb12], [Web10], [RH04]	