PREREQUISITES
Basic knowledge of Programming in R. It is highly recommended to have passed the BDBA subjects from the previous year. We assume that the reader is at least vaguely familiar with a high-level programming language, such as R or Python, and that he or she understands the main constructs from such a high-level language, including:
- Variables and expressions.
- Decision structures (such as if-statements and switch-statements).
- Iteration structures (for loops and while loops).
- Functions.
SUBJECT DESCRIPTION

I’m not sure that you know that every app you are using in your mobile is based on an awesome algorithm that some genius has developed, but I’m sure you want to be the one who will develop the next revolutionary algorithm. Did you know about the only algorithm that have its own song? Why don’t you take a minute to check the following: quicksort song. It is quite impressive, isn’t it?

For any data scientist, knowing the data structures and the tools necessary to manipulate them is essential. When a problem arises, the first step is to establish the relevant model to manage the data and optimize the solution. In other words, it is crucial to determine the data structures to be used in managing the data in order to create the algorithm(s) that automate all of the data management processes.

Algorithms development and analysis for basic data structure management are covered in this course using Python as the main programming language. R is also used as secondary programming tool.

At the end of the course, students will know how to generate relevant data models for specific problems and automate data management processes using Python algorithms.

The main topics covered in this course are the following:
1. Introduction to algorithms and data structures
2. Big O notation
3. Selection sort
4. Recursion
5. Divide and Conquer and Quicksort
6. Hash tables
7. Breadth-First search / Depth first search
8. Dijkstra’s algorithm
9. Greedy algorithms
OBJECTIVES AND SKILLS
At the end of the course, students will be able to:
- Analyze the efficiency of an algorithm
- Develop algorithms in R and Python
- Handle basic data structures
- Work with graphs
METHODOLOGY

Lectures
Interactive lectures, readings and class discussions will be the basic teaching methodology used during the semester. Lectures will usually include various hands-on tasks. Reading, discussion and critical thinking is expected from the students.

Workshops and practical activities
There will be practical sessions with exercises in Python, consisting of both individual and group work. We will use audio-visual materials, books, papers, and information from other sources. Bringing your laptop is mandatory to all sessions, although its use (or not) will be decided by the professor.
### Teaching Methodology

<table>
<thead>
<tr>
<th>Teaching Methodology</th>
<th>Weighting</th>
<th>Estimated Time a Student Should Dedicate to Prepare for and Participate in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures</td>
<td>26.67 %</td>
<td>40 hours</td>
</tr>
<tr>
<td>Discussions</td>
<td>13.33 %</td>
<td>20 hours</td>
</tr>
<tr>
<td>Exercises</td>
<td>20.0 %</td>
<td>30 hours</td>
</tr>
<tr>
<td>Group work</td>
<td>20.0 %</td>
<td>30 hours</td>
</tr>
<tr>
<td>Other individual studying</td>
<td>20.0 %</td>
<td>30 hours</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100.0 %</strong></td>
<td><strong>150 hours</strong></td>
</tr>
</tbody>
</table>

19th June 2019
PROGRAM

SESSIONS 1 - 2
Introduction to “Algorithms and Data Structures”
- Subject description and subject expectative
- Subject introduction
- What is an algorithm? The Role of algorithms in computing

SESSIONS 3 - 4
Basics of Algorithms (part 1)
- Algorithm running time
- Asymptotic analysis
- Big O notation
- Big O analysis
Related readings:
o Goodrich, Tamassia and Goldwasser (2013). Chapter 3
o Bhargava (2016). Chapter 1
o Cormen et al., (2009). Chapter 1.1

SESSIONS 5 - 6
Basics of Algorithms (part 2)
- Finding time complexity of an algorithm
- Designing algorithms
- Algorithm exercises
Related readings:
o Goodrich, Tamassia and Goldwasser (2013). Chapter 3
o Bhargava (2016). Chapter 1
o Cormen et al., (2009). Chapter 2 and 3

SESSIONS 7 - 8
Selection sort
- Algorithm exercises review
- Arrays
- Linked lists
- Insertion and Deletion
- Selection sort
- Arrays and linked lists exercises
Related readings:
o Goodrich, Tamassia and Goldwasser (2013). Chapter 5 and 7
o Bhargava (2016). Chapter 2
SESSIONS 9 - 10

Recursion
- Arrays and linked lists exercises review
- Recursion
- Illustrative examples
- Analyzing recursive algorithms
- Designing recursive algorithms
- The stack with or without recursion
- Recursion exercises

Related readings:
- Cormen et al., (2009). Chapter 10

SESSIONS 11 - 12

Divide and Conquer
- Recursion exercises review
- Divide and conquer introduction
- Some illustrative examples
- Quicksort
- Big O notation comparison
- Divide and conquer exercises

Related readings:
- Cormen et al., (2009). Chapter 4 and 7
- Bhargava (2016). Chapter 4

SESSIONS 13 - 14

Review Session

SESSIONS 15 - 16

MidTerm Exam

SESSIONS 17 - 18

Hash tables
- Divide and conquer exercises review
- Hash functions
- Use cases
- Collisions
- Performance
- Hash tables exercises
Related readings:
- Goodrich, Tamassia and Goldwasser (2013). Chapter 10
- Bhargava (2016). Chapter 5
- Cormen et al., (2009). Chapter 11

**SECTIONS 19 - 20**

**Binary Search Trees**
- Hash tables exercises review
- Binary trees
- Binary search trees theory
- Binary search trees implementation in Python
- Balanced binary trees: AVL trees vs. Red-Black trees
- Binary search trees exercises

Related readings:
- Goodrich, Tamassia and Goldwasser (2013). Chapter 11
- Cormen et al., (2009). Chapter 12

**SECTIONS 21 - 22**

**Graph Algorithms**
- Binary search trees exercises review
- Introduction to graphs
- Breadth-first search
- Depth-first search
- Implementing the graph
- Implementing the algorithm
- Graph algorithms exercises

Related readings:
- Goodrich, Tamassia and Goldwasser (2013). Chapter 14
- Bhargava (2016). Chapter 6
- Cormen et al., (2009). Chapter 22

**SECTIONS 23 - 24**

**Shortest Paths Algorithms**
- Graph algorithms exercises review
- Shortest paths introduction
- Dijkstra's Algorithm
- Bellman-Ford Algorithm
- Shortest paths algorithms implementation
- Shortest paths algorithms exercises

Related readings:
- Goodrich, Tamassia and Goldwasser (2013). Chapter 14
- Bhargava (2016). Chapter 7

19th June 2019
SESSIONS 25 - 26

Greedy Algorithms

- Shortest paths algorithms exercises review
- Greedy algorithms introduction
- An illustrative example
- Elements of the greedy strategy
- Greedy Algorithms exercises

Related readings:

- Bhargava (2016). Chapter 8
- Cormen et al., (2009). Chapter 16

SESSIONS 27 - 28

Group Presentations and Review session

SESSIONS 29 - 30

Final Exam
BIBLIOGRAPHY

EVALUATION CRITERIA

Your final grade in the course will be based on class participation, in-class quizzes, midterm exam, group project and the final exam. The weight of each one will be as follows:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Percentage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Participation</td>
<td>10 %</td>
<td></td>
</tr>
<tr>
<td>In-class quizzes</td>
<td>10 %</td>
<td></td>
</tr>
<tr>
<td>MidTerm</td>
<td>20 %</td>
<td></td>
</tr>
<tr>
<td>Workgroups</td>
<td>30 %</td>
<td></td>
</tr>
<tr>
<td>Final Exam</td>
<td>30 %</td>
<td></td>
</tr>
</tbody>
</table>

Participation in Activities/Discussions & Lab Attendance (10%)

Active participation in class activities, discussions, and labs is an especially important aspect in this course because our focus will be on understanding how the concepts discussed in class can be applied in real-world contexts. Attendance will form the basis of your participation grade. Specifically, 1% will be deducted for each missed class unless official documentation (e.g., from a medical doctor, counsellor) of illness or other extenuating circumstances is provided to the professor within 24 hours of the missed lab.

Short Quizzes (10%)

Over the course of the semester, you will be given 11 in-class quizzes. These quizzes are intended to evaluate your understanding of the material discussed in the prior class. Each quiz will consist of 10 multiple choice questions. 10 quizzes will count toward your final grade, at 1% per quiz. You have the option of either not writing one quiz or dropping the quiz with the lowest grade if all 11 quizzes are written.

Midterm Exam (20%)

The midterm exam will only include material from class. The exam format will include programming and short answer.

Group Project (30%)

In small groups you will be tasked with critically analyzing an issue that requires applying the knowledge you have learned in this course. As a group, you will need to discuss the issue, analyze the problems, and then propose evidence-based recommendations that will be communicated in a short, written report. A detailed description of the project requirements can be found in the “Assignments” folder on Blackboard. Must be submitted via Turnitin.

Final Exam (30%)

The final exam will only include material from the PowerPoint slides covered in class after the midterm exam. The exam format will include multiple choice, short answer and long answer questions. The final exam will be held during scheduled class time on TBD, from XX-YYpm.

Late Assignments/Presentation:

Will be penalized 2% per 24-hour period, starting on the day they are due. Only in cases of emergency or illness can changes be made to due dates of assignments or projects. ALL such arrangements are the full responsibility of the student and must be made PRIOR to the due date. Failure to confirm any changes to the due date with the professor prior to the due date will result in a grade of zero.

Minimum passing grade:

To ensure quality, we will set a minimum passing grade in all final exams (3.5). If your score is lower than this minimum you will have to go to June retake, irrespective of your overall course grade. Also keep in mind that the overall passing course grade is 5.0.
Kaggle competitions
During the course students will be encouraged to compete in Kaggle competitions that boost their profile as data scientists. These competitions will be selected by me with the help of your career director, and mentoring work will be carried out on our part to try to secure a good position in these competitions that will help you make a significant leap in your profile.

PROFESSOR BIO
Professor: ALEJANDRO MARTÍNEZ MINGO
E-mail: amartinezm@faculty.ie.edu

ALEJANDRO MARTÍNEZ MINGO
amartinezm@faculty.ie.edu

Alejandro Martínez holds a Master’s Degree in Behavioral & Health Science Methodology from the Universidad Autónoma de Madrid (Spain), an MBA from the Lazarus project developed by the "Escuela de Organización Industrial" and the "Caja Rural" and is certified Big Data developer course in python. His research interests include natural language processing, quantum models, machine learning and deep learning techniques, image processing, and statistical computing in R and Python. He has developed several technological solutions throughout his career, including an automatic system of constructed responses evaluation based on natural language processing, an automatic system of risk assessment in cases of violence against women and a solution based on artificial intelligence systems for social media management. He has worked as a researcher at the Instituto de Ciencias Forenses y de la Seguridad of the Universidad Autónoma de Madrid, has created the company Wibber and currently works in his own Artificial Intelligence consultancy (Compai) in which they carry out training and implementation projects of digitization based on Artificial Intelligence systems for big companies.

OTHER INFORMATION
As per University Policy:

Each student has 4 chances to pass any given course distributed in two consecutive academic years (regular period and July period).

It is mandatory to attend 100% of the classes. Students who do not comply with at least 70% attendance will lose their 1st and 2nd chance, and go directly to the 3rd one (they will need to enroll again in this course the next academic year).

Grading for retakes will be subject to the following rules:

1. Those students who failed the subject in the first regular period will have to do a retake in July (except those not complying with attendance rules who are banned from this possibility).
2. Dates and location of the July retakes will be posted in advance and will not be changed. Please take this into consideration when planning your summer.
3. The maximum grade that a student may obtain in the 2nd exam session is 8 out of 10. Those students in the 3rd call will be required to attend 50% of the classes. If due to schedule overlap, a different option will be discussed with the professor in order to pass the subject.

Attendance:

Attendance at all scheduled classes is mandatory and essential for success in the course. If you miss class for any reason, you are responsible for getting notes from classmates. If you have questions about any assignment please send me an email. Under most circumstances, students who miss a class in which a presentation, mid-term, or final exam is held will not be granted an exception or given an opportunity to do a make-up assignment or exam. However, if illness or other circumstances prevent you from adhering to the assignment/presentation due dates stated in this syllabus, an exception may be granted at the discretion of the professor. In all cases, the student must provide official documentation (e.g., from a medical doctor, counsellor) to the professor within 24 hours of the missed due date.

Students with Special Needs:
To request academic accommodations due to a disability, please contact Rafif Srour via email at: Rafif.Srour@ie.edu.

Student Privacy Statement:
At times, students may disclose personal information through class discussions. It is expected that all members of the class will respect the privacy of their classmates. This means that the information disclosed in the class will not be repeated or discussed with other students outside of the course.

**Decisions about Grades:**

Decisions about grades are made very carefully, and are final at the end of the course. If you have questions regarding a certain grade or you would like to receive personal feedback, you must request a meeting with me to discuss grades on specific assignments before the last class of the course. Any disputes regarding grades must be resolved before the final exam. “Extra credit” or makeup assignments will only be allowed under extenuating circumstances at the sole discretion of the course professor.

**ACADEMIC INTEGRITY**

Unless you are specifically instructed to work with other students in a group, all of your assignments, papers, projects, presentations, and any work I assign must reflect your own work and thinking.

What is academic integrity? When you do the right thing even though no one is watching. The core values of integrity, both academic and otherwise include: honesty, fairness, respect, responsibility, and trust. Academic Integrity requires that all students within Instituto de Empresa (IE) act in accordance with these values in the conduct of their academic work, and that they follow the rules and regulations concerning the accepted conduct, practices and procedures of academic research and writing. Academic Integrity violations are defined as Cheating, Plagiarism or other violations of academic ethics. Cheating and plagiarism are very serious offenses governed by the IE student code of conduct. Any student found cheating or plagiarizing on any assignment or component of this course will at a minimum receive a “0” on the affected assignment. Moreover, the student will also be referred to the University Judicial System for further action. Additional penalties could include a note on your transcript, failing the class, or expulsion from the university.

It is important to note that, while the list below is comprehensive, it should not be considered exhaustive.

**Cheating includes:**

a. An act or attempt to give, receive, share, or utilize unauthorized information or unauthorized assistance at any time for assignments, papers, projects, presentations, tests or examinations. Students are permitted to mentor and/or assist other students with assignments by providing insight and/or advice. However, students must not allow other students to copy their work, nor will students be permitted to copy the work of other students. Students must acknowledge when they have received assistance from others.

b. Failure to follow rules on assignments, papers, projects, presentations, tests or examinations as provided by the course professor and/or as stipulated by IE.

c. Unauthorized co-operation or collaboration.

d. Tampering with official documents, including electronic records.

e. The impersonation of a student on presentations, exercises, tests or an examination. This includes logging onto any electronic course management tool or program (e.g. Black Board, etc.) using someone else’s login and password.

**Plagiarism includes:**

a. Using the work of others and attempting to present it as your own. For example, using phrases or passages from books, articles, newspapers, or the internet and not referencing them properly in your document. This includes using information from others without citing it, misrepresentation of cited work, and misuse of quotation marks.

b. Submitting an assignment or paper that is highly similar to what someone else has written (i.e., minimal changes in wording, or where the sentences are similar, but in a different order).
c. You don’t have to commit “word for word” copying to plagiarize – you can also plagiarize if you turn in something that is “thought for thought” the same as someone else.

**Other violations of academic ethics include:**

a. Not acknowledging that your work or any part thereof has been submitted for credit elsewhere.

b. Misleading or false statements regarding work completed.

Knowingly aiding or abetting anyone in committing any form of an Academic Integrity violation.
**CODE OF CONDUCT IN CLASS**

1. **Be on time**: Students arriving more than 5 minutes late will be marked as “Absent”. Only students that notify in advance in writing that they will be late for a specific session may be granted an exception (at the discretion of the professor).

2. **If applicable, bring your name card and strictly follow the seating chart.** It helps faculty members and fellow students learn your names.

3. **Do not leave the room during the lecture**: Students are not allowed to leave the room during lectures. If a student leaves the room during lectures, he/she will not be allowed to re-enter and, therefore, will be marked as “Absent”. Only students that notify that they have a special reason to leave the session early will be granted an exception (at the discretion of the professor).

4. **Do not engage in side conversation.** As a sign of respect toward the person presenting the lecture (the teacher as well as fellow students), side conversations are not allowed. If you have a question, raise your hand and ask it. If you do not want to ask it during the lecture, feel free to approach your teacher after class.

   If a student is disrupting the flow of the lecture, he/she will be asked to leave the classroom and, consequently, will be marked as “Absent”.

5. **Use your laptop for course-related purposes only.** The use of laptops during lectures must be authorized by the professor. The use of Social Media or accessing any type of content not related to the lecture is penalized. The student will be asked to leave the room and, consequently, will be marked as “Absent”.

6. **No cellular phones**: IE University implements a “Phone-free Classroom” policy and, therefore, the use of phones, tablets, etc. is forbidden inside the classroom. Failing to abide by this rule entails expulsion from the room and will be counted as one absence.

7. **Escalation policy: 1/3/5.** Items 4, 5, and 6 above entail expulsion from the classroom and the consequent marking of the student as “Absent.” IE University implements an “escalation policy”: The first time a student is asked to leave the room for disciplinary reasons (as per items 4, 5, and 6 above), the student will incur one absence, the second time it will count as three absences, and from the third time onward, any expulsion from the classroom due to disciplinary issues will entail 5 absences.