CS 5012 Foundations of Computer Science

Spring 2021

Contact

Instructor:
Prof. Panagiotis Apostolellis
Email: panaga@virginia.edu

Teaching assistants:

Siddharth Surapaneni	Lead TA	sss2ea@virginia.edu
Masum Billah	HW Lead	mb2vj@virginia.edu
Yuxin Zi	MOE & ICA Lead	yz5vt@virginia.edu

Primary Textbooks

- Introduction to Algorithms, Cormen, Leiserson, Rivest, Stein. The MIT Press, ISBN: 978-0262033848
- Database System Concepts, Seventh Edition, Silberschatz, Korth, Sudarshan. McGraw-Hill, ISBN 978-0-07-802215-9
- (optional): Tymann, P. & Schneider, G. M.; Modern Software Development Using Java. (A free copy of this textbook can be found here).
- (optional): Rosen, K.H. (2011). Discrete Mathematics and its Applications. New York, NY: McGraw-Hill. ISBN 978- 0073383095

Supplemental readings/material may be assigned and will be made available in Resources on Collab.

Course Objectives

The main goal of this course is to provide an *overview* of fundamental computer science concepts, such as algorithm design, data structures, databases and analysis techniques. To reach this goal, topics include: algorithms for hash tables, trees, queues, sorting, graphs; key-value stores at scale; database topics such as RA, ER, and the MySQL language; and finally some advanced analysis techniques.

The purpose of this class is to introduce to you the main CS concepts that you will learn in more detail in the remaining Data Science Master's program. Due to introducing a variety of concepts, the tradeoff is that there is not enough time to cover them into detail. A deeper understanding of these concepts will come during subsequent DS courses and while you engage with practicing on your own. As a graduate level course, CS5012 depends a lot on *self-regulated learning* and further *exploration* (and practice) of the concepts introduced in this class, at your own time.

Course Topic Details

The topics covered in this course include the following, presented in the approximate order in which they will be taught. This list of topics is to be considered a *reference* that can be adjusted through the course of the semester to address changing needs.

- Discrete math* [Review on your own]
    1. Propositional logic
    2. Predicate logic
    3. Sets and set operations
    4. Functions and relations
- Classic algorithms and data structures
    1. Big-O notation; selection/order statistics
    2. Sorting, searching, hashing and indexing
    3. Linked Lists
    4. Priority queues
    5. Trees
    6. Graphs: paths, cuts, search
- Relational databases
    1. Relational Algebra
    2. Entity-Relationship (ER) diagrams (focus on DB design)
    3. SQL
    4. Transactions and concurrency control
- Distributed databases
- NoSQL databases (types and contrast to Relational)
- Introduction to parallel computing (concurrency)
- Overview of advanced analysis techniques (if time permits)

*Note: This course will assume you are knowledgeable about these four discrete math topics, which will not be covered in class. Material will be provided for review, or for you to learn on your own. This material IS testable material!

Course Outcomes

It is expected, at the completion of this course, students will be able to:

1. Have a working knowledge of the theoretical foundations of the discipline.
2. Use logic and basic proof techniques, such as mathematical induction.
3. Define and use discrete structures such as functions, relations, and sets.
4. Use trees and graphs to formulate computational problems.
5. Select and use the appropriate data structures for computational problems.
6. Create an E-R Diagram based on the data and topic at hand.
7. Construct appropriate SQL commands to query the data in a database.
8. Have a working knowledge of relational databases.
9. Analyze define the differences between relational and NoSQL databases.
10. Select the appropriate kind of database for the data and task at hand.
11. Select and use the appropriate sort and search algorithms for relevant problems.
12. Select and use appropriate algorithms based on computational complexity.
13. Have a working knowledge of parallel computing.
14. Apply and use advanced analysis techniques on relevant problems.

Course Requirements

As a prerequisite, a student should have taken the following courses:

1. An introductory course in programming
2. Calculus
3. Probability/statistics
4. Linear algebra

Assessment

A combination of different assessments was designed to help you learn the concepts presented in the class. The types of assignments, their objective, and their weighted score is included in the table below:

Assessment	Objective	Due	Weight
Homework Assignments (HW)	Longer assignments aim to help you practice concepts learned in specific modules (i.e., modules 0, 2, 3, 8, 9).	Sunday midnight	20%
Module Exercises (MOE)	Shorter assignments on the week's topic that should be completed before class, mostly on your own.	Wednesday 4:59 pm	10%
In-class Activities (ICA)	Exercises that should be completed during the live session on the week's topic, mostly in groups.	Wednesday midnight	10%
Exams (EX)	Two mid-term exams and one final exam aim as formative and summative assessments, respectively, of your understanding of the concepts presented in the class.	On the posted date (modules 5, 9, 12)	40%
Mini-Project	A short project that spans multiple modules and will cover the topics of SQL and Databases. This will be a group project.	On the posted date (module 9)	10%
Participation	Includes completion of extra assignments that show engagement in the class, such as supplemental quizzes and discussion posts.	Sunday midnight	10%

The final letter grade will be determined by the following scale:

Grade	C/GC/NC	Minimum	Maximum
A+	C	98.0	100
A	C	93.0	97.999
A-	C	90.0	92.999
B+	C	87.0	89.999
B	C	83.0	86.999
B-	C	80.0	82.999
C+	C	77.0	79.999
C	C	73.0	76.999
C-	GC	70.0	72.999
D+	GC	67.0	69.999
D	GC	63.0	66.999
D-	GC	60.0	62.999
F	NC	0.0	59.999

Class Management

General

- Please feel free to join the office hours (with me and TA's) to discuss any issues. Also, we can arrange a mutually agreeable time outside of the office hours.
- Email is the best way to get in touch with the instructor. **Please include "CS 5012" in the subject line of your email.**
- Please do not hesitate to contact me if you have any problems, concerns, questions, or issues regarding the course, material, or anything else in the class.
- Please do not hesitate to talk to me if there are situations in your life that are affecting your performance in the class or your life here at UVa. I might not be able to help, but I might know of resources that might help.

Homework Assignments

- Specific grading criteria will be provided with each homework assignment.
- For some homework assignments you are encouraged to work in a group. A few homework assignments require you to work alone. How many people you can work with will be clearly stated for every assignment. When in doubt, please ask!
- Lowest one (1) homework grade will be dropped (however, you must submit and complete every homework assignment.)

Modules Exercises (MOE) and In-class Activities (ICA)

- Module exercises should be completed before class, as they will help you follow the live sessions and ask questions more effectively, as well as be productive during ICAs.
- In-class activities aim to enhance your understanding of presented concepts while working in groups, so it's important to attend the live session each week; ICAs will be completed in Zoom breakout rooms.
- Lowest one (1) grade will be dropped for each one of these categories (however, you should aim to submit and complete every assignment.)

Participation

- Learning that really sticks can be achieved by being active. Success in this course relies on everyone preparing for class and participating in activities and discussions during the live sessions.
- Further, interacting with peers and the TAs during and after class (e.g., using Piazza or the Collab Discussions), will result in different points of view and ideas to come to the surface.

Creating a Positive Class Environment

Your success in this class depends on others! These are your classmates, your instructor, and the teaching assistants. Learning is a fundamentally social process and learning communities thrive when they value what every individual has to share. You each bring in knowledge and experiences about how to create a positive course environment, which you might need to challenge or build upon to help you succeed in this course. We will work together to create an environment where each person is valued as an individual, and where you can learn and contribute with your full potential, whatever your sex, gender, race, ethnicity, sexual orientation, religion, disability status and other aspects of your identity. Creating a positive environment is a learning process, because social and cultural norms influence our behavior in ways we are or aren't aware of (positive or negative), so we are all going to make mistakes in how we treat others. I am working on learning how to respond appropriately and promptly when I make or witness such mistakes. When I personally make mistakes or miss an opportunity to respond, please let me know privately either in person (visiting office hours) or by email. You should always remember that our cultural or other difference should act as a strength, and not a hurdle, to how we work and communicate with each other. This is a learning opportunity to everyone and I will be grateful for your constructive feedback, which helps me learn and improve.

This Syllabus

This syllabus is to be considered a reference document that can and will be adjusted through the course of the semester to address changing needs. This syllabus can be changed at any time without notification. It is up to the student to monitor this page for any changes. Final authority on any decision in this course rests with the professor, not with this document.

Academic Integrity

The School of Engineering and Applied Science relies upon and cherishes its community of trust. We firmly endorse, uphold, and embrace the University's Honor principle that students will not lie, cheat, or steal, nor shall they tolerate those who do. We recognize that even one honor infraction can destroy an exemplary reputation that has taken years to build. Acting in a manner consistent with the principles of honor will benefit every member of the community both while enrolled in the Engineering School and in the future.

Students are expected to be familiar with the university honor code, including the section on academic fraud (http://www.student.virginia.edu/ honor/proc/fraud.html). Each assignment will describe allowed collaborations, and deviations from these will be considered Honor violations. If you have questions on what is allowable, ask! Unless otherwise noted, exams and individual assignments will be considered pledged that you have neither given nor received help. (Among other things, this means that you are not allowed to describe problems on an exam to a student who has not taken it yet. You are not allowed to show exam papers to another student or view another student's exam papers while working on an exam.) Sending, receiving or otherwise copying electronic files that are part of course assignments are not allowed collaborations (except for those explicitly allowed in assignment instructions).

Assignments or exams where honor infractions or prohibited collaborations occur will receive a zero grade for that entire assignment or exam. Such infractions will also be submitted to the Honor Committee

if that is appropriate. Students who have had prohibited collaborations may not be allowed to work with partners on remaining homework assignments.

SDAC and Other Special Circumstances

If you have been identified as a Student Disability Access Center (SDAC) student, please let the Center know you are taking this class. If you suspect you should be an SDAC student, please schedule an appointment with them for an evaluation. The recommended accommodations will be provided for those students identified by the SDAC. Please contact your instructor one week before an exam so we can make accommodations. Website: http://www.virginia.edu/studenthealth/sdac/sdac.html

If you are affected by a situation that falls within issues addressed by the SDAC and the instructor and staff are not informed about this in advance, this prevents us from helping during the semester, and it is unfair to request special considerations at the end of the term or after work is completed. So we request you inform the instructor as early in the term as possible your circumstances. If you have other special circumstances (athletics, other university-related activities, etc.) please contact your instructor and/or TA as soon as you know these may affect you in class.