IE 405: Computing for ISE

Fall 2022 TR 3:30 - 4:50 PM CT

114 Transportation Building (Zoom link is provided on CANVAS)

(Syllabus)

Instructor:	Jugal Garg (jugal@illinois.edu), 216B Transportation Building
TA:	John Qin (johnqin2@illinois.edu)
Course website:	`canvas.illinois.edu`
Zoom link:	Available on CANVAS
Slack link:	TBD
Office hours (Zoom):	TBD (Jugal)
	TBD (John)

Course Communication

All announcements, assignments, lecture slides, and other materials will be done through the course website on CANVAS.

Course Description

This course will introduce students to algorithm design, computer programming in `C++`, and database SQL queries. It will provide the fundamental methods, concepts and principles of these topics to give students enough breadth to use these techniques in their jobs and to prepare them to pursue advanced topics in these areas. There will be weekly programming assignments to implement algorithms and SQL covered in the class.

Course Overview

This course aims to cover the breadth of three different topics, namely computer programming in `C++`, algorithm design and SQL queries. In particular it will cover fundamental techniques such as divide and conquer, greedy algorithms, basic graph algorithms, and dynamic programming. Also, it will cover how to analyze the cost of computing and the limits of what we can and cannot compute in a reasonable amount of time. Furthermore, the basic principles of computer programming in `C++`, database design and SQL queries will be covered.

Prerequisites

- CS 101 or equivalent, IE 310 or equivalent

References

1. *Algorithm Design* by Jon Kleinberg and Éva Tardos. Pearson Education (2013)
2. *Introduction to Algorithms* by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein. 3rd Edition, MIT Press (2009)

3. *Database System Concepts* by Abraham Silberschatz, Henry Korth, S. Sudarshan. 6th edition, McGraw-Hill (2010)
4. *Database Management Systems* by Raghu Ramakrishnan, Johannes Gehrke. 3rd Edition, McGraw-Hill (2002)
5. *Starting Out with* `C++` *from Control Structures to Objects* by Tony Gaddis, 8th Edition, Pearson (2014)

Course Objectives

Students completing this course will be able to:

1. write computer programs in `C++`
2. design algorithms using greedy, dynamic programming and divide-and-conquer paradigm, and prove its correctness.
3. analyze an algorithm and how to count number of steps it takes
4. understand basic data structures, e.g., array, list, queue, stack, etc.
5. implement algorithms, designed in the *theory* class, in `C++`, e.g., Gale-Shapley algorithm for stable matching, Dijkstra's algorithm for shortest path, Kruskal's and Prim's algorithm for minimum spanning tree, check whether a graph is bipartite using Breadth-First-Search (BFS) algorithm, dynamic programming algorithm for knapsack problem, Merge sort, etc.
6. understand complexity classes `P`/`NP` and computational intractability
7. understand the role of a database management system in an organization
8. understand the structure and operation of the relational database model
9. construct simple and intermediate level database queries using Structured Query Language (SQL)

Course Project

The goal is to develop a fully-fledged `C++` program in a collaborative, team environment, written entirely from the scratch with proper documentation and instructions on how to use the program. Another option is to choose a topic in database design and SQL. More details will be provided in the middle of the course.

Course Topics

- Algorithm Design
  - Stable Matching (Gale-Shapley Algorithm), Basics of Algorithm Analysis (Computational Tractability, Asymptotic Order of Growth, Big O Notation), Graphs (Basic Definitions and Applications, Graph Connectivity, Breadth-First-Search (BFS), Testing Bipartiteness: an application of BFS), Greedy Algorithms (Interval Scheduling, Scheduling to Minimize Lateness, Shortest Paths in a Graph, Minimum Spanning Tree Problem), Divide and Conquer (Merge sort, Integer Multiplication), Dynamic Programming (Rod Cutting Problem, Weighted Interval Scheduling, Knapsack), `P`/`NP` and Computational Intractability (Polynomial Time Reductions, Efficient Certification and the Definition of `NP`, `NP`-complete Problems).
- `C++` Programming

  - Variables and Literals, Statements, Relational and Logical Operators, Loops, Functions, Scope, Arrays, Pointers, Dynamic Memory Allocation, Pseudorandom Number Generator, File I/O, Classes, Libraries, etc.

- Database Design and SQL Queries
  - Relational Model, Entity-Relationship Model, Database Schema, Keys, Schema Diagrams, Basic SQL (SQL Data Definitions, Set Operations, NULL Values, Aggregate Functions, Nested Subqueries, Modification of a Database), Intermediate SQL (Join Expressions, Integrity Constraints, SQL Data Types and Schemas).

Required Work and Grading Policy

- Undergraduate Credit
  1. Homework – Weekly assignments (40%)
  2. 2 Midterm exams (15% each)
  3. Final Exam (30%)
- Graduate Credit
  1. Homework – Weekly assignments (30%)
  2. 2 Midterm exams (12.5% each)
  3. Final Exam (25%)
  4. Project (20%)

Contact Hours

1 Theory and 1 Lab class (80 minutes each) per week.

Academic Integrity

We will follow Student Code Part 4 1-401 through 1-406 (`https://studentcode.illinois.edu/article1/part4/1-401/`).

COVID-19

From the University:

> *Following University policy, all students are required to engage in appropriate behavior to protect the health and safety of the community, including wearing a facial covering properly, maintaining social distance (at least 6 feet from others at all times), disinfecting the immediate seating area, and using hand sanitizer. Students are also required to follow the campus COVID-19 testing protocol.*
>
> *Students who feel ill must not come to class. In addition, students who test positive for COVID-19 or have had an exposure that requires testing and/or quarantine must not attend class. The University will provide information to the instructor, in a manner that complies*

with privacy laws, about students in these latter categories. These students are judged to have excused absences for the class period and should contact the instructor via email about making up the work.

Students who fail to abide by these rules will first be asked to comply; if they refuse, they will be required to leave the classroom immediately. If a student is asked to leave the classroom, the non-compliant student will be judged to have an unexcused absence and reported to the Office for Student Conflict Resolution for disciplinary action. Accumulation of non-compliance complaints against a student may result in dismissal from the University.

Diminished mental health, including significant stress, mood changes, excessive worry, substance/alcohol abuse, or problems with eating and/or sleeping can interfere with optimal academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings at no additional cost. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do – for yourself and for those who care about you.

Counseling Center: 217-333-3704, 610 East John Street Champaign, IL 61820

McKinley Health Center:217-333-2700, 1109 South Lincoln Avenue, Urbana, Illinois 61801