COSC 6340 | Database Systems

Section: 19457 | Hybrid
MoWe 01:00 PM-02:30 PM | University of Houston; Classroom and Business Bldg.; CBB 110

Cr: 3. (3-0) Prerequisites: Consent of the instructor. Database design with ER model, relational model and normalization. Relational algebra and SQL language. Database systems internals including storage, indexing, query optimizer, transaction processing, recovery, security.

General Course Information

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Course Objectives and Student Learning Outcomes

NEW COURSE NAME: Database Theory.

NEW REVISED TOPICS: First order logic, advanced set theory. Relational algebra, advanced database normalization (BCNF, 4NF, 5NF) Query optimization: query plans, models, NP-hard and NP-complete database problems Transactions: serializability, recovery. Algorithms and data structures for secondary storage. Parallel and distributed database computations. Applied math for large data sets.

These changes have been approved. The new course title will be updated in 2026.

DETAILED EXPLANATION

This is a graduate course covering theory of data systems (relational databases, logic and non-relational), I/O efficient algorithms for large data sets, parallel and distributed algorithms for large data sets to store, update, search, query and analyze large data sets. On the other hand, the course will briefly cover applied mathematics from calculus, linear algebra, statistics, machine learning and numerical methods, which is needed to analyze data at large scale.

Required Instructional Materials

The instructor will provide access to textbooks in PDF form.

Course Schedule, Assignments, and Assessments

Topics will be covered in the order of the course catalog description, 80% of the course will be CS theory and 20% applied math.

There is one exam around the 12th week, 2 weeks before the final class. There are 2 written theory assignments, covering 50% of the course each. There is one project due in 2 phases.

Discussion and Lecture Topics

This is a detailed list of topics covered 100%. Database systems topics: Set theory and first order logic. Relational database systems theory: tuple, relational calculus, completeness and consistency. Algebras for set and relational operators. Queries: Conjunctive, negation, linearly recursive queries, query plans, NP-complete query optimization problems, I/O cost models.

Transactions: schedules, serializability, recovery, locking, timestamp ordering, deadlock avoidance/resolution, indexing for append-only workloads, log-based algorithms. Algorithms and data structures for secondary storage: external merge sort, blocked binary search, B+-trees, extensible hashing, hash join, sort-merge join, multidimensional indexing. CAP Theorem, time complexity, I/O cost. Parallel and ditributed processing: speedup, scaleout, Amdahls Law, distributed vs one-node multicore architectures.

Applied math on large data sets topics (20% of course, partially covered, depending on students interest, as time allows): large sparse matrix multiplication, large matrix factorization, non-convex optimization, stochastic gradient descent for large n, summarization of large data sets via sufficient statistics, central limit theorem, approximating functions with mixtures of distributions, extending and generalizing regression models to neural networks.

Grading Rubrics and Weights

- 0%: diagnostic exam (required, individual, in class, closed-everything)
- 30%: 1 partial exam (individual, in class, closed-everything).
- 30%: 2 written theory homeworks (team of 2 students).
- 40%: 1 project (2 pheases, team of 2 students).

DETAILS

Required diagnostic exam on CS theory. The exam will happen during the 1st week of class, in the classroom. Topics: first order logic, algorithms, complexity, relational databases, query languages, automata, concurrent processing. The exam has 10 questions, requiring short answers. The exam is closed everything (no electronics, or notes). The exam will be graded by the instructor.

30%: 1 written exam: individual, in class, closed-electronics, covering 2/3 of the course. based mostly on textbook chapters and papers covered in class. Questions are on the theory side, rather than programming. Slides should be used only as a guideline, but not as study reference.

30%: 2 written theory homeworks, developed by a team of 2 students. Deliverable: PDF with clean math notation. It is acceptable to use AI chatbots (ChatGPT, Meta AI, Claude), disclosing which chatbot and for which specific aspects they were used (theory or programming). Extra file: submit your "chat" with ``polished" questions and answers in a text file "chatbot.txt", include also any prompts for text rewritten by AI. The instructor will use AI itself to double check your answers.

40%: team project applying and extending theory to solve a specific analytic problem. Problem list (tentative): parallel graph algorithms solved with queries (transitive closure, clique detection, graph compression); parallel I/O efficient algorithms for large sparse matrices (addition, multiplication, numerical methods); machine learning without memory limits (classical ML models). Neural networks with data set on secondary storage (TBD..tentative: querying and inference; GCNs, deep learning for classification, transformers probably not).

TEAM: Developed by a team of 2 students. Instructor will assign teams.

Deliverables: PDF (delivered first) and working code on our Linux server (1 week later).

Course Policies and Procedures

1. Office hours: students are encouraged to meet instructor after class, outside classroom, or office, after every lecture. Professor will be available to answer any questions or discuss any concerns.
2. On-line lectures: 50% of lectures will be on-line, covering programming, deeper theory and reviews for exams. There may be additional on-line lectures with optional attendance (recorded if necessary).
3. Messaging: we will setup a discord group, which will be monitored by TAs. MS Teams will be used only during online lectures, but not for constant messaging. Students are asked to post questions in discord, instead of email. The goal is that everyone learns and know what is going on.
4. Teams message: preferred communication for personal issues (medical, family, exceptional circumstances). Email should not be used to ask for HW extensions. Any request must be

made in person with the instructor, before the deadline.

University Policies and Student Support Resources

Mental Health and Wellness Resources

The University of Houston has a number of resources to support students' mental health and overall wellness, including CoogsCARE and the UH Go App. UH Counseling and Psychological Services (CAPS) offers 24/7 mental health support for all students, addressing various concerns like stress, college adjustment and sadness. CAPS provides individual and couples counseling, group therapy, workshops and connections to other support services on and off- campus. For assistance visit uh.edu/caps, call 713-743-5454, or visit a Let's Talk location in-person or virtually. Let's Talk are daily, informal confidential consultations with CAPS therapists where no appointment or paperwork is needed.

Need Support Now? If you or someone you know is struggling or in crisis, help is available. Call CAPS crisis support 24/7 at 713-743-5454, or the National Suicide and Crisis Lifeline: call or text 988, or chat 988lifeline.org.

Title IX/Sexual Misconduct

Per the UHS Sexual Misconduct Policy, your instructor is a "responsible employee" for reporting purposes under Title IX regulations and state law and must report incidents of sexual misconduct (sexual harassment, non-consensual sexual contact, sexual assault, sexual exploitation, sexual intimidation, intimate partner violence, or stalking) about which they become aware to the Title IX office (known at UH as the Equal Opportunity Services office or "EOS"). Please know there are places on campus where you can make a report in confidence. You can find more information about resources on the UH Title IX/Sexual Misconduct Resources page. Please note that you may also report concerns of discrimination based on your protected class identity to EOS.

Reasonable Academic Adjustments/Auxiliary Aids

The University of Houston is committed to providing an academic environment and educational programs that are accessible for its students. Any student with a disability who is experiencing barriers to learning, assessment or participation is encouraged to contact the Justin Dart, Jr.

Student Accessibility Center (Dart Center) to learn more about academic accommodations and support that may be available to them. Students seeking academic accommodations will need to register with the Dart Center as soon as possible to ensure timely implementation of approved accommodations. Please contact the Dart Center by visiting the website: https://uh.edu/accessibility/ calling (713) 743-5400, or emailing jdcenter@Central.UH.EDU.

The Student Health Center offers a Psychiatry Clinic for enrolled UH students. Call 713-743-5149 during clinic hours, Monday through Friday 8 a.m. - 4:30 p.m. to schedule an appointment.

The A.D. Bruce Religion Center offers spiritual support and a variety of programs centered on well-being.

The Center for Student Advocacy and Community (CSAC) is where you can go if you need help but don't know where to start. CSAC is a "home away from home" and serves as a resource hub to help you get the resources needed to support academic and personal success. Through our Cougar Cupboard, all students can get up to 30 lbs of FREE groceries a week. Additionally, we provide 1:1 appointments to get you connected to on- and off-campus resources related to essential needs, safety and advocacy, and more. The Cougar Closet is a registered student organization advised by our office and offers free clothes to students so that all Coogs can feel good in their fit. We also host a series of cultural and community-based events that fosters social connection and helps the cougar community come closer together. Visit the CSAC homepage or follow us on Instagram: @uh_CSAC and @uhcupbrd. YOU belong here.

Women and Gender Resource Center

The mission of the WGRC is to advance the University of Houston and promote the success of all students, faculty, and staff through educating, empowering, and supporting the UH community. The WGRC suite is open to you. Stop by the office for a study space, to take a break, grab a snack, or check out one of the WGRC programs or resources. Stop by Student Center South room B12 (Basement floor near Starbucks and down the hall from Creation Station) from 9 am to 5 pm Monday through Friday.

Academic Honesty Policy

High ethical standards are critical to the integrity of any institution, and bear directly on the ultimate value of conferred degrees. All UH community members are expected to contribute to an atmosphere of the highest possible ethical standards. Maintaining such an atmosphere requires

that any instances of academic dishonesty be recognized and addressed. The UH Academic Honesty Policy is designed to handle those instances with fairness to all parties involved: the students, the instructors, and the University itself. All students and faculty of the University of Houston are responsible for being familiar with this policy.

Excused Absence Policy

Regular class attendance, participation, and engagement in coursework are important contributors to student success. Absences may be excused as provided in the University of Houston Undergraduate Excused Absence Policy and Graduate Excused Absence Policy for reasons including medical illness of student or close relative, death of a close family member, legal or government proceeding that a student is obligated to attend, recognized professional and educational activities where the student is presenting, and University-sponsored activity or athletic competition. Under these policies, students with excused absences will be provided with an opportunity to make up any quiz, exam or other work that contributes to the course grade or a satisfactory alternative. Please read the full policy for details regarding reasons for excused absences, the approval process, and extended absences. Additional policies address absences related to military service, religious holy days, pregnancy and related conditions, and disability.

Recording of Class

Students may not record all or part of class, livestream all or part of class, or make/distribute screen captures, without advanced written consent of the instructor. If you have or think you may have a disability such that you need to record class-related activities, please contact the Justin Dart, Jr. Student Accessibility Center. If you have an accommodation to record class-related activities, those recordings may not be shared with any other student, whether in this course or not, or with any other person or on any other platform. Classes may be recorded by the instructor. Students may use instructor's recordings for their own studying and notetaking. Instructor's recordings are not authorized to be shared with anyone without the prior written approval of the instructor. Failure to comply with requirements regarding recordings will result in a disciplinary referral to the Dean of Students Office and may result in disciplinary action.