

CPSC 350 — Applications of Databases

Professor: Stephen Davies
Fall semester 2022

M 9–10:50am, WF 10–10:50am, Monroe 115

...or...

M 12–1:50pm, WF 1–1:50pm, Monroe 115

Final exam: Monday, Dec. 5th, 8:30am or High Noon

Office Hours:

Tue 12pm–2pm, **HCC ground floor lobby**

Wed 11am–12:30pm, **James Farmer Hall 221**

Thu 3:30–5pm, **HCC ground floor lobby**

<http://stephendavies.org/cpsc350>

We’re in the information age, or haven’t you heard? Electronic data is being generated at a breathtaking pace, capturing everything from satellite images to medical analyses to supermarket purchases to voter preferences. How do we cope with all this stuff so it can be usable?

Welcome to the world of databases. Here, storing, managing, structuring, and retrieving information is our specialty. Nearly every major software system – from Spotify to UPS package tracking to TikTok to an oil drilling control system – has a database right at the center of it. It’s arguably the most important component of most computer science applications. And that’s because many applications are about the *data* as much as (or more than) the program. Treating this stuff right is of vital importance.

What you’re going to learn this semester is how to use a database as a tool to accomplish a larger task. That’s why the course is called “applications of databases.” We’re not going to be looking under the hood at how a Database Management System (DBMS) like Oracle or Cassandra is implemented. That’s a niche field nowadays anyway, that not every comp sci major needs to know. Instead, we’re going to treat the DBMS as a black box, and discuss how to use it to create and operate on databases. That’s something every comp sci major *does* need to know, and know well, which is why this course is required for the major.

Course Objectives

- Understand the big picture about what database systems do and how they can be applied.
- Appreciate the importance of the database *model*, and what role it plays in how information can be structured and retrieved.
- Take a tour of both the relational model and the various NoSQL alternatives (key-value stores, document stores, column stores, triple stores). Grasp the pros and cons of each of the various choices.
- Acquire data modeling skills and learn how to design a database schema in any of the aforementioned models.
- Discover how to write software applications that can programmatically store, retrieve, and query information in a database.
- Learn how to integrate a backend database with a server-side Web program so that browser-based applications can interact with the information.

Student Learning Outcomes

After completing this course, students will be able to:

- Describe the role that database systems play in modern computing solutions.
- Explain the importance of the database *model*, and what role it plays in how information can be structured and retrieved.
- Identify the pros and cons of both the relational model and the various NoSQL alternatives (key-value stores, document stores, column stores, triple stores), and assess which model is best for a given application.
- Design a clean, flexible, and anomaly-free database schema in any of the aforementioned models.
- Write software applications that can programmatically store, retrieve, and query information in a database.
- Integrate a backend database with a server-side Web program so that browser-based applications can interact with the information.

Rules of the game

1. There are NO stupid questions. I will never belittle you or make you feel dumb about anything. Your job is not to already know everything before you start, but to roll up your sleeves and work hard to try and learn. Even if your question is, “Stephen, I totally didn’t even get that, can you start over and explain it again?”, please ask.
2. This class will be interactive. When I point at you in class, say your first name, and be prepared to try and answer questions. (Don’t worry if you don’t know all the answers.)
3. Exams and quizzes will be based solely on the material I cover in class. Just come to class, participate, and make good notes.
4. Don’t skip class. Just don’t. It’s bad form. I work hard on preparing for class, to make it compelling and relevant. It hurts my feelings when you don’t come. Plus you miss out on important stuff, and you’ll end up falling behind if you skip lecture. So come every time. Come happy, fresh, excited, ready to think and to participate.
5. **Please, no laptops/tablets/phones during class.** I’ve had students claim that they take notes on their laptop during lecture, but even if it’s true, those things are too big a distraction to you and your fellow students to make it worth it. Just stay tuned in, because I move fast.

Books

There aren’t any. I’ll point you to various electronic resources throughout the semester, which you may consult. Mainly, though, the material will be coming to you through lecture. (So don’t miss class! And if you absolutely have to miss a day, get the notes from a classmate!)

Submitting programs and things

Some of your assignments this semester will be submitted electronically, and some by hardcopy.

For electronic submissions, I’ll give special instructions for each assignment. Some will involve sending me an email with an attachment that is either a SQLite database file or a Python source file. For some (the “Tour” assignments), you’ll simply send

me a URL to your Cloud-hosted web application. No matter what, though, **I do insist that you *exactly* perform the submission procedures I specify.** This includes adhering to the specific subject line I specify so I can readily distinguish submissions from my hordes of other email. Be forewarned: you will **not** get the full XP for the assignment unless you follow the instructions exactly.

For hardcopy assignments, stick them in my “350” manilla folder hanging outside my office door in James Farmer Hall 221.

Grading

Grading this semester will be based on “experience points” (XP). As you complete activities, you will earn XP towards your final total. XP can never be lost, only gained, but you have to earn what you get (*i.e.*, you don’t “start off with a 100%” and lose points based on mistakes you make).

There will be opportunities to earn XP throughout the course. Some of these will be spontaneous as the mood strikes me. Some you can earn by completing in-class activities. Some may be in response to impressive things I see you do as the semester progresses. The following opportunities, however, are *guaranteed* to be available to you:

Guaranteed XP opportunities:

| Activity | Possible XP |
|----------------------------|-------------|
| Eight quizzes | 30 each |
| Nine homework assignments | 40 each |
| Final exam (comprehensive) | 100 |
| Various and sundry others | varies |

Here are the levels you may achieve (following the Ben & Jerry’s ice cream theme we’ll be using a lot in class), with their semester grade and the XP requirements:

| Level | Total XP | Semester grade |
|---|------------|----------------|
| Half Baked [®] | 650 | A+ |
| Cherry Garcia [®] | 600 | A |
| Chocolate Fudge Brownie | 560 | A- |
| Chocolate Chip Cookie Dough | 530 | B+ |
| The Tonight Dough [®] | 500 | B |
| Phish Food [®] | 470 | B- |
| Strawberry Cheesecake | 440 | C+ |
| Americone Dream [®] | 420 | C |
| Chunky Monkey [®] | 400 | C- |
| Brownie Batter Core | 380 | D+ |
| Milk & Cookies | 360 | D |
| Minter Wonderland [™] | 340 | D- |
| Chocolate Therapy [®] | 320 | . |
| Chubby Hubby [®] | 300 | . |
| Everything But The... [®] | 280 | . |
| Gimme S'more! [™] | 260 | . |
| New York Super Fudge Chunk [®] | 240 | . |
| Oat of This Whirled [™] | 220 | . |
| Sugar Plum | 200 | . |
| Fred & Ginger | 175 | . |
| Mocha Walnut | 150 | . |
| Black & Tan | 125 | . |
| Piña Colada | 100 | . |
| Hazed & Confused [™] | 75 | . |
| Aloha Macadamia | 50 | . |
| Oh Pear | 25 | . |
| Make Mine Vanilla | 0 | . |

Basis for determining mid-semester reports

If you get a “U” (unsatisfactory) for this class on your mid-semester report, it means that I’m giving you a red flag that you’re underachieving in the class. Normally that means you’re not engaged, and that you have turned in late (or not at all) multiple assignments. If you don’t get a “U,” that doesn’t necessarily mean you’re ace-ing the class: it just means I chose not to sound a big alarm.

The Honor Code and this course

For this course:

- The quizzes must be taken **alone**, in a quiet place, **without any form of contact with anyone**. They will be open-notes, but **closed-Internet**-other-than-Canvas.
- You must turn in **your own work** for all your homework assignments, but it is okay to work with classmates in a study group. **If you do work with others, you must state who you worked with on the homework submission. If you don't do that, it is an Honor Code violation.**
- For the programming assignments specifically, do **not** copy or share code verbatim with anyone, but you can talk general strategy with classmates, or ask classmates how they solved something. You may **not** discuss any assignment with anyone not currently in the class (which includes people not even at UMW, of course).
- The final exam is open-notes, pencil and paper, timed at $2\frac{1}{2}$ hours, in the classroom, on December 5th. It must be taken alone without any help from anyone.

Late policy

No late work will be accepted this semester. Get your stuff in on time: there's no excuse not to!

Guidelines for class participation

I believe that students learn best when they participate wholeheartedly in all aspects of the learning process. Hence while your grade will not be partially determined by any "class participation score" *per se*, it is very much to your advantage, and very much recommended, that you join in during class discussions, ask questions, and make comments.

How to reach me

Come to office hours, see me after class, or e-mail me (stephen@umw.edu)!

How to reach you

I will post announcements to *the course website* (not Canvas) often, so be sure to subscribe to its RSS feed or check it manually at least once a day! Also, I will occasionally be communicating with you outside of class time via e-mail, so make sure to check your UMW e-mail every day!

Title IX Statement

UMW faculty are committed to supporting students and upholding the University's *Policy on Sexual and Gender Based Harassment and Other Forms of Interpersonal Violence*. Under Title IX and this Policy, discrimination based upon sex or gender is prohibited. If you experience an incident of sex or gender based discrimination, we encourage you to report it. **While you may talk to me, understand that as a "Responsible Employee" of the University, I must report to UMW's Title IX Coordinator what you share.** If you wish to speak to someone confidentially, please contact the confidential resources below. They can connect you with support services and help you explore your options. You may also seek assistance from UMW's Title IX Coordinator; their contact information can be found below. Please visit <http://diversity.umw.edu/title-ix/> to view *UMW's Policy on Sexual and Gender Based Harassment and Other Forms of Interpersonal Violence* and to find further information on support and resources.

Resources

Ruth Davison, Ph.D.
Title IX Coordinator
Lee Hall, Room 401
540-654-5656
rdavison@umw.edu

Confidential Resources

On-Campus

Talley Center for Counseling Services
Lee Hall 106, 540-654-1053

Student Health Center
Lee Hall 112, 540-654-1040

Off-Campus

Empowerhouse (24-hr hotline)
540-373-9373

RCASA (24-hr hotline)
540-371-1666

Recording Policy

Classroom activities in this course may be recorded by students enrolled in the course for the personal, educational use of that student or for all students presently enrolled in the class only, and may not be further copied, distributed, published or otherwise used

for any other purpose without the express written consent of the course instructor. All students are advised that classroom activities may be taped by students for this purpose. Distribution or sale of class recordings is prohibited without the written permission of the instructor and other students who are recorded. Distribution without permission is a violation of copyright law. This policy is consistent with UMW's *Policy on Recording Class and Distribution of Course Materials*.

Disability resources

The Office of Disability Resources has been designated by the university as the primary office to guide, counsel, and assist students with disabilities. If you receive services through the Office of Disability Resources and require accommodations for this class, please provide me a copy of your accommodation letter via email or during a meeting. I encourage you to follow-up with me about your accommodations and needs within this class. I will hold any information you share with me in the strictest confidence unless you give me permission to do otherwise.

If you have not made contact with the Office of Disability Resources and have reasonable accommodation needs, their office is located in Seacobeck 005, phone number is (540) 654-1266 and email is odr@umw.edu. The office will require appropriate documentation of disability.

Basic needs security

Learning effectively and engaging wholly in class is dependent upon our basic security and having our fundamental needs met: having a safe place to sleep at night, regular access to nutritious food, and some assurance of safety. If you have difficulty affording groceries or accessing sufficient food to eat every day, or if you lack a safe and stable place to live, please contact Chris Porter, Assistant Dean of Students, at cjporter@umw.edu. Additionally, the Gwen Hale Resource Center is a free resource on campus, providing food, toiletries and clothing to any member of our community. It is open Monday, Tuesday and Friday from 1pm-6pm, on the 5th floor (floor A for Attic) of Lee Hall, or resource@umw.edu. Finally, you are always welcome to talk with me about needs, if you are comfortable doing so. This will enable me to provide any resources I may possess.

Road map

The calendar for the course, complete with assignment due dates, tests, etc., will be maintained on the course website at <http://stephendavies.org/cpsc350>. Visit there often. It is guaranteed to change!

As of the first day of class, however, here's a rough preview of my best guess at how things will go:

| Week | Topics | Due |
|------|--|------------|
| 1 | Database concepts and conceptual modeling | |
| 2 | The relational model | Homework 1 |
| 3 | Referential integrity and functional dependencies | Homework 2 |
| 4 | RDBMS's (SQLite, MariaDB/MySQL) and the SQL language | |
| 5 | Programmatic DB access and embedded SQL vs. LINQ | Homework 3 |
| 6 | Normalization, views, and ACID transactions | Homework 4 |
| 7 | Web development basics; the Flask web framework | Homework 5 |
| 8 | The Flask web framework, cont. | |
| 9 | More advanced Web development concepts | Homework 6 |
| 10 | NoSQL databases: key-value stores (Redis) | |
| 11 | Flat vs. hierarchical data structures; JSON and XML | Homework 7 |
| 12 | NoSQL databases: document stores (Mongo) | |
| 13 | NoSQL databases: document stores, cont. | Homework 8 |
| 14 | NoSQL databases: triple stores (Neo4j) | |
| 15 | NoSQL databases: triple stores, cont. | Homework 9 |