CSci 2041: Advanced Programming Principles

Spring 2018, Prof. Eric Van Wyk

(Updated on January 13, 2018 at 11:00am, see change log at end of syllabus.)

Course Description

This is a required course for computer science majors that is to be taken at the end of the sophomore year or the beginning of the junior year. The course will use a functional language to introduce a high-level approach to programming over complex data. It will emphasize a view of such data that abstracts away from their representation, using types as a vehicle for organizing them as values and for structuring computations over them. Advanced programming techniques that use ideas such as recursion, higher-order functions, lazy and eager forms of evaluation and infinite data objects will be explored. The possibility of exploiting parallelism arising from pure forms of expression evaluation will be examined. Other techniques and principles to be studied include search-based programming, modularity and concurrency. Programming projects that focus on symbolic computation will be used in a central way to impart the core ideas in the course; such projects may include writing parsers, type-checkers and interpreters for suitably circumscribed programming languages, and applications of search-based techniques.

Course Topics

The topics to be covered are described below. This is not intended as a week-by-week schedule: material under different topics will be interleaved and reordered in an actual plan for the course.

- Types as an organizing principle for programming. Types as a language, higher-order and polymorphic types, types as means of classifying values, ad hoc & parametric polymorphism.
- Expressions and computation as effect-free evaluation. Binding of names, scoping, environments, closures; strict and non-strict evaluation, opportunities to exploit parallelism; lazy evaluation as a programming technique, infinite data structures; recursive functions and relation to recursive data; iteration as tail recursion, translating general recursion to tail recursion.
- Recursion and relation to inductive reasoning, invariants over functions, types and invariants, designing functions around invariants.
- Functions as first class objects, higher order functions (map, filter, fold) and applications, parametric polymorphism, functions as parameters, continuation passing style.
- Effects and computation. Type safe references, assignments, other side-effecting constructs, iterative control structures; modeling effectful computation via state transforming functions, effects in lazy languages (monads); object oriented programming as combining environments with state; references and circular data structures.
- Programs and analysis of complexity. Recursive functions and recurrence relations; functional data structures, efficiency and programming techniques; mutable data and efficiency.
- Value-based programming and realization. Mapping data objects to memory; memory usage, copying versus pointing; garbage creation and automatic collection, memory management.

- Search-based computation. Search as a computational paradigm and its applications; programming techniques for realizing search.
- Role of modularity in programming-in-the-large. Interface specifications, abstract data types; language support for modular programming, interface checking as type checking; module composition as function application.
- Concurrency. Asynchronous computation as a paradigm, coordination through communication; language mechanisms for organizing and controlling communication.
- Translation of principles into programming in mainstream, non-functional languages.

Contact information, office hours

- **Instructor:** Eric Van Wyk, email: `evw@umn.edu`, phone: 612-625-0329.
  Office hours: Monday, Wednesday, Friday from 2:30pm to 3:25pm, or by appointment; in Keller Hall 6-203.
- **Graduate Teaching Assistants:**
  - Sean Geronimo Anderson, email: `geron018@umn.edu`,
  - Duanyang Jing, email: `jingx061@umn.edu`
  - Mary Southern, email: `south163@umn.edu`,

  As described below, please use `csci2041@umn.edu` when emailing TAs.
- **Undergraduate Teaching Assistants:** There are several undergraduate teaching assistants who will be assisting in labs and holding office hours.
- Office hours for all TAs are listed on the course GitHub page, which is `https://github.umn.edu/umn-csci-2041-S18/public-class-repo`

Important Dates

There are two sections of CSci 2041, but they will be following the same material and the same schedule. All dates for quizzes and assignments will be the same for both.

- Section 1 meets Monday, Wednesday, and Friday, 1:25pm - 2:15pm in Keller Hall 3-210.

  The final exam is scheduled for 10:30 a.m.-12:30 p.m., Tuesday, May 8, 2018.
- Section 2 meets Monday, Wednesday, and Friday, 3:35pm - 4:25pm in Mechanical Engineering 18.

  The final exam is scheduled for 10:30 a.m.-12:30 p.m., Wednesday, May 9, 2018.

Course Prerequisites

- CSci 1913 or 1933: Students need to have the degree of programming experience and maturity obtained from completing one of these courses.
- CSci 2011: 2041 builds on ideas from this course such as induction, recursion/recurrences, and logic.

Course Texts, Resources

- There is no textbook for the class. However, we will make use of several online resources for the OCaml programming language and programming techniques covered in the class. These will be provided electronically from the course GitHub page.
- Course Canvas URL:

  `https://canvas.umn.edu/courses/39626`
- Course GitHub public repository URL:

  `https://github.umn.edu/umn-csci-2041-S18/public-class-repo`

Email protocol

There are over 300 students registered for these two sections of CSci 2041 and thus it is difficult for me and your TAs to keep up with questions sent via email. To get your questions answered in a timely fashion, please follow these guidelines.

1. If you have a questions about an assignment or about lecture content, then chances are good that someone else also has the same question. It is also likely that one of your fellow students has the answer.

   For most questions, first ask them on the appropriate Canvas discussion forum. There will be a specific forum for each assignment to better organize the discussion.

   If you email me or the TAs directly with a question that could be asked on the forums, expect us to reply by asking you to first ask the question there.
2. If your question is about your score on an assignment or if your question my reveal part of the solution to the assignment, then see me or a TA during our office hours. There are many opportunities to do this as office hours are spread out across the week.
3. If you are unsure about where to ask your question or feel compelled to ask it over email then send your email to the CSci 2041 email alias - `csci2041@umn.edu`.
4. If you have concerns about the course, the TAs, or other aspects that only I, as the instructor, can address, then of course please email me directly: `evw@umn.edu`.

Lecture format

Lectures are designed to be rather interactive and less like a traditional lecture. There will be exercises that we do in class. So come prepared to work. Most lectures will have a large "white board" component that will not be found in the slides. Lectures will present material not in the texts and not on the lecture slides, which will be available on the course web pages in various formats.

Engagement

Learning is much more than simply acquiring a collection of facts; it is a process of assimilating knowledge, using it, applying it, and organizing it so that you understand the relationships between different concepts. It is an active process, not a passive one. Thus it is critical that you are **actively engaged** in the course. What does that mean?

- **Attending class:** My classes involve lots of discussion and in-class exercises. If you are not in lecture, then you miss out on this important way to learn the material. To be actively engaged in the course you will come prepared, having read the assigned reading and doing the exercises to prepare you for class. You will also be an active participant in classroom activities.

  I do not count attendance as part of your grade. It turns out that I do not need to. Those who attend and are engaged invariably do much better on assignments and exams that those that do not consistently attend class. The best way to do well in this course is to attend class.

- **Avoiding distraction:** Research has shown that people are very bad at multi-tasking. Your brain cannot do two things well at once and most of out attempts to do two things at once make us slower and, frankly, dumber.

  For this reason, I do not allow laptops in class. There may be a few occasions in which we want to use them as part of an in-class exercise, but otherwise they are to be put away. The distraction to you is significant but they also distract those around you. (If there is a reason that you feel you need to use your laptop to take notes, then please speak to me about it.)

  For similar reasons, I do not allow cell phones or tablets in class. These are to be stored in your bag or in your pocket and not held in your hand or laid on your desk.

  This recent New York Times article describes why this might be beneficial to your learning:

  `https://www.nytimes.com/2017/11/22/business/laptops-not-during-lecture-or-meeting.html`

- Take notes. By taking notes in class your actively interpret and organize the course material, and thus learn much of it. Spending your time wisely in class will mean you don't need to spend as much time reviewing material outside of class. Some evidence of this:

  `http://newyork.cbslocal.com/2016/04/05/note-taking-study/`

- You are responsible for routinely checking Canvas and GitHub for updates and announcements.

- Electronic discussion forums will be available on the Canvas class site. The TAs and I will be reading discussions on this and providing our input, but it will primarily be a forum for students to discuss course topics and questions (not solutions) about homework assignments. Asking and answering questions here is an important part of engaging in the class material.

Course work

You will complete several programming and "on paper" assignments to help you engage the questions laid out above and to learn the finer points of the material.

Several of these assignments will be programming assignments. Many of these will be programming assignments meant to give you experience with the different programming principles and techniques covered in the course. These will be turned in electronically on `http://github.umn.edu`.

Other assignments are written assignments, for example explaining how or why a certain program, perhaps yours, works or to argue or prove that a program meets some correctness specifications. Grading illegible homework can be exceedingly time consuming and thus we do not accept work that is not easy to read. It is suggested that you type your answers to the non-programming homework assignments, perhaps using LaTeX, but if you choose not to, your answers must be written clearly and legible. Illegible answers will be marked as incorrect as we cannot grade what we cannot read.

Quizzes and exams are also an important part of learning and not used solely for evaluation. By properly preparing for an exam you have an opportunity to step back from the specific concepts of individual topics and see how the pieces fit together. To encourage you to do this, your are allowed a "cheat sheet" for the exams on which you can write whatever you like. This sheet must be an 8.5×11 inch piece of paper. You can use one side of it and it must be hand written. Organizing this document and writing it out by hand is a great way to learn the material. Many students report carefully creating their cheat sheet and then not using it in the exam because they've learned all the material they wrote on it.

We will also spend a considerable amount of time doing exercises in class. These are an important component of the course and thus it is important that you consistently attend lecture. We will collect some of these exercises to ascertain how well students understand the material and also, on occasion, to grade them. But their primary purpose is to help you learn the material in class, often by discussing your solution or questions your fellow classmates.

Required Work

The quizzes, exams, and homework assignments will draw questions from potentially all of the material in the specified sections of the assigned readings, even if this material is not covered in detail, or at all, in the lectures. Also, lectures may contain information not in the assigned readings, but you will be responsible for this information on the quizzes, exams, and homework as well. Thus, it is important that you attend lecture.

Numerous in-class exercises will be given during lecture. On occasion these will be collected and graded. But these will primarily be used as learning tools, not assessment tools.

Labs sessions consist of a small amount of work meant to be done in lab with an occasional bit of extra work to be done later. Sometimes this will be work that is meant to be done collaboratively and thus attendance is required.

Homework assignments, however, are to be done on your own. **Collaborative work is not allowed on homework assignments.** See the section on cheating below.

Grading

Your final cumulative score for the course will be determined based on your scores on homework assignments and exams as follows:

- Cumulative homework score: 40%
  - Homework assignments – 35%

    Different homework assignments will contribute different amounts to your cumulative homework score. This distribution will be determined as the course progresses.

    You are required to turn in all (outside-of-class) homework assignments in order to obtain a passing grade.
  - Lab attendance and work – 4%

    Your lowest two lab work scores will be dropped in computing this score. You are required to attend all but two lab sessions of your choosing to pass the course.
  - Class participation, in-class exercises, contribution to forums – 1%

  Your cumulative homework score must be a passing grade (above 60%) to pass the class.

- Cumulative quiz and final exam scores: 60%
  - There will be 12 quizzes during the semester.

    These are every Friday except for the first week (January 19), week before spring break (March 9), and the last week (May 4).

    Your two lowest scores on quizzes will be dropped.

    Each of the remaining 10 quizzes is worth 4%, so all quizzes are worth ~~20%~~ 40% of your final grade.
  - Final exam is worth 20%.

  Your cumulative quiz and exam score must be a passing grade (above 60%) to pass the class.

Your final letter grade will be determined by this final cumulative score. Typically, final grades are assigned on a scale not unlike the following: above 90% - A, above 80% - B, above 70% - C, above 60% - D, otherwise - F. Since each course instance of a course has different exams and assignments these numbers may vary from the scale above.. You will be informed during the semester of tentative cutoff numbers.

Missed quizzes: Since two quiz scores are dropped there are no make-ups on quizzes.

Late assignments: are generally not accepted or allowed unless **previous arrangements** have been made with the instructor or are due to a documented University-approved reason.

You should be aware of the University Senate's policy on make-up exams available at
`http://www.policy.umn.edu/Policies/Education/Education/MAKEUPWORK.html`
and their policy on grading available at
`http://policy.umn.edu/Policies/Education/Education/GRADINGTRANSCRIPTS.html`.

Be sure to keep regular track of your accumulating score to make certain that it is correct. You will be given regular feedback of your scores, either via Canvas or GitHub, and you should make sure that all your scores are correctly recorded. Check with the TA if you find errors. Errors must be reported no later than 2 weeks after the scores are posted.

Academic Integrity

You are encouraged to discuss homework problems with your fellow students. A large part of solving a problem is getting a precise and complete understanding of what the problem asks. This also helps to resolve any misunderstanding you may have of the problem or unintentional ambiguities in the problem description.

Discussing answers to problems, however, is not allowed. The work that you turn in to be graded is to be your own independent work representative of your independent thinking. Your discussions should stop long before you get to details of a solution. If you are still in need of assistance at this point, seek it from the TA or the instructor.

While the Internet is a wonderful resource for all kinds of information, you are expected to solve the homework problems on your own. Copying solutions from the Internet is cheating just as copying from fellow students is.

Discussing solutions to problems or copying solutions from others is considered cheating and there are penalties for such action.

Cheating does not help one learn the material and thus defeats the whole purpose of being in school in the first place. Also, the homework is intended as a warm up for the exams—if you don't learn how to solve the problems by doing the homework then your grades on the exams will surely suffer.

Providing your homework solution to other students is also considered as cheating and is treated as such. We do find cases of cheating when one student provides their solution to another, often in an effort to help out a friend who is struggling. Keep in mind that we make no distinction between the person sharing the work and the person copying the work — both are treated as cheating cases and the same penalties apply to each.

Detection: Software is used to detect similar assignments. When flagged, these are investigated by hand. A determination that cheating has occurred when a preponderance of the evidence indicates as much.

Consequences:

- On the first offense, a zero is recorded as the score for the assignment, quiz, or exam.

  Additionally, one's final grade is dropped one full letter grade. Thus, an A- turns into a B-, a C+ turns into a D+, etc.

- On the second offense, a grade of F is given for the course.

All incidents of cheating will be reported to the Director of Graduate or Undergraduate Studies in the department and to the appropriate parties at the college and university levels.

The Regent's Policy on Student Conduct, specifically Section IV, Subd. 1. Scholastic Dishonesty, addresses these issues and can be found at
`http://regents.umn.edu/sites/default/files/policies/Code_of_Conduct.pdf`
Additional departmental information on academic integrity can be found here:
`http://www-users.cs.umn.edu/~barry/intro/acad-conduct.html`
You are expected to read and understand both of these documents.

The Disability Resource Center

The University of Minnesota is committed to providing all students equal access to learning opportunities. The Disability Resource Center (DRC) is the campus office that works with students who have disabilities to provide and/or arrange reasonable accommodations.

- Students who have, or think they may have, a disability (e.g. mental health, attentional, learning, vision, hearing, physical or systemic), are invited to contact DRC to arrange a confidential discussion at 612-626-1333 (V/TTY) or `ds@umn.edu`.
- Students registered with DRC, who have a letter requesting accommodations, are encouraged to discuss accommodations outlined in the letter with the instructor early in the semester.

Mental Health Resources

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce your ability to participate in daily activities. University of Minnesota services are available to assist you with addressing these and other concerns you may be experiencing. You can learn more about the broad range of confidential mental health services available on campus via `http://www.mentalhealth.umn.edu`.

Additional Policies

All policies (presented above) may evolve and change over the course of the semester at the discretion of the instructor. Sometimes issues arise that cannot (or were not) planned for, and I may need some flexibility in handling them.

Change log

- January 13, 2018, at 11:00am: fix typo on cummulative quiz scores. It was incorrectly given as 20%. It is now, correctly, 40%.