

CISC 360: Programming Paradigms

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WeChat: cstutorcs
Queen's University

Fall 2022

Lecture logistics

- This lecture is (supposed to be) recorded
- The recording will be edited minimally, if at all
 - If you need me to edit out something you said, let me know [Assignment Project Exam Help](https://tutorcs.com)
- If you're participating from Zoom, you can use the Zoom chat, but I won't always notice it immediately

Well, here we are

- I have managed to not get COVID yet
- I had cancer
- Please wear a mask
 - N95 / 95PFE / FFP3 if Project Exam Help
- My mask is N95 (US standard)
 - + 95PFE (Canadian standard)
 - + FFP3 (European standard)
- Open windows whenever you can
 - QUFA, the faculty union, filed a grievance over inadequate ventilation in lecture halls
- *Please stay home* if you have symptoms or were exposed

Queen's University is endangering us

- Masks work (especially N95s)
 - Yes, they are annoying
 - Long COVID can be worse than annoying

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Carbon dioxide monitoring



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- Proxy measure for amount of exhaled breath
 - (And how much you've been cooking with gas)
- Rough upper baseline of COVID risk
- High CO₂ also impairs cognition
- If this gets too high, I will end the lecture

Syllabus

- Instructors are permitted (even not in a pandemic) to change the syllabus *until the end of the second week*
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- Instructors have [the right](https://tutorcs.com) to decide how students are assessed:
I have the right to hold tests and exams over onQ even if Queen's says we are teaching in person

Now

- Who am I?
- Hello, what is this course about?
 - What is a paradigm?
 - Functional programming
 - Logic programming
- Logistics WeChat: cstutorcs
- Next time...

Who am I?

Jana / Prof. Jana / Prof. Dunfield

pronouns: she/her

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Carnegie Mellon —2007→ McGill —2010→
MPI-SWS —2014→ UBC —2017→ Queen's

Who am I?

- I study “programming languages”:
 - Logical and mathematical foundations of programming languages
 - Reasoning about programs and programming languages
 - Formal methods
 - Types (so many types)

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I am transgender



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(a vegan cheesecake that was ordered for me
by my colleagues in the School of Computing)

Who am I?

Jana / Prof. Jana / Prof. Dunfield

[Assignment Project Exam Help](http://dunfieldlab.ca/)

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Virtual office hours (Microsoft Teams): TBA

Indoor office hours: maybe, if so, masks will be required

Hello, what is this course about?

- World domination?

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World domination: this time for sure!

- 196x: Algol was going to dominate
- 1970: PL/I was going to dominate
- 1980: C was going to dominate
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- 1990: C++ was definitely going to dominate
 - James Gosling had to justify why he would dare to design a NewLang (Java)
- 2000: Java was going to dominate

If you keep programming after you graduate...

...you will have to learn languages you don't know yet (and maybe haven't been invented yet)

Learning a new functional language will be easier if you already know one (like Haskell)

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Learning a new logic programming language will be easier if you already know one (like Prolog)

The more languages you know, the easier it becomes to learn new ones

Different languages for different purposes

- Machine-level programming: assembly
- Low-level programming: C, C++, Rust
- Web development: JavaScript, TypeScript, ...
- “Scripting”^{Assignment Project Exam Help}: bash, zsh, Python, Ruby, ...
- Numerical computing: Matlab, R, Fortran, ...
- Symbolic computing:
^{WeChat: cstutorcs}Lisp, Scheme, OCaml, Haskell, ...
- Deductive reasoning: Prolog, Twelf, Agda...
- Destroying (?) the world’s economy: Haskell

“Programming Paradigms”

- What is a paradigm?
 - “a typical example or *pattern* of something; a *model*... a *worldview* underlying the theories and methodology of a particular scientific subject” (Oxford American Dictionary)

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“Programming Paradigms”

- What is a *programming paradigm*?
 - object-oriented programming
 (“object-oriented paradigm”—163K results)
 - imperative [Assignment Project Exam Help](#)
 (“imperative paradigm”—11K results)
 - functional programming
 (“functional [paradigm](https://tutorcs.com)”—58K results)
 “the *functional paradigm* completely changes the way we think about programming”
 —theburningmonk.com

“Programming Paradigms”

- What do these mean?
 - object-oriented programming languages
 - imperative programming languages
 - functional

~~Assignment Project Examples~~

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“Programming Paradigms”

- Object-oriented

features	languages

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- Imperative

features	https://tutorcs.com	languages
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- Functional

features	languages

“Programming Paradigms”

- Object-oriented

features	languages
objects, classes, inheritance, (methods), (instance variables)	Simula-67, Smalltalk, C++, Java, Python (?), OCaml (?)

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- Imperative

features	https://tutorcs.com	languages
commands (“statements”), variable assignment, (procedures), (structs)	WeChat: cstutorcs	Fortran, Algol-60, PL/I, Pascal, C, C++, Java (?), Python (?)

- Functional

features	languages
functions, (recursion), <i>no</i> variable assignment	Lisp, Scheme, Racket, OCaml, Haskell, Python (?), Java (??), C++ (???)

“Programming Paradigms”

- Lots of (?) and overlap (like Python)
- Possible to write in a functional **style** in many languages
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(use lots of anonymous functions)
<https://tutorcs.com>
- Possible to write in an object-oriented **style** in many languages
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(C with function pointers inside structs)

Functional programming (in Haskell)

- “Pure” or “side effect-free” programming
 - no assignment to variables (no overwriting)
 - no loops
 - lots of ~~Assignment Project Exam Help~~
(anything you can do with a loop,
you can do with recursion)
 - no printing; ~~WeChat cstutors~~, weird printing
 - No side effects often makes it **easier to reason about programs**
- Functions can take functions as arguments
- Functions can build new functions

Functional programming (in Haskell)

(\x -> x + 1) 3

4

a function has no name

\: supposed to be a Lambda (λ)

parameter name: x

function body: x + 1

Functional programming (in Haskell)

```
(\x -> x + 1) 3
```

4

```
add1 = map (\x -> x + 1)
```

```
:type add1
```

```
add1 :: Num b
```

```
add1 [1, 10, 100]
```

```
[2, 11, 101]
```

Logic programming (in Prolog)

- Unlike Haskell, Prolog is not usually considered **general-purpose**
- Instead, for **deductive reasoning**
 - A Prolog program is a set of **facts** combined with rules about deriving (deducing) “new” facts

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Fact: smoky(british_columbia)

Rule: on_fire(X) :- smoky(X) “If smoky(X) then on_fire(X)”

$$\frac{\text{smoky}(X)}{\text{on_fire}(X)} \text{ (CISC 204)} \quad \forall X (\text{smoky}(X) \rightarrow \text{on_fire}(X))$$

Is British Columbia on fire?

Logic programming (in Prolog)

- Unlike Haskell, Prolog is not usually considered **general-purpose**
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Fact: smoky(british_columbia)
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Rule: on_fire(X) :- smoky(X)
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Is British Columbia on fire?

1. smoky(british_columbia) [Fact]
2. on_fire(X) :- smoky(X) [Rule]
3. on_fire(british_columbia) [X = british_columbia] 1, 2

Aside: Similar to a 204 natural deduction proof, except Prolog has fewer built-in rules.

Writing programs systematically

- Reasoning about Haskell programs by **stepping** (tracing)
- Proving properties of programs (by stepping)
- Defining what stepping is by **logical rules**
- “Running” the logical rules (in Prolog)

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Some learning outcomes

- Write short programs in a functional language such as Haskell or LISP, including the use of recursion, lists, higher-order functions.
[Assignment](#) [Project](#) [Exam](#) [Help](#)
- Use structural induction to prove simple assertions about functional programs.
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- Write short programs in a logical language such as Prolog.
- Predict the behaviour of small programs written in either paradigm.

Logistics

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Logistics

- Course material
 - Notes, code, slides
- Instructor and TA office hours
 - (being organized) Assignment Project Exam Help
- Discussions on <https://tutorcs.com>, a site designed to let students ask (and answer) questions without feeling intimidated
 - You can be anonymous to other students, but not to me and the TAs

Course grade

- Assignments (5?): 35%
 - Lowest mark dropped
- Quizzes (3): 35%
 - in onQ Assignment Project Exam Help
 - Lowest mark https://tutorcs.com
- Final exam: 30% WeChat: cstutorcs
 - in onQ, no proctoring

Textbooks

- None.
- Several years ago, these were required:
 - Simon Thompson. *Haskell: The Craft of Functional Programming*, third edition.
 - Ivan Bratko. *Prolog Programming for Artificial Intelligence*, fourth edition.

...and then became optional...

...and now I don't really recommend them, but you're welcome to look at them if you like.

Academic integrity

- Don't copy (from anyone or anywhere)
- Don't allow anyone to copy from you
- Work on individual assignments individually
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- Get help from me or the TAs
<https://tutorcs.com>
- On Piazza: you can always post questions
WeChat: cstutorcs about assignments, but be careful answering them—let me and the TAs decide how much to “give away”
 - Please do answer general questions!

Academic integrity

- Sometimes people are tempted to “depart from academic integrity” because they feel desperate
 - Ask for Assignment Project Exam Help
 - Helping individual students is one of the best parts of teaching

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Asking for help

- Try to ask for help as early as you need to
 - “need to” ≠ “can” (believe me, I know)

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Academic Consideration

- Example: If you become ill and can't write a quiz, go to the link below and fill out a request
- [~~Assignment Project Exam Help~~
~~https://tutorcs.com~~](https://wwwqueensu.ca/artsci/undergrad-students/academic-consideration-for-students)
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- *one 3-day request without documentation*
- In general,
I don't need to know personal details
- If you're not in ArtSci, consult your Faculty

Academic Consideration

- If the official system takes too long (which it will, because COVID), or you get rejected for silly reasons:

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email me: jd169@queensu.ca
<https://tutorcs.com>

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Academic Accommodation

- Accommodations are now handled online
- You no longer need to email instructors your QSAS letter

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Software

- Haskell: two major alternatives
 1. GHC (Glasgow Haskell Compiler)
("Haskell Platform")
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 - If you use Windows, some recommend WinGHCi
 - macOS / Linux: ghci
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 2. hugs

They give different, but often equally confusing, error messages

Software

- Prolog: SWI-Prolog
 - more information when we get into Prolog, around Week 7

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Software

- A text editor
 - *not* a word processor (Word,TextEdit, ...)
 - Atom (Windows, macOS, Linux)
 - Notepad ~~Assignment (Windows Project Exam Help)~~
 - If you're old-school, or want to be:
Aquamacs (macOS), Emacs, vim (Linux, ...)
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To do in Week 1

1. Sign up on the 360 Piazza:
 - <https://piazza.com/queensu.ca/fall2022/cisc360>
 - Good for Q & A and discussions
 - onQ for everything else
2. Maybe try to log in to easilab machines
(possibly useful as a backup)
<https://tutorcs.com>
3. *Start trying to install GHCi*
(it's sometimes difficult to install)
4. Find a text editor or IDE that (ideally) supports Haskell well

Next:

Basics of Haskell

(lec2.pdf and (lec2-slides.pptx or lec2-slides.pdf))

Thank you

- If you have questions, you may:
 - follow me into the Mac-Corry courtyard
(behind Dunning Hall)
 - Turn left, turn right, go straight, go out
 - contact me via email, Teams, or Piazza

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