Computer Science 331

Introduction to CPSC 331

Mike Jacobson

Department of Computer Science
University of Calgary

Lecture #1

Outline

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   - Problems and Algorithms
   - Abstract Data Types and Data Structures
   - Algorithm Analysis and Testing
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Course Information

Instructor: Mike Jacobson

- Phone: 210-9410, ICT 612
- email: `jacobs@cpsc.ucalgary.ca`
- URL: `http://pages.cpsc.ucalgary.ca/~jacobs/`

Contact Times:

- Office hours: M 12:00-14:00 or by appointment *only*
- Lectures: MWF 10:00–10:50 in ENA 03
- Tutorial Section #1: M/W 16:00–16:50 in MS 176
- Tutorial Section #2: M/W 13:00–13:50 in MS 176
- Tutorial Section #3: M/W 11:00–11:50 in MS 156
- Tutorial Section #4: TuTh 9:00 - 9:50 in MS 160

First labs: next Monday

Assessment

Components:

- 30% — four assignments (written and programming questions)
- 30% — midterm (March 7, 17-18:30, ST 135)
- 40% — final exam

Take note of term test dates/times: let me know of conflicts as soon as possible (no make up tests)

Submission procedures and guidelines:

- information available on course web site

NOTE: a grade of **C-** or better is required to use this course as a prerequisite for any course offered by Computer Science

Programming by Contract

Programming by Contract:

- An approach for developing computer software in a modern professional context
- *Key Idea:* Software developers should define and use precise and checkable *specifications of requirements* for software components
- Useful (indeed, arguably *necessary*) when software is developed and maintained over a long period of time by a group whose members can change
- Many modern programming languages, including Java, include facilities to support this approach. You will learn about and use these in this course

Specifying a Problem to be Solved

A **specification of requirements** for a problem includes:

- *Precondition:* A condition that is satisfied by any well-formed instance (i.e., set of inputs) for this problem
- *Postcondition:* A condition that should be satisfied if the problem has been solved

Documentation for a method solving this problem should include the above, along with implementation-dependent details (discussed later)

As we'll see shortly, we can — and should — start to design test cases for methods as soon as the above (and nothing more) is available!

Algorithms

An **Algorithm**:

- is *a finite sequence of steps that solves some well-defined problem*
- is often given either by several paragraphs in carefully written English or using *pseudocode*. Such a description is (largely) "implementation independent"
- can be *implemented* as (part of) a program using some programming language

Note: This course will focus at least as much on *algorithms* as on the computer programs generated from them.

$\Longrightarrow$ CPSC 331 is *not a programming course.*

More About Problems and Algorithms

Many computer science applications rely on solutions to a small number of *fundamental problems*

Resource requirements and limitations may also be important — and may differ from application to application

Consequence: It is often useful to know about *several* algorithms for the same problem — because there will be situations in which each is a better choice than the others

In this course we will learn about algorithms for several fundamental problems, including *searching* and *sorting*

Data Types and Abstract Data Types

A *data type* is defined by

- Data values and their representation
- Operations defined on the data values and the implementation of these operations as executable statements (i.e., methods)

An *abstract data type* is, essentially:

- a *specification of requirements* for a data type
- it does not include (or require) a specific implementation — but it may include conditions that data values must satisfy

Data Structures

A **data structure** provides a representation of the data values specified by an ADT

- Together with **algorithms** for an ADT's operations, this provides an *implementation-dependent* description of a data type

We will study several fundamental ADTs, along with data structures and algorithms for their operations, in this course

Algorithm Analysis and Testing

Correctness and **efficiency** of algorithms are both important!

In this course you will

- see numerous *proofs of correctness* of algorithms, and you will become familiar with the structure of a proof of correctness as a result
- design and implement *tests* in order to look for errors and use the results of tests to debug your programs
- learn ways to measure
  - the time an algorithm requires in the "worst case"
  - the amount of *storage space*

In this course we will generally prove the correctness and efficiency of *algorithms* but we will test, debug and profile *programs*.

Java Implementation

Assignments will require Java programming. You will

- implement algorithms and data structures on your own
- use implementations in a standard Java library (the "Java Collections Framework") to solve problems

Java will *not* be taught (much) during the lectures. However, sources of help with Java include

- lots of material on the course web site, textbook
- tutorials, which will include more material about Java programming (some of the time)

Expected Background: Programming

An Object-Oriented Programming Language:

- Java should have been introduced in a prerequisite course
- see Java resources on the course web site or the textbook
- work through Tutorial Exercise #1 as soon as you can! It will be discussed in the first tutorial next week.

Recursion:

- you should understand how recursive programs can be used to solve problems
- recursive *definitions* of various structures and properties will be used in this course as well

Expected Background: Other Areas

Discrete Mathematics and Logic:

- have numerous applications in CPSC 331 (especially proofs and analysis)

$\Longrightarrow$ MATH 271 is a prerequisite of this course!

Technical Reading and Writing:

- this course will include **reading assignments**
- your writing **will be assessed** in this course

How to Succeed

In this course you will **learn by doing**!

- Prepare for and attend **lectures**
  - obtain/read notes and other reading material ahead of time
- Prepare for and attend **tutorials**
  - read and work through exercises ahead of time
  - the more you do *on your own* the better
- Work through the **self-study exercises**
  - will help you learn required aspects of Java for this course
- Take **assignments** seriously
  - start early (not last minute!)
  - make sure that you understand what you are — and what you are *not* — allowed to do when working on these

Make use of my **office hours** if you need more help

Recommended Reference

Textbook:

- Thomas H. Cormen, *et.al., Introduction to Algorithms, 3rd Edition, MIT Press, 2009, eBook via the library (2nd edition)*

Recommended Java Reference:

- Kathy Sierra and Bert Bates, *Head First Java*, O'Reilly, Second Edition, 2005, eBook via the library

Recommended Reference for Correctness:

- Michael Soltys, *An Introduction to the Analysis of Algorithms*, World Scientific, 2009.

Helpful material on proofs of correctness in Chapter 1 (can download for free from book's website).

Other Resources

Course web site: *lots* of information here!

- Available from the instructor's home page
- D2L will be used for assignment submission and access to grades

Lectures: students are expected to attend *all* classes

- Partial notes will be made available online ahead of time
- Additional material on course web site

Tutorials: participation in these is expected too!

- Self-exercises and tutorial exercises will be posted on the web site ahead of time

What to do Next

1. Make sure you are eligible to be *in* this course!
2. Buy the textbook (wil be useful as a reference for a long time!)
3. Request your computer science account if you don't already have one
4. Work through Self-Study Exercise #1! It will be assumed that you have *completed* this before the first tutorial next Monday
5. Then read through Tutorial Exercise #1 and try to answer the questions on it!
6. Check out the course web site! It includes lots of information, including about how to accomplish the above