2011-12

# SC/NATS 1930A The Science of Computation

## Introduction

More than most scientific inventions, computers can be thought of as extending some of the powers of the human mind. But what in the world is a computer? What are the principles that underlie computer hardware and software? In this course we look at this question from two directions, assuming no prior knowledge of computers. This is not a course that is intended to teach programming. Experience in programming is not needed.

**What computers can do:** Starting with the question "What is a computer?" this course investigates different models of computing, working our way from extremely simple computational models to modern software systems that control intelligent robots and other artificial entities. Students will be exposed to a variety of computational models and will explore some of the principles of computing, including fundamental computational resources like time and space, and their measurement. The emphasis is on understanding some of the fundamental scientific principles that underlie computation, rather than programming or theorem proving.

We will look at the control of simple robotic devices as examples of understanding things that computers can do. In labs we will explore manipulating simple interactive computer graphics worlds to tell stories.

**What computers can't do:** Computers exist in the physical world, and are bound by its laws, both physical and logical. In this course some of the fundamental limits of computing will be studied. These can include the physical laws that constrain computers, such as ultimate physical limitations on computer size and speed; as well as the logical limits of computability (problems which provably cannot in principle be solved on computers) and the existence of problems that have computing time requirements that are completely beyond the reach of any present or even future computers.

## Course Organization

Welcome to NATS 1930. The course consists of weekly lectures and bi-weekly tutorials/labs. You have already registered in one tutorial/lab section and you should attend your own lab section. (There may not be space and/or equipment available for you in other sections.) Students need to read the Moodle course pages regularly. Course readings and other materials will be posted on the Moodle site at moodle11.yorku.ca. The moodle site is used to provide copies of the lecture slides, material for the labs, and to communicate news about the course. You should check the moodle site often.

**Required Course Material:** Course text and notes will be announced in the first class and on the course web pages on Moodle.

**Math Background:** High school Math at about Grade 11 level. We will review or teach any additional Math and Computer concepts required. But your reasoning and logical skills will be important in understanding the material.

## Course Times and Locations:

**Lectures:** Wednesdays 16:30-18:30, Stedman (SLH) D. The first lecture is September 7. You are responsible for the material covered in the lectures. Not all of the material covered in the lectures is available in the online resources provided on Moodle.

**Tutorial-Lab:** You must be registered in one tutorial/lab section. Labs meet in CSE 1002, "Maxwell Lab" usually every second week. A significant portion of your grade is based on material that is graded in the tutorial-lab. Dates are announced in class and on Moodle.

**Readings:** There is no assigned textbook for this course. Readings, in the form of weekly pdf documents will be available on the Moodle site. You are responsible for this material.

## Evaluation:

Individual pieces of work will be assigned a numeric grade, and grades combined using the weights given below. Final numeric grades will be converted to a letter grade using the standard Faculty of Science and Engineering table.

Midterm #1 - **November 16, 2011** - 20%
Midterm #2 - **February 29, 2012** - 20%
Final Exam (date TBA) - 40%
Labs/tutorials - 10 labs at 2% each - 20%

Please note that there are no special provisions for making up missed classes, tutorials, labs or tests. No makeup exams/labs/tests will be given. Students missing evaluations with appropriate documentation (e.g., Attending Physician's Statement) will have the weight assigned to the missed evaluation distributed over other tests/labs as appropriate.

## Instructors

This course is being co-taught by Prof. Patrick Dymond and Prof. Michael Jenkin. Their contact information is provided below. The best way of contacting the instructors is via email. In order to ensure that your email is responded to in a timely fashion it is important that you include 'NATS 1930' in the subject line of your email.

Michael Jenkin
Sherman Health Science Building #1028
Office Hours: Wednesday 3-4pm
email: jenkin@cse.yorku.ca

Patrick Dymond
Computer Science and Engineering Building #3051C
Office Hours: TBD
email: dymond@cse.yorku.ca

## Tentative Course Outline:

### Fall 2011:

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|---|---|---|
| Week 1 | September 7 | What computers and robots can and can't do (yet) |
| Week 2 | September 14 | Intro to Artificial Intelligence |
| Week 3 | September 21 | Deterministic Finite Automaton |
| Week 4 | September 28 | More Finite State Machines |
| Week 5 | October 5 | Eliza and the Turing Test |
| *Week 6* | *October 12* | *Reading Week (no lectures or labs)* |
| Week 7 | October 19 | Finite state machines as robot brains |
| Week 8 | October 26 | RoboEthics |
| Week 9 | November 2 | Turing machines, a general model |
| Week 10 | November 9 | Algorithms on Turing machines |
| **Week 11** | **November 16** | **Midterm #1** |
| Week 12 | November 23 | Universal Turing machines |
| Week 13 | November 30 | Surviving the robot uprising |

### Winter 2012:

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|---|---|---|
| Week 14 | January 4 | The Halting Problem |
| Week 15 | January 11 | Today's computers versus Turing's |
| Week 16 | January 18 | Searching and sorting |
| Week 17 | January 25 | Algorithm analysis |

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|---|---|---|
| Week 18 | February 1 | Building intelligent systems |
| Week 19 | February 8 | Complexity Classes |
| Week 20 | February 15 | Intractability |
| *Week 21* | *February 22* | *Reading Week (no lectures or labs)* |
| **Week 22** | **February 29** | **Midterm 2** |
| Week 23 | March 7 | Parallel and distributed computing |
| Week 24 | March 14 | Robot swarms and flocks |
| Week 25 | March 21 | Robots in the real world |
| Week 26 | March 28 | Special robot topics and review |

## Tentative Tutorial-lab Schedule:

You should be enrolled in a lab section. Labs are held bi-weekly most weeks throughout the year, alternating depending on whether your lab/tutorial section number is odd or even. Your lab may be in an alternate week from your fellow students. It is your responsibility to attend your lab session. Planned lab topics are:

| *Week* | *Lab:* | *Lab sections: Even-numbered sections* | *Odd-numbered sections* |
|---|---|---|---|
| 1 | Start of Term - No labs this week, lecture only, September 7, 2011 | | |
| 2,3 | **Lab A** Introduction to Alice | September 12-14 | September 19-21 |
| 4,5 | **Lab B** Finite State Machines | September 26-28 | October 3-5 |
| 6 | *Fall Co-curricular Week (no lecture or labs)* | *October 10-14* | |
| 7,8 | **Lab C** Eliza | October 17-19 | October 24-26 |
| 9,10 | **Lab D** Turing machines | October 31-Nov 2 | November 7-9 |
| 11 | **Midterm 1** (no lab this week) | **November 16** | |
| 12,13 | **Lab E** Directing in Alice | November 21-23 | November 28-30 |
| 14 | Start of Term - No labs this week, lecture only, January 4, 2012 | | |
| 15,16 | **Lab F** Iteration and selection | January 9-11 | January 16-18 |
| 17,18 | **Lab G** Searching | January 23-25 | January 30-Feb 1 |
| 19,20 | **Lab H** Intelligent systems | February 6-8 | February 13-15 |
| 21 | *Reading Week (no lecture or labs)* | *February 20-24* | |
| 22 | **Midterm 2** (no formal lab this week) | **February 29** | |
| 23,24 | **Lab I** Telling stories in Alice | March 5-7 | March 12-14 |
| 25,26 | **Lab J** Parallel computing | March 19-22 | March 26-28 |

In addition to the lectures and labs described above, review tutorial will be scheduled roughly one week before the two midterms and towards the end of the course. These review tutorials will not provide new material, but rather will review key portions of the course and work through exercises.