# Syllabus: CS 4124
# Theory of Computation
# Fall, 2005

**Instructor: Lenwood S. Heath**

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**Web Site:** `http://courses.cs.vt.edu/cs4124/fall2005/`

**Blackboard (Course Grades Only):** `https://learn.vt.edu/`

**Class Listserv:** `CS4124_91536@listserv.vt.edu`

**CRN: 91536**

**Prerequisites:** MATH 3134 or MATH 3034

**Required Textbook:** Models of Computation: Exploring the Power of Computing (Corrected Edition). John E. Savage. XanAdu OriginalWorks, 2004. ISBN: 0-201-89539-0.

## Course Description

This course emphasizes *theoretical models of computation* and their analysis. The aim of analysis is to identify and prove the capabilities and limitations of particular models of computation. It is shown that there are problems that are *unsolvable,* that is, there are questions that cannot be answered by any model of computation. Limits on computation in the context of resource bounds are also investigated. Techniques (reductions) are developed to show that one model of computation is equivalent in power to another or

that it is different in power from another. Models of computation that are covered include Boolean formulas, logic circuits, straight-line programs, deterministic and nondeterministic finite-state machines, random-access machines, pushdown automata, Turing machines, and grammars. The Chomsky hierarchy is described.

# Grading Policy

Grading for the course is on a 1000-point scale. There is a homework assignment almost every week, for a total of 12 assignments (see Course Calendar). The best 10 of the 12 homework grades will be counted. Each assignment will be worth 40 points. This is the point distribution:

| | |
|---|---|
| **Homework assignments:** Best 10 of 12 grades | **400** |
| **First exam:** October 4 | **150** |
| **Second exam:** November 1 | **150** |
| **Final exam:** Wednesday, December 14, 2:05–4:05 | **300** |
| **Total:** | **1000** |

A typical homework assignment consists of 2 problems, posted on the course web site approximately one week before the due date. Each assignment will be distributed in both PDF and LaTeX formats. (See LaTeX resources on the course web site.)

All homework must be prepared with LaTeX or other word processing system and submitted as a stapled printout, in class, on the due date (see Course Schedule). **No late homework will be accepted.**

# Readings

For most classes, there is a reading assignment (see Course Schedule) to be completed by class time. Each assignment consists of sections in the textbook.

# Ethics

The Honor Code applies. All work submitted must be the student's own work. Students may solicit help only from the instructor or the GTA.

# Announcement

If any student needs special accommodations because of a disability, please contact the instructor during the first week of classes.

# Course Schedule — August–September

| Date | Significant Event | Topics |
|---|---|---|
| | August | |
| 8/23 | Sections 1.1–1.3 | Boolean and predicate logic |
| 8/25 | Sections 2.1–2.2 | Circuits and straight-line programs; circuit depth and size |
| 8/30 | Sections 2.3–2.4 | Normal forms of Boolean functions; reductions |
| | September | |
| 9/1 | Section 2.5 | Logical operations; particular operations and circuits |
| 9/6 | Section 2.6–2.8 | Prefix computation; addition; subtraction |
| 9/8 | Section 2.11 | Symmetric functions |
| 9/13 | Section 2.12 | Lower bounds on circuit complexity |
| 9/15 | Section 2.13 | Upper bounds on circuit complexity |
| 9/20 | Section 3.1 | Finite-state machines |
| 9/22 | Sections 3.3 | Sequential circuits |
| 9/27 | Sections 3.4–3.6 | Random-access machines |
| 9/29 | Section 3.7 | Turing machines |

Schedule Continues on the Next Page

# Course Schedule — October

| Date | Significant Event | Topics |
|---|---|---|
| | October | |
| 10/4 | **First Exam** | Boolean logic; boolean formulas; logic circuits; straight-line programs; symmetric functions; bounds on circuit complexity; finite-state machines |
| 10/6 | Section 3.8 | Universal Turing machine |
| 10/11 | Sections 3.9.1–3.9.3 | Simulating a Turing machine with a sequential circuit; reductions |
| 10/13 | Sections 3.9.4–3.9.6 | P-complete and NP-complete languages; reductions |
| 10/18 | Sections 4.1–4.3 | Equivalence of deterministic and nondeterministic finite-state machines; regular expressions |
| 10/20 | Section 4.4 | Finite-state machines recognize regular expression languages; regular expressions generate finite-state machine languages |
| 10/25 | Sections 4.5–4.6 | Pumping lemma; properties of regular languages |
| 10/27 | Sections 4.8–4.9 | Pushdown automata; formal languages; the Chomsky hierarchy |

Schedule Concludes on the Next Page

# Course Schedule — November–December

| Date | Significant Event | Topics |
|---|---|---|
| | November | |
| 11/1 | **Second Exam** | Finite-state machines; sequential circuits; random-access machines; Turing machines; P-complete; NP-complete; deterministic and nondeterministic automata |
| 11/3 | Section 5.1 | Standard Turing machines |
| 11/8 | Sections 5.2–5.3 | Other Turing machines; Turing machine configurations |
| 11/10 | Sections 5.4–5.5 | Phrase-structure languages are the same as the languages accepted by Turing machines; encoding strings and Turing machines |
| 11/15 | Section 5.6 | Universal Turing machines |
| 11/17 | Section 5.7 | Decidable and undecidable languages |
| | Thanksgiving | |
| 11/29 | Section 5.8 | The halting problem; reductions |
| | December | |
| 12/1 | Section 5.8 | Reductions and unsolvable problems |
| 12/6 | **Last Day of Classes** | Review for final; questions on homework solutions and course material |
| 12/14 | **Final Exam — 2:05–4:05** | Comprehensive final exam |

End of Syllabus