# Syllabus: CS 5114
# Theory of Algorithms
# Spring, 2022

## 1 General Course Information

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| CRN | 21405 |
| MEETING TIME | 4:00 PM–5:15 PM; Mondays and Wednesdays |
| CLASSROOM | Whittemore 349 |

**Instructor: Lenwood S. Heath**

- **Office:** Zoom link for office hours on Canvas

- **Office Hours:** 8:00 AM–9:00 AM, Mondays, Tuesdays, Wednesdays, and Thursdays

- **Email:** heath@vt.edu

**Teaching Assistant: Kaiyi Zhang**

- **Office Hours Held in:** Zoom link for office hours on Canvas

- **Office Hours:** 3:00 PM–6:00 PM, Tuesdays; 10:00 AM–Noon, Fridays

- **Email:** kaiyiz@vt.edu

**Website:** http://courses.cs.vt.edu/cs5114/spring2022/index.php

**Canvas:** https://canvas.vt.edu/

**Prerequisites:** Graduate standing in the CSA program. If your CS background is less than a VT CS minor, then please discuss your enrollment with me.

**Required Textbook:** Introduction to Algorithms (Third Edition). Cormen, Leiserson, Rivest, and Stein. MIT Press, 2009. ISBN: 978-0-262-03384-8.

## 2 Course Description

This course emphasizes the **computational complexity** of a problem, the **efficiency** of an algorithm for solving a problem, **techniques** for designing algorithms, and the **inherent intractability** of certain problems. Skills that the student will take away from this course include: (1) determining whether a problem is NP-complete, (2) analyzing the time complexity of an algorithm, and (3) applying techniques for designing efficient algorithms.

# 3   Grading Policy

Grading for the course is on a 1000-point scale, with the points distributed as follows:

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|---|---|
| **Homework assignments: 10 at about 60 points each** | 600 |
| **Midterm exam: March 2, 2022** | 150 |
| **Final exam: Distributed May 6, due May 9** | 250 |

A typical homework assignment consists of 2 to 4 problems, posted on the course Web site approximately one week before the due date.

All homework must be prepared with LaTeX[1] and submitted as a PDF to Canvas by 5:00 PM on the due date[2]. Also, any required drawings must be drawn in a drawing program, not scanned and inserted. **If you must submit homework late due to illness, then please email me before the due date.**

The midterm exam will be an in-class exam on March 2, 2022. It will be an open book exam with problems on paper, as well as answers on paper.

The final exam will be a take-home exam, distributed through the course Web site as a LaTeX document. Exam solutions must be prepared with LaTeX and submitted as a PDF to Canvas by 5:00 PM on May 9, 2022. Also, any required drawings must be drawn in a drawing program, not scanned and inserted.

# 4   Grading Scale

| Grade | Points |
|---|---|
| A | 930–1000 |
| A- | 900–929 |
| B+ | 870–899 |
| B | 830–869 |
| B- | 800–829 |
| C+ | 770–799 |
| C | 730–769 |
| C- | 700–729 |
| D+ | 670–699 |
| D | 630–669 |
| D- | 600–629 |
| F | 0–599 |

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[1]See LaTeX resources on the course Web site.
[2]See Calendar on the course Web site.

# 5   Accommodations Announcement

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

# 6   Manner of Instruction

The manner of instruction for this class is face-to-face in Whittemore 349. There will be no online instruction. While there will be PDF lecture notes (Beamer slides) available online, some content will be presented only on the board in the classroom.

# 7   Readings

For most classes, there is a reading assignment (see Section 8) to be completed by class time. Each assignment consists of sections or chapters in the required textbook or in another textbook.

# 8   Planned Topics

The topics to be covered this semester are somewhat fluid, but here is the list of topics that we are prepared to cover, along with readings from the required textbook for most topics. Note that a PDF of the first edition of the textbook Probability and Computing, by Michael Mitzenmacher and Eli Upfal, is available under Resources on the course website. I do not have a way to make the textbook Algorithm Design, by Jon Kleinberg and Eva Tardos, available.

The **Core Topics** will be covered, in the order given. The order of the **Optional Topics** is not guaranteed, and it is certain that they will not all be covered. Be prepared!

- **Core Topics**

  - **Chapters 1, 2, 3, and 4.** Problems, complexity, analysis; divide and conquer; mergesort
  - **Chapters 7.** Quicksort
  - **Chapters 9.** Order statistics
  - **Chapter 15.** Dynamic programming
  - **Chapter 16.** Greedy algorithms
  - **Chapters 22.** Elementary graph algorithms
  - **Chapters 23.** Minimum spanning trees
  - **Chapter 34.** Encoding problems; polynomial time (P); polynomial-time verification (NP)

- **Chapter 34.** NP-completeness and reducibility
- **Chapter 34.** NP-completeness proofs
- **Chapter 34.** NP-complete problems
- **Sections 35.1–35.3.** Approximation algorithms

- **Optional Topics**

  - **Chapter 32.** String matching
  - **Chapter 33.** Computational geometry
  - **Sections 26.1–26.2.** Maximum flow
  - **Section 26.3.** Maximum bipartite matching
  - **Chapter 24** Single-source shortest path
  - **Chapter 25** All-pairs shortest path
  - **Chapter 6 of Kleinberg and Tardos.** More dynamic programming; RNA secondary structure
  - **Chapter 7 of Kleinberg and Tardos.** A different presentation of network flow; disjoint paths
  - **Chapter 8 of Kleinberg and Tardos.** A different presentation of NP-completeness; additional NP-completeness proofs
  - **Chapter 10 of Kleinberg and Tardos.** Special cases of NP-complete problems; NP-complete problems on trees
  - **Chapters 1, 2, 3, and 4 of Mitzenmacher and Upfal.** Randomized algorithms

# 9  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 teaching assistant. In the case of research work on teams, all work submitted or presented must be only the work of the team.

The Undergraduate Honor Code pledge that each member of the university community agrees to abide by states:

"As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do." Students enrolled in this course are responsible for abiding by the Honor Code. A student who has doubts about how the Honor Code applies to any assignment is responsible for obtaining specific guidance from the course instructor before submitting the assignment for evaluation. Ignorance of the rules does not exclude any member of the University community from the requirements and expectations of the Honor Code.

Academic integrity expectations are the same for online classes as they are for in person classes. The use of technology assists such as Chegg, CourseHero, and GroupMe must be avoided. The Honor System is able to effectively investigate the use of these websites. All university policies and procedures apply in any Virginia Tech academic environment, and all students are expected to follow them.

For additional information about the Honor Code, please visit:

> `https://www.honorsystem.vt.edu/`

Honor Code Pledge for Assignments: The Virginia Tech honor code pledge for assignments is as follows:

> ''I have neither given nor received unauthorized assistance on this assignment."

The pledge is to be written out on all graded assignments at the university and signed by the student. The honor pledge represents both an expression of the student's support of the honor code and a commitment to uphold the academic standards at Virginia Tech.

Here are some more detailed considerations.

1. All assignments submitted shall be considered "graded work" and all aspects of your coursework are covered by the honor code. All projects and homework assignments are to be completed individually unless otherwise specified.

2. The Academic Integrity expectations for Hokies are the same in an online class as they are in an in-person class. Hokies are expected to meet the academic integrity standards at Virginia Tech at all times.

3. Commission of any of the acts in the list below shall constitute academic misconduct. This listing is not, however, exclusive of other acts that may reasonably be said to constitute academic misconduct. Clarification is provided for each definition with some examples of prohibited behaviors in the Undergraduate Honor Code Manual located at `https://www.honorsystem.vt.edu/`.

   **Acts of Misconduct**

   - **CHEATING:** Cheating includes the intentional use of unauthorized materials, information, notes, study aids or other devices or materials in any academic exercise, or attempts thereof.

   - **PLAGIARISM:** Plagiarism includes the copying of the language, structure, programming, computer code, ideas, and/or thoughts of another and passing off the same as one's own original work, or attempts thereof.

   - **FALSIFICATION:** Falsification includes the statement of any untruth, either verbally or in writing, with respect to any element of one's academic work, or attempts thereof.

- **FABRICATION:** Fabrication includes making up data and results, and recording or reporting them, or submitting fabricated documents, or attempts thereof.
- **MULTIPLE SUBMISSION:** Multiple submission involves the submission for credit — without authorization from the instructor receiving the work — of substantial portions of any work (including oral reports) previously submitted for credit at any academic institution of attempts thereof.
- **COMPLICITY:** Complicity includes intentionally helping another to engage in an act of academic misconduct, or attempts thereof.
- **VIOLATION OF UNIVERSITY, COLLEGE, DEPARTMENTAL, PROGRAM, COURSE, OR FACULTY RULES:** The violation of any University, College, Departmental, Program, Course, or Faculty Rules relating to academic matters that may lead to an unfair academic advantage by the student violating the rule(s).

4. Lecture notes, assignments, quizzes, tests, exams, solutions, and other materials distributed to or generated in this class are intended for use only by students enrolled in this CRN (section) this semester. Without the instructor's written permission, no one may show, give, or otherwise make such class materials available to anyone not enrolled in this CRN this semester. Prohibited activities include, but are not limited to, uploading a test, uploading solutions to problems, and submitting such class materials for online posting. The prohibition on sharing solutions applies to all solutions, regardless of who wrote the solutions.

5. Academic Misconduct Sanctions:

   Here is this instructor's personal statement on honor code sanctions:

   > If you have questions or are unclear about what constitutes academic misconduct on an assignment, please speak with me. I take the honor code very seriously in the course. The normal sanction I will recommend for a violation of the Honor Code is an F* sanction as your final course grade. The F represents failure in the course. The "*" is intended to identify a student who has failed to uphold the values of academic integrity at Virginia Tech. A student who receives a sanction of F* as their final course grade shall have it documented on their transcript with the notation "FAILURE DUE TO ACADEMIC HONOR CODE VIOLATION." You would be required to complete an education program administered by the Honor System in order to have the "*" and notation "FAILURE DUE TO ACADEMIC HONOR CODE VIOLATION" removed from your transcript. The "F" however would be permanently on your transcript.

# 10   Mask Mandate Enforcement

Section 9.9: Class Conduct of the Faculty Handbook states that "... [t]he teacher should endeavor to create a classroom atmosphere that is comfortable and welcoming to all students, including women and members of minority groups. Disruptive classroom conduct on the part of some students may be distracting, annoying, or intimidating to other students and should not be tolerated by the teacher." This part of the handbook clearly states that the instructor has the responsibility and the authority for maintaining the classroom conduct, including upholding the universitys mask mandate. If a student fails to follow or meet the outlined expectations for masking or general health and safety, the instructor

- should engage with student(s) first and address the situation proportional to the exhibited behavior in a deescalating way. The student should be redirected to either meet masking expectations or leave the class meeting.

- can terminate the class meeting but contact the department chair or head if this is done.

- should contact the Office of Student Conduct for guidance and direction if there are persistent disruptions and refusal to comply with expectations.

- should call the Virginia Tech Police if a student engages in behaviors that could be immediately dangerous or threatening to the instructor or the students in the class.

# 11 Your Mental Health and Well-Being

Here is a timely statement from Dr. Christopher Flynn, Director of the Mental Health Initiatives:

> As awareness of mental health concerns in the college population grows, student advocacy groups at Virginia Tech have banded together as the Mental Health Coalition. One of the groups is **Active Minds at Virginia Tech**, and it seeks to raise awareness and fight stigma about mental health; to that end, Alyssa Wills and Saad Khan, two officers of Active Minds, have requested that faculty include the following statement regarding resources for students at Virginia Tech in their syllabi each semester. This statement has the approval of all student groups in the Mental Health Coalition as well as the professionals in each of the offices included below.

Here is the requested statement:

> Supporting the mental health and well-being of students in this class is of high priority to the instructor and to Virginia Tech. If you are feeling overwhelmed academically, having trouble functioning, or are worried about a friend, please reach out to any of the following offices:
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> - Cook Counseling:
>   - 540-231-6557 to schedule an appointment and/or 24/7 crisis support
>   - `http://www.ucc.vt.edu/` for more information
> - Dean of Students Office:
>   - 540 231-3787 for general advice
>   - 540-231-6411 for after-hours crisis
>   - `http://www.dos.vt.edu/` for more information
> - Hokie Wellness:
>   - `http://www.hokiewellness.vt.edu/` for more information about health and wellness workshops and consultations
> - Services for Students with Disabilities (SSD):
>   - 540-231-3788 or `http://www.ssd.vt.edu/` for more information about accommodations and other disability-related supports
>
> For a full listing of campus resources check out:
>
> `http://www.well-being.vt.edu/`

Please also feel free to speak with the instructor, who also does care about your well-being.