CSC-301: Analysis of Algorithms; Fall 2021

Instructor Information
- Nicole Eikmeier, Assistant Professor of Computer Science
- She/Her Pronouns
- Preferred name: Professor Eikmeier
- Email: eikmeier@grinnell.edu
- Office Hours: Book online at calendly.com/eikmeier

Course Information
- Number: CSC-301-01
- Title: Analysis of Algorithms
- Pre-Requisites: CSC-207 and [CSC-208 or MAT-218]
- Class Meetings: 2:00 – 3:50pm Central Time T & TH.

Mentoring Sessions
This course employs the use of a mentor to aid you in navigating the course. Our course mentor will assist us in class, and host 1 – 2 mentor sessions throughout the week. Mentor Sessions may review course content, provide practice problems, practice interview skills, or provide homework help.
- Course Mentor: Ally Rogers
- They/them Pronouns
- Email: rogersal@grinnell.edu
- Mentor Session Times: TBD

Course Overview and Goals
In this course, we will develop your skills in the design, implementation, analysis, and verification of algorithms. We will also explore advanced abstract data types and data structures. Along the way, we will consider a variety of classic algorithms, ADTs, and data structures – the “literature” of CS, as it were. Why do we read the literature? Because knowing how problems have been solved in the past helps us solve future problems.

Goals
1. Students will be familiar with and apply classic algorithms, ADTs and data structures.
2. Students will learn to read the literature of computer science, specifically within the domain of algorithms.
3. Students can explain why comparison-based sorts take order $n \log n$ in the worst case.
4. Students will have a better understanding of the interplay between algorithms, technology, bias and structural inequity.
5. Students will gain practice in a coding interview, which may help prepare for internship or job interviews.
6. Students will improve their ability to justify the runtime and correctness of their algorithms.
Learning Outcomes (LO)
Upon completion of this course, students will be able to:
1. write/develop a loop invariant alongside an algorithm.
2. prove the correctness of an algorithm via loop-invariant technique.
3. use the formal definitions of Big-Oh, little-oh, Big-Omega and Big-Theta to prove properties of these classes.
4. develop a recurrence relation, given an algorithm which uses divide-and-conquer.
5. solve problems using divide and conquer.
6. solve a given recurrence relation using the substitution method.
7. solve a given recurrence relation using CLRS Theorem 4.1.
8. recall and apply linear sorting techniques (Radix, Bucket, Counting) to relevant problem cases.
9. solve problems using the greedy strategy.
10. solve problems using dynamic programming.
11. solve problems using Network Flow.
12. students can justify algorithmic design choices they make when solving problems.
13. explain the tradeoffs between different data structures when they are used for similar problems.
14. implement an advanced data structure or algorithm, demonstrating good software design practices including documentation and testing.
15. can implement a balanced tree.
16. have a stronger sense of growth mindset.

Class Requirements/Components

Quizzes (Assessment of LO 1-11)
We will have in class quizzes to test individual Learning Outcomes. The quizzes will have a time limit. Each problem on the quiz will be graded on a scale of satisfactory (S) or not-satisfactory (NS). Any Learning Outcome for which you do not receive satisfactory you will have the opportunity to retake the next time we take a quiz.

Problem Sets (Assessment of LO 1-16)
There will be problem sets in which you will put into practice what we are learning, through analyzing algorithms and implementation of data structures. Problem sets will be graded on a scale of satisfactory (S) or not-satisfactory (NS). Any problem set that is marked NS may be resubmitted once with no penalty. You may receive an S on each problem set by meeting the following criteria:
• The assignment must be complete, by providing answers to all questions, and/or following all instructions
• It must show a good faith effort on every problem
• Key understanding is shown for each concept (this will vary by problem set)
• Mistakes are minimal - mistakes which do not reflect understanding can still result in an S
Essay (Assessment of Goal 4)
As computer scientists, and as Grinnell scholars, it is critical to examine the role of racism, and bias more broadly, in your chosen field. In this written assignment you will be asked to think deeply about the role of algorithm design more broadly in society, and the potential for harm. This assignment should be completed individually. This assignment will be graded primarily on the depth of your thoughts, and secondly on the grammar and clarity. The essay will be graded on the (S)/(NS) scale, and may be resubmitted if marked as NS.

Attendance & Participation
Your attendance and participation in class is an integral part of your learning. On each day of class, you will either be marked as satisfactory (S) or not-satisfactory (NS). You may obtain an S each day by meeting the following requirements:
• Arrive on time for class, do not leave early
• Arrive prepared for class activities by having completed the required reading
• Actively engage and participate in all small group work
• Ask a question or provide an answer in full group discussion/lecture

You may be excused for a class under certain situations. Excusable reasons to miss class include college sponsored sports absences, religious holidays, family emergencies, and illness. Please email me at least a week in advance in the event of a planned absence. In the case of illness, I may request documentation from a doctor’s office or SHAW. Please do not attend class if you suspect you may have COVID-19. If you are excused from class, then you will receive an S for the day.

Informal Writing (Assessment of LO 1-12)
Throughout the course of the semester, I will ask you take notes in a journal, along with other informal writing tasks. I ask you to write in order to check your understanding and to work through your thoughts. All informal writing should be completed individually and will be graded on the scale of satisfactory (S) or not-satisfactory (NS). If you receive a grade of NS, you may resubmit one time. An informal writing assignment will receive an S by meeting the following requirements:
• The writing assignment is completed (all questions are answered)
• The assignment shows a good faith effort, and engagement with the material
**Letter Grades**

This course will rely on ideas of *specifications grading*. One of the fundamental principles behind this grading scheme is that you will have opportunities to re-try assignments if they do not originally obtain a satisfactory grade. My goal in using this schema is to reduce the stress that accompanies typical grading rubrics and give you permission to make mistakes and learn as much as possible. Ultimately, my goal is for each student to learn as much as possible, and I would be very happy to give every student an A.

Letter grades for the entire course will be assigned according to the bundles in the table below. You will receive the grade corresponding to the bundle for which you meet all the requirements. All bundles list minimum amounts, you may exceed the requirements for a bundle and still qualify for it.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Attendance &amp; Participation (out of 27)</th>
<th>Problem Sets (out of 7)</th>
<th>Informal Writing (out of 15)</th>
<th>Quizzes (out of 11)</th>
<th>Essay</th>
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<tbody>
<tr>
<td>C</td>
<td>20xS</td>
<td>4xS</td>
<td>12xS</td>
<td>7xS</td>
<td>S</td>
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<tr>
<td>B</td>
<td>23xS</td>
<td>6xS</td>
<td>14xS</td>
<td>9xS</td>
<td>S</td>
</tr>
<tr>
<td>A</td>
<td>25xS</td>
<td>7xS</td>
<td>15xS</td>
<td>11xS</td>
<td>S</td>
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</tbody>
</table>

D: 3-4 requirements of a C are met  
F: 0-2 requirements of a C are met

To move from a B to a B+ or a C to a C+: you must have completed the requirements of the lower tier (B/C) and meet the requirements of at least two components of \{Attendance, Problem Sets, Informal Writing, Quizzes\} in the higher tier (A/B).

To move from a B to an A- or a C to a B-: you must have completed the requirements of the lower tier (B/C) and meet the requirements of at least 3 components of \{Attendance, Problem Sets, Informal Writing, Quizzes\} in the higher tier (A/B).
Course Materials

Required Textbooks & Materials (Note: CLRS is the only book you need to purchase)

- *Introduction to Algorithms*, Cormen, Leiserson, Rivest, and Stein (CLRS)
- *Sliding Suffix Tree*, Andrej Brodnik and Matevz Jekovec

Resources

- Access our course materials: PWeb ([https://pioneerweb.grinnell.edu](https://pioneerweb.grinnell.edu))
- Submit your assignments on gradescope ([https://gradescope.com](https://gradescope.com)) Entry code: ZRB7K3
- Databases, journal articles, and more: Grinnell Library ([https://www.grinnell.edu/academics/libraries](https://www.grinnell.edu/academics/libraries))
- Receive Assistance with strengthening your writing: Grinnell Writing Lab ([https://www.grinnell.edu/academics/centers-programs-and-resources/writing-lab](https://www.grinnell.edu/academics/centers-programs-and-resources/writing-lab))
- Health and Wellness: SHAW ([https://www.grinnell.edu/about/offices-services/student-health](https://www.grinnell.edu/about/offices-services/student-health))
Course & College Policies

Attendance
I highly encourage you to attend all class sessions. Attendance affects your learning in this course, and thus affects your grade. If you know in advance that you will miss class due to a college-sponsored sport or a religious holiday, please let me know in the first two weeks of the semester. If you have another emergency come up please let me (or the college) know when safe for you.

Late Policy
All assignments are to be turned in electronically by 10:30PM Central Time on the day they are due, typically Tuesdays. Due to the exceptional nature of this year I will attempt to be as flexible as possible in accepting late work. I am aware that there are a number of things outside of your control that may affect your ability to complete work on time. If possible, please let me know if you plan to turn in work late. Assignments turned in more than three days late, without prior approval (before the original due date) of the instructor will not be accepted. Please refer to the Student Workload statement below, to emphasize that you should attempt to follow the posted deadlines. Please keep in mind that if you turn in work late, I may not be able to grade it as quickly as you or I hope.

Incomplete Grade Policy
All work for the course is due by 5:00 pm on the last day of finals (12/17/2020). In exceptional circumstances, incomplete grades can be granted. Talk with me if you think you might need an incomplete to complete all the requirements of the course.

Student Workload
You can expect to spend 12 hours per week on this course, including all in-class and out of class time. This number is based off of the Grinnell Guidelines for credit-hours. Since our class meets for approximately 4 hours each week, you can expect to work 8 additional hours outside of class time. This may include: readings, mentor sessions, office hours, problem sets, and studying.

Academic Honesty Statement
Grinnell College’s Academic Honesty policy is located in the online Student Handbook. It is the College’s expectation that students be aware of and meet the expectations expressed in this policy. In addition, in this course, it is my expectation that students may collaborate on the Problem Sets, however your collaboration must be attributed. It is my expectation that Journals, Exams, and the Essay will be completed independently.

In this course, you are not allowed to use solutions you find on the internet, and further, you are not allowed to search for problem solutions on the internet. I know that there is great temptation to look for solutions online when things get difficult. I will provide you with numerous resources to get help which include office hours, group class work, and mentor sessions. It is my hope that allowing you to resubmit problem sets without penalty eases some of the pressure that you might
feel. Additionally, we will work to build our *growth mindset* in this course, which makes it less uncomfortable to sit with a challenging problem.

If you have questions about how a particular assignment relates to the College’s policy, or how to attribute your collaboration, I will gladly consult with you in advance of the assignment’s due date.

**Religious Observance**  
I encourage students who plan to observe holy days that coincide with class meetings or assignment due dates to consult with me in the first two weeks of classes so that we may reach a mutual understanding of how you can meet the terms of your religious observance and also the requirements for this course.

**Students with Disabilities**  
I encourage students with documented disabilities, including invisible disabilities such as chronic illness, learning disabilities, and psychiatric disabilities, to discuss appropriate accommodations with me. You will also need to have a conversation about and provide documentation of your disability to the Coordinator for Disability Resources, located on the ground level of Steiner Hall (641-269-3124).

**Technology Usage Policy**  
Materials you have obtained from this course including lecture videos and problem sets should not be distributed outside of the members of our class. Live synchronous sessions should not be recorded by students.

**Inclusion Statement**  
It is my intention that students from all backgrounds and perspectives will be well served by this course, and that the diversity that students bring to this class will be viewed as an asset. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, socioeconomic background, family education level, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class. Your suggestions are encouraged and appreciated.

**Take care of yourself**  
Do your best to maintain a healthy lifestyle this term by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available through campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

If you or anyone you know experiences any academic stress, difficult life events, or
feelings like anxiety or depression, I strongly encourage you to seek support. Student Health and Wellness (SHAW) is here to help: call 641-269-3230 and visit their website at https://www.grinnell.edu/about/offices-services/student-health. Consider reaching out to a friend, faculty, or family member you trust for help getting connected to the support that can help.

If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:

- Need to Talk Line: 641-269-4404 (available 24/7 for counseling needs)
- 24/7 Suicidal Hotline: 1-800-273-8255
- **If the situation is life threatening, call 911**

**Acknowledgements**

- The inclusion statement has been taken verbatim from https://lgbtq.asee.org/resources/ally-resources/
- The Take Care of Yourself Section has been taken verbatim from https://www.cmu.edu/teaching/designteach/design/syllabus/syllabussupport.html
- Ideas for specifications grading were developed by Peter-Michael Osera and adapted to meet the needs of this course.
# Course Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Topics/Activities</th>
<th>Readings and Deadlines</th>
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<tbody>
<tr>
<td>8/26</td>
<td>Introduction to the Course</td>
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<td>8/31</td>
<td>Growth Mindset</td>
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| 8/31  | Fundamentals of Analysis                                                        | *The Secret to Raising Smart Kids* – Carol S. Dweck  
<pre><code>                                | CLRS: 2.1 – 2.3                       |
</code></pre>
<p>| 9/2   | Asymptotic Notation and proofs of classes                                      | CLRS: 3.1 – 3.2                        |
| 9/7   | Algorithm Design Strategies: Divide &amp; Conquer                                    | <strong>Due: Problem Set 1</strong>                 |
| 9/9   | The substitution method for solving recurrences                                 | CLRS: 4.3 – 4.4                        |
| 9/14  | Theorem 4.1 for solving recurrences                                             | <strong>Quiz over LO 1-4</strong>                   |
| 9/16  | Comparison based sorts                                                          | CLRS: 8.1                               |
| 9/21  | Advanced Sorting Ideas: Radix Sort, Counting Sort Bucket Sort                   | <strong>Due: Problem Set 2</strong>                 |
| 9/23  | Advanced Data Structures: Balanced Trees                                        | CLRS: 13.1 – 13.4                      |
| 9/28  | Advanced Data Structures: Balanced Trees                                        | <strong>Quiz over LO 5-8 + makeups</strong>          |
| 9/30  | No Class                                                                        |                                         |
| 10/5  | Race and Ethnicity                                                              | Race After Technology by Ruha Benjamin  |
| 10/7  | Ethical Concerns                                                                |                                         |
| 10/12 | Algorithm Design Strategies: Dynamic Programming                                | CLRS: 15.1, 15.3 – 15.5                |
| 10/14 | Algorithm Design Strategies: Dynamic Programming                                | <strong>Due: Problem Set 3</strong>                 |
| 10/19 | Fall Break                                                                      |                                         |
| 10/21 | Fall Break                                                                      |                                         |</p>
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<tr>
<th>Date</th>
<th>Topic</th>
<th>Notes</th>
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<td>Algorithms</td>
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<tr>
<td>10/28</td>
<td>Algorithm Design Strategies: Greedy</td>
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<td>Algorithms</td>
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<td>Due: Problem Set 4</td>
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<td>11/4</td>
<td>Advanced Data Structures: Disjoint Sets</td>
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<td>11/9</td>
<td>Advanced Sorting Ideas: Topological Sort</td>
<td>CLRS: 22.4</td>
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<td>Due: Problem Set 5</td>
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<td></td>
<td>Review of Network Algorithms</td>
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<tr>
<td>11/16</td>
<td>Tries</td>
<td>Quiz over LO 9-10 + makeups</td>
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<tr>
<td>11/18</td>
<td>Reading a Computer Science Research paper</td>
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<td></td>
<td>String Matching</td>
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<td>11/23</td>
<td>&lt;Cancel Class&gt;</td>
<td>Due: Problem Set 6</td>
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<td>11/25</td>
<td>Thanksgiving Break</td>
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<tr>
<td>11/30</td>
<td>Sliding Suffix Tree</td>
<td>Sliding Suffix Tree, Research Paper</td>
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<td>Quiz over LO 11 + makeups</td>
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<tr>
<td>12/2</td>
<td>Implementation of Sliding Suffix Tree</td>
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<td>12/7</td>
<td>Mock Interviews</td>
<td>Due: Problem Set 7</td>
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<td>12/9</td>
<td>Course Evaluations</td>
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<td>Course Wrap-Up</td>
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<tr>
<td>12/17</td>
<td>Final</td>
<td>Quiz LO 1 - 11 makeups</td>
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<td></td>
<td>(Friday)</td>
<td>2-5pm</td>
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