# CS 456 : Advanced Algorithms

Instructor: Thoshitha Gamage, Ph.D.
Southern Illinois University at Edwardsville

Spring 2020 Syllabus

Course Information:

| | |
|---|---|
| Title: | CS 456 : Advanced Algorithms (3 Credits) |
| Location: | ~~SE 0214~~ EB 3140 |
| Time: | M & W 10:00 – 11:15 a.m. |
| Course Website: | http://www.cs.siue.edu/~tgamage/courses/456S20 |
| Assignment Dropbox: | https://classes.cs.siue.edu/spring-2020 |

Contact Information:

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|---|---|
| Office: | EB 3053 |
| Phone: | 650-2407 |
| Email: | tgamage@siue.edu |
| Web Site: | http://www.cs.siue.edu/~tgamage |
| Office Hours: | M & W 01:30 – 03:00 p.m.<br>T 10:00 – 11:00 a.m. *or by appointment* |

This is an upper-level undergraduate course in design and analysis of algorithms. The primary course objectives are:

1. to study algorithmic design strategies, empirical validation of theoretical results, and to learn algorithmic problem solving skills;
2. to build on CS340 knowledge of complexity and correctness analysis techniques;
3. to mathematically reason about algorithms and their designs;
4. to facilitate a learning environment that strengthens participants' *theoretical* and *empirical* knowledge, and understanding through hand-on experiments; and
5. to improve participants' critical thinking, reading, and writing skills;

By the end of the semester, students are expected to be proficient in algorithmic design strategies, complexity analysis, and correctness proofs of general computer programs.
The content of this course is influenced by and was developed in accordance to the IEEE/ACM Computer Science Curriculum Guidelines (2013) https://www.acm.org/binaries/content/assets/education/cs2013_web_final.pdf.

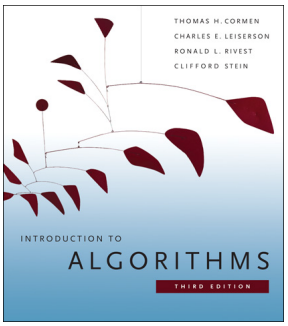
## 1 Course Prerequisites

CS340 (Data Structure and Algorithms) or the instructor's permission. Also *fluency and significant experience* in at least one programming language, preferably C, C++, Java, or Python, and **Unix/Linux** will be essential. If you do not meet these prerequisites, you **MUST** come and talk with me the first week of class. I reserve the right to drop you from the course if it becomes obvious that you do not meet the course prerequisites.

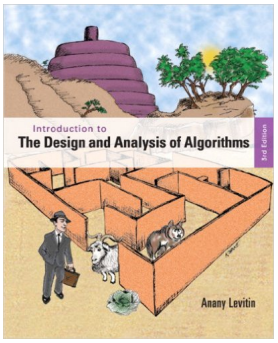
## 2 Textbook & Resources

**[Required]** **[CLRS3e]** Introduction to Algorithms, $3^{rd}$ ed., Corman et al., MIT Press, ISBN: 978-0262033848

**[Supplemental]** **[AL3e]** Introduction to the Design and Analysis of Algorithms, $3^{rd}$ ed., Anany Levitin, Pearson, ISBN: 978-0132316811




(a) **[CLRS3e]**




(b) **[AL3e]**

My lecture notes are based on numerous textbooks from my personal library and recent literature. The presentation slides you find on the course website are from the publisher of **[AL3e]**. You may also find another set of useful and complementary slides Professor Kevin Wayne at Princeton graciously let me borrow in my Fall '14 offering (`http://www.cs.siue.edu/~tgamage/F14/CS456/`). Material I present in class typically have a **strong mathematical flavor** to them.
Students are **required** to regularly check the course website and the SIUE email account for any important course related updates.

# 3 Assigned Work and Tentative Grading Policy

The following grade allocation breakdown is ***tentative***, and may change during the semester. Unless the circumstances change, I am **NOT** planning on curving or rounding the final grade.

| **Grading Allocation** | | **BS** | **MS** |
|---|---|---|---|
| Exams | | 40% | 35% |
| Midterm | 15% / 13% | | |
| Final *(comprehensive!!)* | 25% / 22% | | |
| Attendance & Scribing | | 5% | 5% |
| Problem Solving | | 25% | 20% |
| Programing Projects | | 30% | 25% |
| Graduate Standing Project | | – | 15% |

| **Final Letter Grade** | |
|---|---|
| 90–100 | A |
| 80–89 | B |
| 70–79 | C |
| 60–69 | D |
| below 60 | F |

## 3.1 Exams

All exams and quizzes will be held in the lecture room.

- **Midterm** : Monday March $02^{nd}$ 10:00 – 11:15 a.m.
- **Final** : Monday May $04^{th}$ 10:00 – 11:40 a.m.

## 3.2 Class Participation

You are expected to **proactively** participate in in-class discussions. This aids your learning and that of your classmates, and provides valuable feedback on the lecture. Constructive and proactive participation in in-class discussions and scribing accounts for 5% of your final grade. I, therefore, expect you to attend each and every class.

Each student is required to submit their scribe notes a **minimum of twice** for the semester, preferably once before the mid-term and once after. Scribe notes are due through *Moodle* within **48 hours** after the lecture. Only the top two scribe submissions (based on Moodle timestamp) will be counted as valid submissions. Scribe notes serve as a baseline set of complementary notes to you and to your colleagues, hence try your level best to to make them legible.

## 3.3 Problem Solving

There will be roughly ~3-4 in-class problem solving sessions during the course of the semester. In preparation, I will ask you to research and read about specific algorithmic problems, some which might be new to you. I will try my best to direct you to relevant resources where applicable, but you are fully expected to **take the responsibility of your own learning** and come fully prepared to the class.

## 3.4 Programming Projects

You will be given roughly ~3 hands-on programming assignments with a strong 2 weeks deadline. These assignments place a higher emphasis on *empirical validation* over "programming practice". Specifics of these assignments will be posted on the course website. I will give you the option to choose a language of your choice for programming (though C++, Java, or Python is recommended) but the development platform is fixed to Unix/Linux. You **must** make sure your code compiles and runs on a typical **Linux** system and be sure to provide a Makefile with your submission. It is also advisable to set up a Linux virtual machine that can be used for your programming assignments. Additionally, EB1036 PCs will have a Linux dual-boot option.

## 3.5 Graduate Standing Project

Graduate students are required to conduct a mini-research project that is worth 10% of their final grade. Ideally, this would be a fairly comprehensive literature survey of a topic of your choosing with some empirical validation. Your topic should be relevant to the theme of this course. Important milestones for your project are listed below. All assignments are due at the beginning of class through Moodle.

- Wednesday January $29^{th}$, 2020 – **M1:** One page research proposal and a justification of your proposed research.
- Wednesday March $04^{th}$ 2020 – **M2:** ~3-4 page intermediate report of your research progress.
- Wednesday April $15^{th}$ 2020 – **M3:** Project presentation slides.
- Wednesday April $29^{th}$ 2020 – **M4:** Final report.

Places to look for a research topic includes (but not limited to) IEEE FOCS, ACM STOC, ISAAC, SODA, IEEE S&P, ACM CCS, SOCG, IEEE CCC, ACM PODC, IEEE IPDPS, CSF, DSN, IEEE ICDCS, USENIX, etc. Topics in Cybersecurity are **highly favorable**.
A typical graduate level research of this scope would include a bare-minimum 20-25 *highly cited* research papers. I reserve the right to decide which projects meet graduate standing and lower the grade for those who don't; hence, make sure to clearly exchange your research ideas with me, find out about my expectations, and set yourself up for success **early** in the semester.
You are to present your research to the class at the conclusion of your research during weeks 15 and 16. In addition, you are required to produce an IEEE conference style minimum 8-page paper of your research. A template can be found at `http://www.ieee.org/conferences_events/conferences/publishing/templates.html`. You are **highly encouraged** to produce your report using Latex.
In addition, graduate students may have additional mandatory questions in exams. Accordingly, graduate students will be graded on separate scale. Please refer Section 3.

# 4 Course Requirements and Policies

## 4.1 Attendance Policy

Based on University Class Attendance Policy 1I9: It is the responsibility of students to ascertain the policies of instructors with regard to absence from class, and to make arrangements satisfactory to instructors with regard to missed course work. Failure to attend the first session of a course may result in the student's place in class being assigned to another student. You may be dropped from the course at any time for the following reasons:

- Failure to attend the first scheduled class
- Missing an exam or quiz without an acceptable reason
- Missing more than one week of class or two class sessions

**There will be no opportunities to make up missed exams or quizzes!**

## 4.2 Late Policy

Unless otherwise noted or announced in-class, all deadlines are hard deadlines and assignments are due at the beginning of class on the due date. Assignments may be turned within 48 hours *grace period* after the deadline (except any final projects) with a 20% late penalty. No assignment is accepted beyond this grace period. Graduate project milestones do not have any grace periods.

## 4.3 Responsible Learning Policy

There is a no tolerance policy with regards to cheating. **Anyone caught cheating will fail the course**. Do your own work. Your exams, homeworks, and programming projects are subject to the academic honor code. Following activities will be considered academic dishonesty:

- Submitting work (such as assigned work, projects, and code) done by somebody else (this includes any human/electronic sources (such as web sites));
- Watching and copying your neighbors' solutions during problem solving and/or exams;
- Collaboratively develop solutions to individual assignments;
- Using materials not allowed during problem solving and exams;
- Using materials not allowed for the programming projects.

You are expected to know and observe the SIUE Student Conduct Code (3C1) and Student Academic Code (3C2) found at `http://www.siue.edu/policies`. If you are unsure about what constitutes as plagiarism, check this website: `https://www.siue.edu/education/psychology/plagiarism.shtml`

### 4.3.1 Online Repositories

If you indent to keep any project source code in online repositories, ensure those repositories are **private** and **only accessible to you**. By making source code publicly available to others, you might be involuntarily participating in plagiarism.

### 4.3.2 Advice

This course will require a substantial amount of time reading and solving problems outside of class time. It is imperative that you keep up with the assigned reading and other tasks as much as possible. If you do not, it will be very difficult to be successful in this course.
Know the information, how to approach the problem/solution, and present it in a clear and organized manner. On exams and in programming projects, you are attempting to demonstrate understanding of concepts and the ability to solve problems. If I have to try to determine **how** you came up with your answer, then you will **not** receive full credit.
The following conditions are subject to loss of some or all credit for a given problem:

- Illegible work/answers

- work/answers that cannot be easily located
- no work
- missing/incorrect units
- compile-time and/or run-time errors

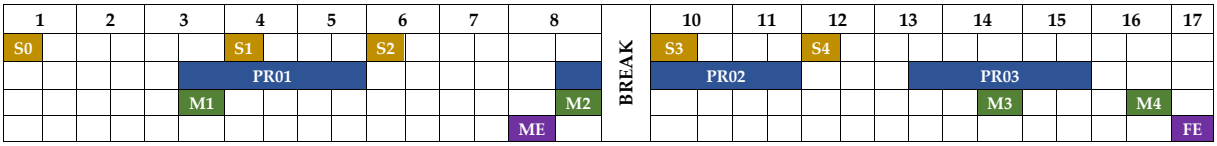
Solutions which clearly demonstrate understanding of the material, but have a minor error may receive partial credit. The final score for such problems is at the discretion of the grader and/or the instructor.

a. Don't wait until the last minute to do homework or projects. Labs get busy, computers break down, and people get sick. These are not sufficient excuses for an extension.
b. Save early; save often!
c. Contact me if you are confused. Don't wait for office hours; send an email.
d. I strongly discourage you from getting into discussions with me about grades and how you can get a better one. This includes emailing me about possible ways to "bump" your grade. Such requests only mean one thing; that you have already fallen behind on your own expectations.

### 4.4 Accessible Campus Community & Equitable Student Support: http://www.siue.edu/access

Students needing accommodations because of medical diagnosis or major life impairment will need to register with Accessible Campus Community & Equitable Student Support (ACCESS) and complete an intake process before accommodations will be given. Students who believe they have a diagnosis but do not have documentation should contact ACCESS for assistance and/or appropriate referral. The ACCESS office is located in the Student Success Center, Room 1270. You can also reach the office by e-mail at myaccess@siue.edu or by calling 618.650.3726. For more information on policies, procedures, or necessary forms, please visit the ACCESS website at `www.siue.edu/access`.

# 5 CS 456 in a Nutshell




S# – Problem Solving Sessions, M# – Graduate Standing Project Milestones, PR## – Programming Projects, ME – Mid-Term, FE – Final

## 5.1 Tentative Schedule*

*Subject to adjustment and change. I reserve the right to change topics or add an item of related interest. All changes will be announced in class.

| Week | Dates | Topics | References | Assignments/Exams |
|---|---|---|---|---|
| 01 | Jan. 13, 15 | Introduction and Course Overview<br>**Mathematics of Algorithmic Analysis:** | CLRS3e/01 | S0 |
| 02 | Jan. 20, 22 | **MLK Day** | | |
| 03 | Jan. 27, 29 | | | PR01 > out, M1 < in |
| 04 | Feb. 03, 05 | **Greedy Strategy:** | CLRS3e/16 | S1 (in-class) |
| 05 | Feb. 10, 12 | | | PR01 < in |
| 06 | Feb. 17, 19 | **Divide-and-Conquer Strategy:** | CLRS3e/04 | S2 (in-class) |
| 07 | Feb. 24, 26 | | | |
| 08 | Mar. 02‡, 04 | Midterm Exam | | PR02 > out, M2 < in |
| 09 | Mar. 09†, 11† | **Spring Break** | | |
| 10 | Mar. 16, 18 | **Dynamic Programming:** | CLRS3e/15 | S3 (in-class) |
| 11 | Mar. 23, 25 | | | PR02 < in |
| 12 | Mar. 30, Apr. 01 | **Network Flow:** | CLRS3e/26 | S4 (in-class) |
| 13 | Apr. 06, 08 | **Randomized & Approximation Algorithms:** | CLRS3e/05, 35 | PR03 > out |
| 14 | Apr. 13, 15 | **Algorithmic Intractability:** | CLRS3e/34 | M3 < in |
| 15 | Apr. 20§, 22§ | *Topic TBA* | | PR03 < in |
| 16 | Apr. 27§, 29§ | *Topic TBA* | | M4 < in |
| 17 | May. 04 | **Final Exam: 10:00 – 11:40 a.m.** | | |