CS 456 : Advanced Algorithms

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

Spring 2019 Syllabus

Course Information:
Title: CS 456 : Advanced Algorithms (3 Credits)
Location: EB 2170
Time: M & W 10:00 – 11:15 a.m.
Course Web site: http://www.cs.siue.edu/~tgamage/S19/CS456

Contact Information:
Office: EB 3053
Phone ☑: 650-2407
Email ⌨: tgamage@siue.edu
Web Site ⚑: http://www.cs.siue.edu/~tgamage
Office Hours: M & W 01:20 – 02:20 p.m.
T 09:30 – 10:30 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) http://www.acm.org/education/CS2013-final-report.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


last updated: 01/15/19 @ 10:36am
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.

<table>
<thead>
<tr>
<th>Grading Allocation</th>
<th>BS</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exams</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>Midterm</td>
<td>15% / 15%</td>
<td></td>
</tr>
<tr>
<td>Final (comprehensive!!)</td>
<td>25% / 25%</td>
<td></td>
</tr>
<tr>
<td>Attendance &amp; Scribing</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>25%</td>
<td>20%</td>
</tr>
<tr>
<td>Programing Projects</td>
<td>30%</td>
<td>25%</td>
</tr>
<tr>
<td>Graduate Standing Project</td>
<td>–</td>
<td>10%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Letter Grade</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>90–100</td>
<td>A</td>
</tr>
<tr>
<td>80–89</td>
<td>B</td>
</tr>
<tr>
<td>70–79</td>
<td>C</td>
</tr>
<tr>
<td>60–69</td>
<td>D</td>
</tr>
<tr>
<td>below 60</td>
<td>F</td>
</tr>
</tbody>
</table>

3.1 Exams

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

- **Midterm**: Monday March 04th 10:00 – 11:15 a.m.
- **Final**: Wednesday May 08th 12:00 – 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.

last updated: 01/15/19 @ 10:36am
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 28th, 2019 – M1: One page research proposal and a justification of your proposed research.
- Wednesday March 06th, 2019 – M2: ~3-4 page intermediate report of your research progress.
- Wednesday April 17th, 2019 – M3: Project presentation slides.
- Wednesday May 01th, 2019 – 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

I allow you to miss at most 2 classes for the semester without any penalties. Medical emergencies are outside this “absentee allowance”, but should be accompanied by proper documented proof of medical services. For planned absences, assignments should be turned in before the absence rather than after. I reserve the right to lower the grade of any student who is markedly deficient in attendance and/or in in-class participation. If you miss a class, it is your responsibility to find out what happened and to collect any material that was handed out in the class.

last updated: 01/15/19 @ 10:36am
### 4.2 Late Policy

Unless otherwise noted or announced in-class, all deadlines are hard deadlines and are due at the beginning of class on the due date. Programming assignments typically have a 2 week deadline. Assignments may be turned within 48 hours *grace period* after the deadline (except PR03) 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

I expect *you* to own your degree of success in this class *and*, I expect you to contribute to the success of others. Examples:

- Read outside the class on your own in preparation for each lecture, jot down any questions your encounter on your reading (strongly encouraged), and bring those to the class as discussion points;
- Be respectful of the learning environment. Refrain from activities that may disturb the flow of the lecture or the environment;
  - Refrain from engaging in disruptive “little talk” while I am conducting the lecture; if you have a concern, raise your hand and grab my attention. be respective of your colleagues time and desire to learn.
  - Put your cell phones to vibrate mode and refrain from using your computers for casual web browsing. Take full advantage of the opportunity to learn.
- Cooperate with other students and to share your knowledge during in-class discussions. Respect the differences in learning and understanding of each other. Seek ways of taking advantage of those differences;
- If another student is confused, help him or her out without disturbing the class;
- I enjoy engaging in technical conversations with students with the goal of helping them create an accurate understanding of course material. Participating in such conversations is very favorable for your class participation grade;
- If I am systematically doing something that inhibits your learning, tell me;
- Engage in proactive learning: speak up when you don’t understand, question assumptions, relate course material to your experience outside class, seek out additional experience and reading related to the class. You must *construct* your understanding of the material;
- If a lecture point is unclear, ask questions and ask me to repeat what I said, preferably in class, during office hours, or by e-mail. You are probably not alone in your confusion;
- Promptly review feedback you receive from me or other students to actively clarify the feedback if the material is still unclear and to incorporate the feedback in your future work;
- Spend adequate time on the course. Adequate time includes getting enough rest so that time you spend on course tasks is well-spent time. Adequate time includes proofreading and reviewing your assignments before you hand them in;
- Have high expectations of yourself: set goals for yourself and try to do your very best. Consciously think about the balance between what you do to earn a grade and what you do to learn (If I’m doing something that puts these in opposition to each other, please let me know.); and,
- Check your SIUE assigned student email and the course website regularly for important class announcements.

**IMPORTANT:** 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.

Do your own work. Your exams, homeworks, and programming projects are subject to the academic honor code.

**DO NOT CHEAT IN ANY WAY: DO YOUR OWN WORK!** 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 quizzes and/or exams;
- Using materials not allowed during quizzes and exams;
- Using materials not allowed for the programming projects.
It is quite acceptable to ask others things like “Have you come across this particular issue/error/exception before?,” and even having them briefly look briefly at your stack trace and/or its code. To have them spend hours helping develop or seriously rearrange your program’s logic, on the other hand, is not acceptable. And, of course, it is unacceptable for two or more people to collaboratively develop the solutions to assignments. If you are tempted to collaborate on such assignments, DON’T!!.

I expect you to know and observe the SIUE Student Conduct Code (3C1) and Student Academic Code (3C2). Copying of other students’ work, working together on individual assignments, plagiarism of published sources and other forms of academic dishonesty will result in zero credit on the assignment for all students involved and a lower grade in the class. A second offense (across the University) will result in an automatic F in the course and exposes the violator to University sanctions up to and including expulsion. All offenses will be reported to Student Affairs.

4.4 Online Repositories

If you intend 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.

4.4.1 Advice

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.

4.5 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

<table>
<thead>
<tr>
<th>Week</th>
<th>Dates</th>
<th>Topics</th>
<th>References</th>
<th>Assignments/Exams</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Jan. 14, 16</td>
<td>Introduction and Course Overview; Mathematics of Algorithmic Analysis:</td>
<td>CLRS\textsuperscript{3e}/01</td>
<td>So</td>
</tr>
<tr>
<td>02</td>
<td>Jan. 21, 23</td>
<td>MLK Day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Jan. 28, 30</td>
<td>PR\textsuperscript{01} &gt; out, M\textsubscript{1} &lt; in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>Feb. 04, 06</td>
<td>Greedy Strategy:</td>
<td>CLRS\textsuperscript{3e}/16</td>
<td>S\textsubscript{1} (in-class)</td>
</tr>
<tr>
<td>05</td>
<td>Feb. 11, 13</td>
<td>PR\textsuperscript{01} &lt; in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>06</td>
<td>Feb. 18, 20</td>
<td>Divide-and-Conquer Strategy:</td>
<td>CLRS\textsuperscript{3e}/04</td>
<td>S\textsubscript{2} (in-class)</td>
</tr>
<tr>
<td>07</td>
<td>Feb. 25, 27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08</td>
<td>Mar. 04\textsuperscript{1}, 06</td>
<td>Midterm Exam</td>
<td></td>
<td>PR\textsuperscript{02} &gt; out, M\textsubscript{2} &lt; in</td>
</tr>
<tr>
<td>09</td>
<td>Mar. 11\textsuperscript{1}, 13\textsuperscript{1}</td>
<td>Spring Break</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Mar. 18, 20</td>
<td>Dynamic Programming:</td>
<td>CLRS\textsuperscript{3e}/15</td>
<td>S\textsubscript{3} (in-class)</td>
</tr>
<tr>
<td>11</td>
<td>Mar. 25, 27</td>
<td></td>
<td></td>
<td>PR\textsuperscript{02} &lt; in</td>
</tr>
<tr>
<td>12</td>
<td>Apr. 01, 03</td>
<td>Network Flow:</td>
<td>CLRS\textsuperscript{3e}/26</td>
<td>S\textsubscript{4} (in-class)</td>
</tr>
<tr>
<td>13</td>
<td>Apr. 08, 10</td>
<td>Randomized &amp; Approximation Algorithms:</td>
<td>CLRS\textsuperscript{3e}/05, 35</td>
<td>PR\textsuperscript{03} &gt; out</td>
</tr>
<tr>
<td>14</td>
<td>Apr. 15, 17</td>
<td>Algorithmic Intractability:</td>
<td>CLRS\textsuperscript{3e}/34</td>
<td>M\textsubscript{3} &lt; in</td>
</tr>
<tr>
<td>15</td>
<td>Apr. 22\textsuperscript{5}, 24\textsuperscript{8}</td>
<td>Topic TBA</td>
<td></td>
<td>PR\textsuperscript{03} &lt; in</td>
</tr>
<tr>
<td>16</td>
<td>Apr. 29\textsuperscript{5}, May 01\textsuperscript{8}</td>
<td>Topic TBA</td>
<td></td>
<td>M\textsubscript{4} &lt; in</td>
</tr>
<tr>
<td>17</td>
<td>May. 08</td>
<td>Final Exam: 10:00 – 11:40 a.m.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S\textsuperscript{#} – Problem Solving Sessions, M\textsuperscript{#} – Graduate Standing Project Milestones, PR\textsuperscript{##} – 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.