

# CS 59000-RA:Randomized Algorithms

## Syllabus (draft date: February 7, 2019)

<b>Course Web Page:</b>	we will use Purdue's Blackboard Learn course page
<b>Instructor:</b>	Prof. Petros Drineas, LWSN 1203
<b>Instructor's e-mail:</b>	pdrineas@purdue.edu
<b>Instructor's web page:</b>	<a href="http://www.drineas.org/">http://www.drineas.org/</a>
<b>Lecture:</b>	see Blackboard Learn
<b>Office hours:</b>	see Blackboard Learn
<b>Required textbook:</b>	Randomized Algorithms, by R. Motwani and P. Raghavan, Cambridge University Press

### Course Description

Randomized Algorithms are the state of the art in contemporary algorithm design. They are usually simple, sometimes even easy to analyze, and they work well in practice. They have found numerous applications in every field of Computer Science, and also in Mathematics, Physics, Economics, etc. Randomized Algorithms is an active and vibrant research area with many exciting new results every year.

The course is appropriate for advanced undergraduate and graduate students in computer science, statistics, and mathematics.

### Prerequisites

Some advanced algorithms course (covering basic graph algorithms, elementary data structures, etc.) as well as familiarity with basic calculus, probability theory, and elementary linear algebra. The instructor will cover most of the probability theory that is necessary for this course.

### References

Beyond the required textbook, we will also cover material from other sources (e.g. papers), that will be made available at the course web page.

### Goals and objectives

At the end of the course, the student

1. is able to apply fundamental algorithmic ideas to design randomized algorithms,
2. is able to apply measure concentration results from probability theory in order to analyze randomized algorithms,
3. has developed a solid background on randomized algorithms for graph-theoretic, number theoretic, and linear algebraic problems,
4. is able to determine the running times, failure probabilities, and accuracy guarantees of the aforementioned algorithms,
5. is able to present material from published research in the area of randomized algorithms using field-specific language, and
6. is able to critique material from published research in the area of randomized algorithms.

## Requirements and Grading

Semester requirements will include five homeworks, two midterms, class participation (students are expected to actively participate during lectures, answering questions and contributing to the discussion), and a conference-style project presentation (12 minute presentation of a topic assigned to the student by the instructor; the 12 minute presentation will be split in 10 minutes for the actual presentation and 2 minutes for questions; dates and details will be announced via Blackboard Learn).

All homeworks will be submitted electronically, typed in LaTeX (preferably), MS Word, or other editors of comparable quality. **Handwritten homeworks will not be graded.**

The formal requirements and percentage of the total course grade are:

- Homeworks: 30%
- Midterms:  $50\% = 25\% + 25\%$
- Conference-style presentation: 15%
- Class participation: 5%

## Policies

**Announcements:** There will be announcements relevant to the course made through the Blackboard Learn course email list. This will send an email message to your Purdue email address and you are expected to check this account for information related to the class.

**Conduct and Courtesy:** Students are expected to maintain a professional and respectful classroom environment. In particular, this includes: silencing personal electronics; arriving on time and remaining throughout the class; do not insult or deride others for any reason (even in jest); be on time for class; leave class promptly and wait to ask the instructor questions in the hall, unless they pertain to material on the blackboard. You may use non-disruptive personal electronics during class.

**Correspondence with the instructor:** The best way to correspond in this class is by emailing the instructor. Please feel free to email the instructor with any questions, but please prefix all email titles with the string “CS-5900-RA:” to aid in filtering email. The instructor will make every effort to respond promptly, however, replies could be delayed due to circumstances outside the instructor’s control. Typical response time to emails would be between 24 and 48 hours. Please do not attempt to call, google chat, or skype with the instructor without prior arrangement.

**Missing or late work:** Except as discussed below, or by prior arrangement, missing or late work will be counted as a zero.

**Collaboration:** Collaboration in homeworks is not allowed.

**Academic integrity:** Behavior consistent with cheating, copying, and academic dishonesty is not tolerated. Depending on the severity, this may result in a zero score on the assignment or exam, and could result in a failing grade for the class. Purdue prohibits “dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty.” (Part 5, Section III-B-2-a, University Regulations) Furthermore, the University Senate has stipulated that “the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other

parties in committing dishonest acts is in itself dishonest.” (University Senate Document 72-18, December 15, 1972). You are expected to read both Purdue’s guide to academic integrity ([http://www.purdue.edu/purdue/about/integrity\\_statement.html](http://www.purdue.edu/purdue/about/integrity_statement.html)) and Prof. Gene’s Spaford’s guide (<http://spaf.cerias.purdue.edu/integrity.html>) as well. You are responsible for understanding their contents and how it applies to this class.

**Attendance:** Students are expected to be present for every meeting of the classes in which they are enrolled. Only the instructor can excuse a student from a course requirement or responsibility. When conflicts or absences can be anticipated, such as for many University sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency absences when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email, or by contacting the main office that offers the course. When the student is unable to make direct contact with the instructor and is unable to leave word with the instructor’s department because of circumstances beyond the student’s control, and in cases of bereavement, the student or the student’s representative should contact the Office of the Dean of Students.

**Grief Absence Policy:** Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). According to GAPS Policy, students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for missed assignments or assessments in the event of the death of a member of the student’s family.

**Violent Behavior Policy:** Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity.

**Students with Disabilities:** Purdue University is required to respond to the needs of the students with disabilities as outlined in both the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 through the provision of auxiliary aids and services that allow a student with a disability to fully access and participate in the programs, services, and activities at Purdue University. If you have a disability that requires special academic accommodation, please make an appointment to speak with the instructor within the first three (3) weeks of the semester in order to discuss any adjustments. It is important to talk about this at the beginning of the semester. It is the student’s responsibility to notify the Disability Resource Center (<http://www.purdue.edu/drc>) of an impairment/condition that may require accommodations and/or classroom modifications.

**Emergencies:** In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructors control. Relevant changes to this course will be posted onto the course website and/or announced via email. You are expected to read your [purdue.edu](http://www.purdue.edu) email on a frequent basis.

**Emergency Preparedness:** Emergency notification procedures are based on a simple concept: *If you hear a alarm inside, proceed outside. If you hear a siren outside, proceed inside.* Indoor Fire Alarms are mean to stop class or research and immediately evacuate the building. Proceed to your Emergency Assembly Area away from building doors. Remain outside until police, fire, or other emergency response personnel provide additional guidance or tell you it is safe to leave. All Hazards Outdoor Emergency Warning sirens mean to immediately seek shelter (Shelter in Place) in a safe location within the closest building. “Shelter in place” means seeking immediate shelter

inside a building or University residence. This course of action may need to be taken during a tornado, a civil disturbance including a shooting or release of hazardous materials in the outside air. Once safely inside, find out more details about the emergency. Remain in place until police, fire, or other emergency response personnel provide additional guidance or tell you it is safe to leave. In both cases, you should seek additional clarifying information by all means possible: Purdue Home page, email alert, TV, radio, etc. Review the Purdue Emergency Warning Notification System multi-communication layers at [http://www.purdue.edu/ehps/emergency\\_preparedness/warning-system.html](http://www.purdue.edu/ehps/emergency_preparedness/warning-system.html). Please review the Emergency Response Procedures at [https://www.purdue.edu/emergency\\_preparedness/flipchart/index.html](https://www.purdue.edu/emergency_preparedness/flipchart/index.html). Please review the evacuation routes, exit points, emergency assembly area and shelter in place procedures and locations for our building. Video resources include a 20-minute active shooter awareness video that illustrates what to look for and how to prepare and react to this type of incident. See <http://www.purdue.edu/securePurdue/news/2010/emergency-preparedness-shots-firedon-campus-video.cfm>

**Nondiscrimination:** Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, marital status, parental status, sexual orientation, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies.

**Instructor absence:** The instructor will be away for a few classes. There will be a guest instructor for these classes. If we need to reschedule additional classes, we will do so on an as-needed basis. Our plan is to use video lectures to supplement for any missing class periods.

**Changes to the syllabus:** This syllabus is subject to change. Updates will be posted and dated on the course website.

## Schedule

Here is a description of the material that will be covered (subject to change; check Blackboard Learn for up-to-date, lecture-by-lecture schedule).

- Randomized algorithms overview; Randomized Quicksort; Randomized Complexity Theory.
- Basic probability theory.
- Markov and Chebyshev inequalities, randomized selection, coupon collector's problem.
- Tail inequalities and applications; Chernoff bounds and applications.
- Oblivious routing on the hypercube, the probabilistic method, Max-SAT, expanding graphs.
- Lovasz Local Lemma and applications, the method of conditional probabilities.
- Randomized Data Structures: Hashing.
- Fingerprinting, Schwartz-Zippel, Pattern Matching.

- Markov Chains and the MCMC method (overview).
- Random projections.
- AMS algorithm for frequency moments.
- Randomized matrix multiplication and martingales.
- Graph sparsification; Laplacian linear equation solvers.
- The Kaczmarz algorithm.