This is a graduate level course studying the applications of combinatorics and graph theory in computer science. We will start with some basic combinatorial techniques such as counting and pigeon hole principle, and then move to advanced techniques such as the probabilistic method, spectral graph theory and additive combinatorics. We shall see their applications in various areas in computer science, such as proving lower bounds in computational models, randomized algorithms, coding theory and pseudorandomness. Students may receive credit for only one of EN.601.430 and EN.601.630.

**Prerequisites**
Discrete Math or permission. Probability theory and linear algebra strongly recommended.

**Selective Elective**
Course Goals
Specific Outcomes for this course are that:

- Students will learn to establish a formal foundation of the theory of computation.
- Students will learn to analyze and solve problems formally and mathematically.

This course will address the following Criterion 3 Student Outcomes:

- An ability to apply knowledge of computing and mathematics appropriate to the discipline (a)
- An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution (b)

Tentative Course Topics

- Basic Techniques: Counting; Pigeon hole principle; Matching and Hall’s theorem; Chains and Antichains, with applications to LIS.
- The Probabilistic Method: Basic method; Lovaz local lemma and its constructive proof; Linearity of Expectation; The deletion method; Concentration bounds; Random walks and randomized algorithm for finding satisfying assignment for 2-CNF.
- Spectral Graph theory: Basic properties of graph spectrum; Cheeger’s inequality and approximation of graph expansion; Expander graphs and applications to superconcentrators and pseudorandomness; Error correcting codes and expander codes.
- Ramsey Type Theorems and Constructions of Ramsey Graphs.
- Additive Combinatorics: Sum product theorem, Szemeredi-Trotter theorem, Kakeya set problem and applications to randomness extractors.
Course Expectations & Grading
There will be four or five homework problem sets, one mid-term exam and one final exam. Grading will be based on the following rule:

- Homework: 40%.
- Mid-term exam: 30%.
- Final exam: 30%.

Key Dates
The mid-term exam will be held on October 14. The final exam will be cumulative and be held on date TBD. The specific formats of the exams (either on-line or in person) will be decided later. No make-up exams will be given, unless you have legitimate reasons, so plan accordingly. If the exams are held in person, for the midterm, you may bring a single, 8.5x11 inch, handwritten sheet of paper (you may use both sides). For the final exam you may bring two sheets. No calculators are allowed (they won’t be necessary).

Assignments & Readings
Assignments and further readings will be posted on the course website http://www.cs.jhu.edu/~lixints/class/fall21.html

Gradescope: https://gradescope.com/ coursecode: 86JDXK
CampusWire: https://campuswire.com/p/GB8BA4990 Code: 8174

Ethics
The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful, abiding by the Computer Science Academic Integrity Policy:

Cheating is wrong. Cheating hurts our community by undermining academic integrity, creating mistrust, and fostering unfair competition. The university will punish cheaters with failure on an assignment, failure in a course, permanent transcript notation, suspension, and/or expulsion. Offenses may be reported to medical, law or other professional or graduate schools when a cheater applies.

Violations can include cheating on exams, plagiarism, reuse of assignments without permission, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition. Ignorance of these rules is not an excuse.

Academic honesty is required in all work you submit to be graded. Except where the instructor specifies group work, you must solve all homework and programming assignments without the help of others. For example, you must not look at anyone else’s solutions (including program code) to your homework problems. However, you may discuss assignment specifications (not solutions) with others to be sure you understand what is required by the assignment.

If your instructor permits using fragments of source code from outside sources, such as your textbook or on-line resources, you must properly cite the source. Not citing it constitutes plagiarism. Similarly, your group projects must list everyone who participated.

Falsifying program output or results is prohibited.

Your instructor is free to override parts of this policy for particular assignments. To protect yourself: (1) Ask the instructor if you are not sure what is permissible. (2) Seek help from the instructor, TA or CAs, as you are always encouraged to do, rather than from other students. (3) Cite any questionable sources of help you may have received.

On every exam, you will sign the following pledge: “I agree to complete this exam without unauthorized assistance from any person, materials or device. [Signed and dated]”.
Your course instructors will let you know where to find copies of old exams, if they are available.

[In addition, the specific ethics guidelines for this course are:

(1) **Collaboration policy:** While you should first think about homework problems on your own, I encourage you to discuss homework problems with your classmates. However, you must write up your own solutions. Students found sharing the same paragraph in their homework will receive 0 point for the homework, and risk further punishment such as automatic failure and report to the University. Furthermore, you must acknowledge any collaboration by writing the names of your collaborators on the front page of the assignment. You don’t lose points by having collaborators.

(2) **Citation policy:** Try to solve the problems without reading any published literature or websites, besides the class text. If, however, you do use a solution or part of a solution that you found in the literature or on the web, you must cite it. Furthermore, you must write up the solution in your own words. You will get at most half credit for solutions found in the literature or on the web. Using solutions from other resources without citation is considered plagiarism and will result in 0 point and potential further punishment as in (1).

(3) **Late Policy:** Homework are due at the beginning of the class. You have a total of two late days that you can use for your assignments without penalty (for example, you can use one late day for one assignment and one late day for another assignment, or use two late days for one assignment). A day here means 24 hours. Once your late days are used up, your homework will not be graded.

Report any violations you witness to the instructor.

You can find more information about university misconduct policies on the web at these sites:

- Undergraduates: https://studentaffairs.jhu.edu/policies-guidelines/undergrad-ethics/
- Graduate students: http://e-catalog.jhu.edu/grad-students/graduate-specific-policies/#misconduct

**Personal Wellbeing**

- If you are sick please notify me by email so that we can make appropriate accommodations should this affect your ability to attend class, complete assignments, or participate in assessments. The Student Health and Wellness Center(https://studentaffairs.jhu.edu/student-health/) is open and operational for primary care needs. If you would like to speak with a medical provider, please call 410-516-8270, and staff will determine an appropriate course of action based on your geographic location, presenting symptoms, and insurance needs. Telemedicine visits are available only to people currently in Maryland. See also http://studentaffairs.jhu.edu/student-life/support-and-assistance/absences-from-class/illness-note-policy/
- The Johns Hopkins COVID-19 Call Center (JHCCC), which can be reached at 833-546-7546 seven days a week from 7 a.m. to 7 p.m., supports all JHU students, faculty, and staff experiencing COVID-19 symptoms. Primarily intended for those currently within driving distance of Baltimore, the JHCCC will evaluate your symptoms, order testing if needed, and conduct contact investigation for those affiliates who test positive. More information on the JHCCC and testing is on the coronavirus information website https://covidinfo.jhu.edu/health-safety/johns-hopkins-covid-19-call-center/.
  COVID-19 testing information: https://covidinfo.jhu.edu/diagnostic-testing/testing-locations-and-schedules/.
- Johns Hopkins University values diversity and inclusion. We are committed to providing welcoming, equitable, and accessible educational experiences for all students. Students with disabilities (including those with psychological conditions, medical conditions and temporary disabilities) can request accommodations for this course by providing an Accommodation Letter issued by Student
Disability Services (SDS). Please request accommodations for this course as early as possible to provide time for effective communication and arrangements.

For further information or to start the process of requesting accommodations, please contact Student Disability Services at Homewood Campus, Shaffer Hall 101, call: 410-516-4720 and email: studentdisabilityservices@jhu.edu or visit the website https://studentaffairs.jhu.edu/disabilities/.

- If you are struggling with anxiety, stress, depression or other mental health related concerns, please consider visiting the JHU Counseling Center. If you are concerned about a friend, please encourage that person to seek out their services. The Counseling Center is located at 3003 North Charles Street in Suite S-200 and can be reached at 410-516-8278 and online at http://studentaffairs.jhu.edu/counselingcenter/.

Classroom Climate

I am committed to creating a classroom environment that values the diversity of experiences and perspectives that all students bring. Everyone here has the right to be treated with dignity and respect. I believe fostering an inclusive climate is important because research and my experience show that students who interact with peers who are different from themselves learn new things and experience tangible educational outcomes. Please join me in creating a welcoming and vibrant classroom climate. Note that you should expect to be challenged intellectually by me, the TAs, and your peers, and at times this may feel uncomfortable. Indeed, it can be helpful to be pushed sometimes in order to learn and grow. But at no time in this learning process should someone be singled out or treated unequally on the basis of any seen or unseen part of their identity.

If you ever have concerns in this course about harassment, discrimination, or any unequal treatment, or if you seek accommodations or resources, I invite you to share directly with me or the TAs. I promise that we will take your communication seriously and to seek mutually acceptable resolutions and accommodations. Reporting will never impact your course grade. You may also share concerns with the Department Head (Randal Burns, randal@cs.jhu.edu), the Director of Undergraduate Studies (Joanne Selinski, joanne@cs.jhu.edu), the Assistant Dean for Diversity and Inclusion (Darlene Saporu, dsaporu@jhu.edu), or the Office of Institutional Equity (oie@jhu.edu). In handling reports, people will protect your privacy as much as possible, but faculty and staff are required to officially report information for some cases (e.g. sexual harassment).