# 640:454: COMBINATORICS
## Syllabus

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| Days: | M/T/W/Th |
| Time: | 12:20—2:20PM EDT |
| Location: | Zoom (online); link posted on our Canvas page |

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| **Instructor:** | Corrine Yap (call me Corrine) | **Office:** | Canvas |
| **Email:** | corrine.yap@rutgers.edu | **Office Hours:** | TBD |
| **Website:** | `canvas.rutgers.edu` | | |

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| **Textbook:** | Discrete Mathematics: an Open Introduction by Oscar Levin (`http://discrete.openmathbooks.org/dmoi3.html`) + Supplemental Readings |

*Disclaimer: The instructor reserves the right to change any of the items on this syllabus throughout the course. Students will be notified and the information on the website will be updated accordingly.*

**About this class:** Combinatorics is a broad subject that mainly deals with the counting, construction, and optimization of discrete objects (as opposed to continuous objects - think of the natural numbers, versus the real numbers). Such problems are near the intersection of mathematics and computer science; many can be solved using algorithms, but many cannot! We will study different types of combinatorial problems and the techniques used to answer these problems, which form the foundations of today's research in discrete mathematics.

This class is not lecture-based but discovery-based. Why, you might ask? Because when people discover ideas for themselves, they tend to retain those ideas longer and to understand them more deeply than if someone else revealed the ideas. Much of class time will be spent in developing and exploring key concepts by working on problems in groups. But at the same time, it's easy to miss part of a relevant idea when you're thinking about it on your own, so we will always follow up on what we discover with class check-ins, informal presentations of ideas and solutions, and assigned reading. Practice problems will be assigned after every class, to be discussed at the beginning of the next class. Longer problem sets will be assigned on a weekly basis.

The prerequisites are Calc II and Linear Algebra. Intro to Proofs (Math 300) is not required, but we will see many proofs and practice writing proofs both in homework and during class.

**Our skill-oriented goals for the summer:**

- Discover combinatorial concepts by generating examples and making conjectures.

- Communicate about mathematics in a clear and articulate manner, both orally and in writing, in large discussions and in small groups.

- Apply the theorems and proof techniques discussed in class to discrete problems with demonstrated examples to real-world scenarios.

**Our virtue-oriented goals for the summer:**

- Develop persistence to struggle through problems and learn from that struggle.

- Approach new and unfamiliar problems strategically but with an openness to creativity and imaginative solutions.

**Some Guidelines:**

**Math does not exist in a void.** Each of you will enter the class with different math-and-life experiences. I do not expect us to leave our identities at the door - they inform how we learn, view, discuss, teach, and internalize math. Regardless of how you view yourself or how society views you, you are capable of excelling in this course, and I am here to help you.

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**Minimum technology requirements** consist of a computer, webcam, and microphone. **Be prepared to turn your webcam and microphone on during every class.** You will not often be required to, but you should be able to if you are asked. If doing this isn't easy (e.g. loud home, family members around, etc), let me know so we can discuss how you can participate as well as your situation allows.

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**Attendance** is important, especially since much of class time will consist of activities that will help you discover new material or understand material more deeply. Repeated absences will affect your grade in the course. If your absence is unavoidable (e.g. religious holiday, personal emergency), speak to me beforehand about turning in work, and speak to me and your classmates about the material you missed.
**Online attendance means *you* are present, not just your avatar.**

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**Participation** is expected and is part of your grade. In order to participate to the fullest of your abilities, **you must come to class prepared.** This means doing the assigned reading and problems before class.

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**Late submissions** for weekly problems will be accepted once, up to 24 hours after the deadline, without questions or penalty. To turn in subsequent late work or work more than 24 hours after the deadline, you must meet with me outside of class to discuss it. Credit will be awarded only if the circumstance was unavoidable.
Late submissions for the daily problems will not be given credit, since the solution will be discussed in class and on the discussion boards.
I would prefer you turn in homework late, rather than plagiarize someone else's work in order to hand it in on time. If you find yourself having to make this choice, come talk to me.

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**Academic integrity** is taken seriously. All students are expected to be familiar with the university's academic integrity policies, found at
[academicintegrity.rutgers.edu/academic-integrity-at-rutgers](academicintegrity.rutgers.edu/academic-integrity-at-rutgers).
In particular, copying work from the internet or another student and submitting it as your own is a violation, and it will not help you succeed in this course.

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**Collaboration is not the same as copying.** You are encouraged to work with other students when solving problems, but when you write up a solution to be handed in, you should do so on your own, without the aid of others.

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**Feedback** is more than welcome. If you have any thoughts on how the course is going, or personal circumstances that are affecting your ability to participate, I want to know. **Email me**, and I will try to answer as soon as possible, but give me 48 hours before expecting a response.

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**Lastly, a note about being online:** I understand that the spring semester may have been tough for some of you—maybe you didn't have a good place to study, maybe your mental health suffered, maybe your classes got more difficult and your professors less communicative. Or maybe you just felt a lot less motivated. I experienced a lot of this for the graduate classes I was taking. Not everything got worse—I don't have to commute 40 minutes to campus twice a day. I have time to play with my cat. In particular, maybe you wouldn't have been able to take an in-person summer course because of the commute, but now you have the opportunity.

My goal for this course is not to give a second-rate online substitute for the course you should have taken in person, but to give you a valuable worthwhile learning experience in and of itself. I will try to be empathetic of the situation that we're all in right now, but I will not lower my standards because that would be doing a disservice to you and the education that you've signed up for. At the end of the day, we have six weeks to complete a semester's worth of material. The pace will be fast. But as I said at the beginning, you have the capability to succeed.

**Student Resources:**

- **Disability Services**

  (848) 445-6800 // https://ods.rutgers.edu

  Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: https://ods.rutgers.edu/students/documentation-guidelines.
  If the documentation supports your request for reasonable accommodations, your campus's disability services office will provide you with a Letter of Accommodations. Please share this letter and discuss the accommodations with me as early as possible.

  To begin this process, complete the Registration form on the ODS web site at: https://ods.rutgers.edu/students/registration-form.

- **Counseling, ADAP & Psychiatric Services (CAPS)**

  (848) 932-7884 // http://health.rutgers.edu/medical-counseling-services/counseling/

  CAPS is a University mental health support service that includes counseling, alcohol and other drug assistance, and psychiatric services staffed by a team of professional within Rutgers Health services to support students' efforts to succeed at Rutgers University.

  All CAPS locations are physically closed but are providing services remotely, including individual therapy and virtual workshops.

- **Just In Case Web App**

  www.justincaseforcolleges.com

  Access helpful mental health information and resources for yourself or a friend in a mental health crisis on your smartphone or tablet and easily contact CAPS or RUPD.

- **Violence Prevention & Victim Assistance (VPVA)**

  (848) 932-1181 //www.vpva.rutgers.edu

  The Office for Violence Prevention and Victim Assistance provides confidential crisis intervention, counseling and advocacy for victims of sexual and relationship violence and stalking to students, staff and faculty. To reach staff during office hours when the university is open or to reach an advocate after hours, call 848-932-1181.

## Course Outline:
Note that this is subject to change. A day-by-day breakdown will be posted on our website and updated frequently.

- Week 1: Set Theory and Functions, Basic Counting Principles, Binomial Coefficients

- Week 2: Combinations and Permutations, Combinatorial Proofs, Balls and Boxes Problems, Inclusion-Exclusion, Bijective Proofs

- Week 3: Induction, Sequences, Recurrence Relations, Generating Functions, Midterm

- Week 4: Generating Functions, Graph Theory

- Week 5: Ramsey Theory, Combinatorial Designs, Discrete Probability, Probabilistic Methods

- Week 6: Smorgasbord of Remaining/Additional Topics, Final Exam

**Midterm Dates:** June 11 (take-home), June 12 (oral)
**Final Dates:** July 2 (take-home), July 3 (oral)

## Assessments Overview:
*Not all assessments are mandatory.* The many different types are meant to give you several possible paths to an A. You can pick which one best suits you, but I have starred the ones that I view the most necessary. A more detailed description of each assessment is at the end of this document.

| Assessment Type | Description | Max Pts |
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| Daily Problem Sets* | Assigned after class, due before next class; 6 pts, checked for completion only | 126 pts |
| Weekly Problem Sets* | Two problems assigned after each class; 5 pts per problems; due the following week | 200 pts |
| Daily Participation* | 6 pts per day; see participation rubric | 126 pts |
| Discussion Board Posts | 10 pts per week; see rubric | 60 pts |
| Informal Presentations | 5 pts for sharing solution from Daily Problems or worksheets in class | 50 pts |
| Quizzes | 20 pts each; end of Weeks 2, 4, 5 | 60 pts |
| Midterm Exam* | Take-home portion with follow-up oral portion taking place at end of Week 3 | 200 pts |
| Final Exam* | Take-home portion with follow-up oral portion taking place on day of last class | 200 pts |

**Maximum Points Possible: 1022**

**Letter Grades:**
This information is the most subject to change throughout the course. What you should take away from this chart is that point totals will be converted to letter grades in a way that is *no stricter than* the following; I may widen the ranges or decrease the point ceilings as I see fit. But there will *not* be a curve and there will *not* be any rationing of the number of A's, B's, etc that are handed out.

A ........................901 to 1022 pts
B+ .......................851 to 900 pts
B .........................801 to 850 pts
C+ .......................751 to 800 pts
C .........................701 to 750 pts
D ........................601 to 700 pts
F .........................below 600 pts

# More Detailed Syllabus Items

**Course Materials:**
Most of the material in the course will be worksheets written by the instructor. In the first four weeks, we will reference the open-source textbook *Discrete Mathematics* by Oscar Levin. I chose this book for two reasons: (1) it is open-source and thus freely available in an interactive web version or a pdf version. And (2) it is intentionally written for an inquiry/discovery-based classroom. However, it does not contain all the material we will discuss, so we will occasionally supplement with excerpts from other texts, including *Discrete Mathematics with Ducks* by sarah-marie belcastro, *Combinatorics* by Joy Morris, and *Applied Combinatorics* by Fred Roberts and Barry Tesman. All materials will be accessible from our course website.

   After every class, any relevant notes and recordings will be posted on the course website.

**Class Format:**
   Here's how a typical class day will go:

1. Check in, discuss last night's assigned reading and problems. Ask and answer each other's questions. Opportunity for informal presentations of any particularly interesting problems.

2. Break into groups and work on today's worksheet via Google Docs.

3. Come back together as an entire class. Groups report their progress and have an opportunity to present any solutions. We may do some work all together on one Google doc.

4. Lather, rinse, repeat (2) and (3) as necessary.

5. At the end of class, we come back together to tie up any loose ends material-wise.

6. After class, I will post the assigned reading, daily problems that are due before the next class, and 2 or 3 of the weekly problem set problems. I will also post some discussion board prompts about the assigned reading.

**Assessments:**

Here's a description of all the different ways you can earn points towards your final grade. Not all of them are required! The ones with stars are highly recommended for helping you learn the material.

- Daily Practice Problems: After every class, you will be assigned practice problems and reading to review the new topics. These are due the following day before class and will inform our beginning-of-class discussions + posts on the Canvas discussion boards. DPs will be graded for completion but not correctness (as in, I'll glance to make sure you wrote some reasonable-looking words, not just nonsense). Each set of DPs will be worth 6 points. Upload a scan or a typed document to Canvas.

- Weekly Problem Sets: After every class, two-ish problems will be posted for the weekly pset. The entire set is due on Monday at noon. Each is worth 40 points. Upload a scan or a typed document to Canvas.

- Daily Participation: Every day, you will have the chance to earn up to 6 participation points. These points will be awarded based on your contributions to entire-class discussion and groupwork on worksheets. For more details, see the participation rubric.

- Discussion Board Posts: After every class, I will make posts on the discussion board about any of the reading topics or DP solutions that we did not have time to discuss in class. Each week, you can earn up to 10 points by responding to these discussion posts or by creating your own threads about any of the material. A more detailed rubric will appear on our website.

- Informal Presentations: Throughout every class, there will be a chance for individuals and groups to share their work with the rest of the class (e.g. on DPs, on the in-class worksheets, on recommended exercises from the reading). You can earn up to 5 points for each time you present, up to a maximum of 50 points.

- Quizzes: There will be three timed and proctored quizzes during class. They will be on basic concepts and be at or below the level of the daily problems. You will be told the date and time of the quiz in advance, as well as the topics it will cover. *You must have your webcam on during the entire quiz.* We will discuss quiz protocol in more detail during class.

- Exams: There will be one midterm exam and one final exam. Both will have an oral component and a take-home written component. The take-home problems will be similar in format to the weekly problem sets but will be due within a shorter timeframe. The oral exams will be 20-minute discussions scheduled individually, and questions will follow up on the take-home problems. Rubrics and review guides for both components will be discussed in class and posted on Canvas.

  As of now, the oral component for the midterm is scheduled for Friday, June 12, which is a day we do not have class. If you are unavailable that day, let me know so that we can work out a time.

  *The midterm and final exam are mandatory. No makeups will be given. If you miss either, you may be given an automatic F in the course - so please contact me if any issues arise that may prevent you from taking either.*

Participation Rubric:

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| 6 | Student comes to class prepared. Student makes thoughtful contributions that advance the conversation in class, but does not dominate conversation. Student shows interest in and respect for others' views and participates actively in small groups. |
| 5 | Student makes thoughtful contributions that advance the conversation when called upon and contributes occasionally without prompting. Student comes to class prepared, shows interest in and respect for others' views, and participates actively in small groups. |
| 4 | Student comes to class prepared but does not voluntarily contribute to discussions and gives abbreviated answers when called upon. Student shows interest in the discussion, participates in small groups, and takes good notes. Or, student arrives late to class or is unprepared, but is otherwise in the 5 or 6 category. Or, student participates in discussion but in a problematic way, such as by dominating discussion, making rambling or tangential contributions, continually interrupting with digressive questions, or bluffing when unprepared. |
| 3 | Student does not voluntarily contribute to discussions and gives only minimal answers when called upon. Student shows interest in the discussion and listens attentively. Or, student is logged on but not actually present for small portions of class, but when present is in the 5 or 6 category. |
| 2 | Student comes to class late or unprepared. Student seems on the margins of the class and sometimes has a negative effect on the participation of others. Or, student is logged on but not actually present for small portions of class, and when present is in a 3 or 4 category. |
| 1 | Student comes to class late or unprepared. Student has a negative effect on the participation of others. Student may be actually disruptive, overtly rude, or condescending. Or, student is not present for large portions of class. |