Combinatorics
Loyola University Chicago – Math/Comp 418.001 – Spring 2015
Course Syllabus & Ground Rules

Course Details

CLASS MEETINGS: Dumbach Hall, Room 229; MWF 10:25–11:15 a.m.
LAB: Dumbach, Rm 124, Thu. 9:00 a.m.–10:30 a.m.
OFFICE HOURS: BVM Hall, Rm 507, Tues. 1:00–2:30 p.m.; Changes will be posted on my webpage.

FINAL EXAM:
• when: Monday, April 27, 9:00–11:00 a.m.
• format: cumulative, closed-book, closed-notes, approved calculators allowed.
• rescheduling: requests granted for extenuating circumstances must be made through Dean’s office.


Instructor Coordinates
Dr. Aaron Lauve
BVM Hall, Room 507     lauve@math.luc.edu
773.508.3727           www.math.luc.edu/~lauve

Contact
Communication via Piazza is strongly encouraged. Emails to me should include 418 in the subject line.
I will make every effort to reply within 48 hours.

Course Web Page(s)
There are several. Section-specific material and announcements will be posted to one of:
• piazza.com (a discussion forum; will be used extensively)
• cloud.sagemath.com (a site for computation and composition)
• webpages.math.luc.edu/~lauve/318.html (mainly for archiving posts from elsewhere)
• sakai.luc.edu/portal/site/MATH 318 001 2438 1152 (mainly for grades and accessing Piazza)

Important Dates
In-term exam dates are tentative. Scheduled dates will be announced at least a week in advance.

Exams: March 11, April 13
No Class: 1/9, 3/2–3/6, 4/3, 4/6

The last date to drop with a record of “W” is March 23.

Course Summary
SYLLABUS. Chapters 1–10 of the text, with additional topics chosen from 11–20 as times allows. Topics: Permutations, binomial theorem, compositions, partitions, Stirling numbers, Catalan numbers, graphs, trees, Eulerian walks, Hamiltonian cycles, electrical networks, graph colorings, chromatic polynomials, combinatorial algorithms, optimization, among others. Techniques: Pigeon-hole principle, mathematical induction, inclusion-exclusion principle, recurrence relations, generating functions, matrix-tree theorem, Polya theory, Ramsey theory, pattern avoidance, probabilistic methods, partial orders, combinatorial algorithms, among others.
PREREQUISITES. Math 313 or Comp 211.
Technology
A TI-84+ or equivalent graphing calculator is optional for this course. Use of any calculator more advanced than this will not be allowed during exams.

We will use Sage and/or Mathematica throughout the semester. Sage is available for free, but is a bit of a pain to install under Windows... best to stick with the cloud version (cloud.sagemath.com). Get Mathematica for free here: myits.luc.edu/mathematica.

Course Components
Exams (3×20%). There will be two in-term exams and a final exam. The final exam will be cumulative.

Presentation (10%). You will deliver one 50 minute lecture on a topic of your choosing (and my approval). See Page 4 for details.

Homework (10% + 20%). Homework will come in two flavors: “warm-ups” and “problems.” They should be turned in at the start of class, separately, and stapled if appropriate.

- Warm-ups (10%): Generally, a few of these will be due each class period. These exercises already have solutions printed in the text. Each of your solutions of this type will have two portions: (1) a self-grade of ✓−, ✓, or ✓+, with ✓+ given for mostly perfect work; (2) a short sentence of the form: “I got it myself,” “I made some progress, but gave up and looked at the solution,” “I looked at the solution and still don’t get it,” etc. (N.B.: This is an ideal chance for you to ask specific questions about material from the course, for me to address either in class, on Piazza, or during office hours.) To compute your final grade, the warm-up scores will be recorded as follows: absent (0%), ✓− (70%), ✓ (85%), ✓+ (100%). Your top 10 scores will be kept.

- Problems (20%): These will comprise more traditional “homework assignments,” due nearly every week. Assignments should be submitted in .tex and .pdf format to our Sage cloud project (cloud.sagemath.com). See Page 5 for details. Each assignment will be graded out of ten points. Each solution here must be presented carefully, using complete sentences with correct English and mathematical grammar and punctuation. (If a number or one-word answer is asked for, briefly illustrate the ideas/computations behind your answer.) I will generally grade three of the problems carefully, giving each a score between 0 and 3. The final point: I reserve the right to subtract one point for not following directions. (Reread preceding sentences.)

Course Grade
Some curving away from the standard scale (91/A – 81/B – 71/C) may be necessary, but is not expected.

Academic Integrity
The Academic Standards and Regulations web page outlines the definition and ramifications of cheating at Loyola University (the “Academic Integrity” link) as well as the resources available to you should you be accused of cheating (the “Academic Grievance Procedure” link). By attending this course, you agree to uphold the high standards of Loyola. If you are found cheating on an exam, you will receive a zero (0) for the exam and the incident will be reported to your academic dean and recorded in your permanent file.

Disability Services
The Americans with Disabilities Act (ADA) is a federal statute that provides comprehensive civil rights protection for persons with disabilities. It requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring accommodation, please contact the SSWD office: in the Sullivan Center, suite 117, phone 773.508.3700, fax 773.508.3810, or online at www.luc.edu/sswd/.
Getting Help
You are expected to read and comprehend much beyond what is covered in lecture. Use your book well: learn the definitions and theorems; read and understand the proofs; read the examples’ solutions.

Please, SEEK HELP if you are falling behind. Form study groups, work lots of problems, come to office hours, schedule another time to meet, find a tutor or online resources (e.g., ocw.mit.edu/), etc.

Escape Routes
At any time, even after the last date for W-dropping the course, students who are experiencing medical or personal difficulties should not hesitate to consult their advisors or the Student Development Office or their dean. Don’t allow yourself to be overwhelmed by such problems; Loyola has resource persons who may be able to help you (www.luc.edu/wellness  www.luc.edu/bct)

Course Etiquette
Please set your cell phones to “silent” upon entering class; phone noises are a distraction to everyone. Likewise, talking with your neighbor while I am lecturing or leading a discussion is unacceptable behavior. Reading newspapers, surfing the web, or texting your friends is impolite and is a distraction to your instructor; please find a better use for your time.

Finally, and most importantly, respect for others is stressed above all else; please allow me the first chance to answer your fellow students’ questions. I expect everybody to participate in class discussions, but that begins by fostering an environment where we do not hesitate to ask our questions.

Odds and Ends
MAKE-UP QUIZZES/EXAMS. Make-up quizzes and exams will only be given for real emergencies, documented illnesses, or university-sponsored events. Students must notify me of their absence prior to the next regularly scheduled class (and before the examination if possible). If a student fails to appear for a make-up at the mutually arranged time, no further opportunities will be extended. Failure to contact me as stated above or inability to sufficiently document the extenuating circumstances of students’ absence will result in a grade of zero on the examination.

SAGE/LATEX ON THE CLOUD. You are responsible for creating an account on cloud.sagemath.com, after which time I will invite you to join our class “project.” (Please do this as soon as possible, and please use your Loyola email to register; this can always be changed later.)

LOYOLA EMAIL. On the occasion that I need to contact students outside of class, this is the only sensible way to proceed. If you would rather not use your @luc.edu email account, . . . tough! You should receive a “WELCOME” email from me on the Sunday before the second week of class. If you do not receive this message, please let me know as soon as possible.

ACCESSING PIAZZA. Look for the “Piazza” button on the left panel under your MATH 318/418 course in Sakai, or head to piazza.com/luc/spring2015/math318001sp15/home directly. I expect that we will all be spending A LOT of time here: asking questions, answering questions, browsing through posted sample exams, pointing to sage/latex code on the cloud you’re needing help with, etc.

Samples of successful Piazza forums are available for browsing (piazza.com/class/gw9jakygzvs616).1 Piazza Apps for smart phones or tablets are available (Apple and Android). I will enroll you in the Piazza forum. Let me know if you cannot get access it.

MORE MATH. The department maintains a BLOG (blogs.luc.edu/mathstats) and a FACEBOOK page (www.facebook.com/lucmathstats) that will contain interesting math/stats related tidbits throughout the semester. Feel free to join the conversation. (Indeed, if there is a topic that you’d like to see discussed, send an email to webadmin@math.luc.edu and we’ll try to get a post up about it.)

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1It will complain, “Action not allowed for unknown users,” but you can get around it. Just click “OK.”
For 10% of their final grade, graduate students will deliver a 50 minute lecture to the class, provide a one to two page handout for the class (summarizing the lecture), and develop a short homework assignment for the class.

**Handout & Lecture**

Possible Topics. I will cover Chapters 1–10 carefully, and 18 as time permits. Any material from the remaining chapters is fair game. Alternatively, you may find something entirely different that interests you. (Obviously, it should be combinatorics related; I can help with this if you’d like.) **N.B.** Students like applications.

Calendar. You will schedule an appointment to talk with me about your idea for a presentation. This appointment should take place by **February 13**. The following slots are available. They will be assigned on a first-come, first-served basis. Email me your first and second choice at any point after **6:00 a.m., Wednesday, January 21**.

<table>
<thead>
<tr>
<th>Available Presentation Dates</th>
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<tbody>
<tr>
<td>Mon.</td>
</tr>
<tr>
<td>January</td>
</tr>
<tr>
<td>February</td>
</tr>
<tr>
<td>March</td>
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<tr>
<td>April</td>
</tr>
</tbody>
</table>

Two days before your presentation, you must submit a sample handout for my critique and give me an outline of what you plan to cover during your lecture.

**Homework** If you have chosen to present material from the textbook, then choose two or three problems from each of the “regular” and “supplemental” exercises that you think are appropriate. Otherwise, just cook up something analogous (or borrow, from an online search). Post these on Piazza for all to see. It is very likely that some of these questions fill find their way onto the final exam. Be sure they are neither too difficult nor too off-topic.

**Grading**

Your grade will be out of 20 points.

- **Handout:** One point will be subtracted for each (english) spelling or grammar mistake. Two points will be subtracted for each mathematical mistake.

- **Presentation:** Five points will be subtracted if there is judged to be too much math during your lecture. Ten points will be subtracted if there is judged to be an insufficient amount of math during your lecture. (Note: this “math” is *not* meant to include only “equations” and “formulas” but “mathematical ideas” as well.) Two points each will be subtracted if presenter is viewed as: not well-organized; unsure of the material; having exceptionally poor boardwork; not making an effort to connect to audience (e.g., projecting voice, occasional eye-contact or requests for feedback); etc.

- **Homework:** Failure to develop a homework assignment for the class will result in a five point deduction.
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Workshop Write-ups: Guidelines & Hints

Homework assignments will be typeset and submitted (in .tex and .pdf format) to our cloud project (cloud.sagemath.com). There are many Introduction to LaTeX guides on the web. In the past, I have turned to one by Tobias Oetiker fairly often. (Ask me if you want a copy.) These days, I just google a phrase like “latex square root” or “latex include graphics” to more quickly find what I need.

For each assignment, one student will be asked to rework their solutions to near perfection—with my assistance—so that they may be shared as a resource with the rest of the class (318 and 418 students). As mentioned in the groundrules document, this means presentation is important to, not just mathematical correctness. The “volunteer” student’s assignment will be re-scored, based on the second iteration. The due-date for this second iteration will be three class periods after the original assignment due date.

Typesetting help. I have provided a sample LaTeX document in the “latex demos” folder in our Sage cloud project that you should use as a template. Don’t hesitate to ask the Piazza forum—or me!—for help if you cannot figure out how to do something you’d like to do.

Since you may never have been graded on how you present your ideas in math, here are some guidelines.

Look at one of the examples in the book. The author begins by writing a statement of the problem. He uses complete English sentences. He explains those steps which are not obvious to a beginning combinatorics student (and doesn’t explain the steps that are). If there is a graph or figure, he labels it, and he discusses what can be deduced from the graph in the context of the example. At the end, he states the conclusion.

Don’t be discouraged if your initial write-ups receive low grades because of poor exposition. You will improve. Because mathematics is used to solve problems and explain the solutions to others, writing clear solutions is a good habit to develop. Creating a good write-up forces you to think more carefully about how you did the problem—and therefore helps you learn combinatorics.

Precision, part I. Here is a joke:

A mathematician, a physicist, and an engineer are visiting Scotland for the first time and riding through the countryside by train. “Oh!” the engineer says upon seeing a sheep on a hill, “the sheep in Scotland are black!” The physicists chimes in, “no, no, that sheep is black.” “Well,” the mathematician adds, “that side of that sheep is black.”

It may not be very funny to you, but it is because you don’t know many mathematicians yet. Like physicists and engineers, we develop tools and ideas to solve problems. Unlike these individuals, we like to know things for certain and only claim things we certainly know. Precision is our bread-and-butter. We take care to be very precise—both with our language and with our reasoning. This is reflected in our grammar. Consider the following example:

\[ \pi = 3.14159 \quad \text{FALSE!} \quad \pi \approx 3.14159 \quad \text{TRUE.} \]

Take Away: Don’t say things that aren’t true when solving a mathematical problem.

Consistency. Regarding symbol choices, if you name the hypotenuse of a triangle \( C \) at some point, do not later on refer to it as \( c \) (or \( x! \)).

Take Away: Give every quantity one name (symbol) and one name only.
Sentences (Symbols, part I). When reducing a mathematical expression, use the “=” sign only when two things are equal, and the “⇒” sign only when the second statement is a direct consequence of the first:

<table>
<thead>
<tr>
<th>Good Uses</th>
<th>Bad Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n^2 + n^2 )</td>
<td>( n^2 + n^2 )</td>
</tr>
<tr>
<td>( = 2n^2 )</td>
<td>( \frac{2n^2}{\cdot} )</td>
</tr>
</tbody>
</table>

\( 7x = 3 \implies x = \frac{3}{7} \)

Here are two English-language sentence analogs of the bad uses above:

- Apples and apples, two apples. Alexis is the name of the cat is named sophie.

Take Away: *Practice good mathematical grammar; know what the elements of your sentence mean.*

Symbols, part II. Mathematicians invented algebra so we wouldn’t have to write sentences like this:

If thou art diligent and wise, O stranger, compute the **number of cattle of the Sun**, who once upon a time grazed on the fields of the Thrinacian isle of Sicily, divided into four herds of different colours, one **milk white**, another a **glossy black**, a third **yellow** and the last **dappled**. In each herd were bulls, mighty in number according to these proportions: Understand, stranger, that the **white bulls were equal to a half and a third of the black together with the whole of the yellow**, while the **black were equal to the fourth part of the dappled and a fifth, together with, once more, the whole of the yellow**. . . . But come, understand also all these conditions regarding the cattle of the Sun. When the **white bulls mingled their number with the black, they stood firm, equal in depth and breadth**, and the plains of Thrinacia, stretching far in all ways, were filled with their multitude. . . . —Archimedes, 200 B.C.

Full text available [www.math.nyu.edu/~crorres/Archimedes/Cattle/Statement.html](http://www.math.nyu.edu/~crorres/Archimedes/Cattle/Statement.html)

Instead we write something like,

Let \( W, B, Y, D \) be the number of cattle coloured white, black, yellow, and dappled, respectively. Let \( w, b, y, d \) be the number of bull in each herd. The numbers satisfy:

\[
\begin{align*}
    w &= \frac{5}{6} b + y \\
    b &= \frac{9}{20} d + y \\
    & \vdots \\
    w + b &= N^2 \\
    & \vdots
\end{align*}
\]

where \( N \) is some positive integer.

Take Away: *If you have a quantity you’re considering, don’t be afraid to give it a variable name if it will help with the clarity of your exposition.* (With that said, **PLEASE** don’t leave variables undefined, it is sloppy and confusing... though rarely as confusing as the passage above.)

Catching Your Breath. The language of mathematics packs a lot of information into a small space. This makes reading a half-page of equations fairly difficult. The conscientious writer recognizes this.

Take Away: *Pause from time to time and write a sentence.* That sentence should **tell the reader where he is heading NEXT**, not what he just slogged through.

Clarity, part I. Note the use of \( Y \) and \( y \) in the cattle problem above. These are related quantities so they are given related names. Also, they are **codes** in the sense that, as best as possible, the symbols chosen reflect something essential about what they represent (“yellow” things). Similarly, a formula for the volume of a box in terms of its height should begin “\( V(h) = \ldots \)” not “\( f(x) = \ldots \)”

Take Away: *Reserve similar symbols for related quantities and choose your symbols well.*
Clarity, part II  How would you feel listening to the news if every time someone mentioned Vladimir Putin, they suffixed it with the phrase “the nefarious KGB agent turned president of Russia who once seduced George W. Bush using only his eyes?” Pretty insulting right? We all know this, get to the point! Similarly, when using some (well-labeled) figure to setup a related-rates problem, don’t write

$$\tan \theta = \frac{\text{opposite}}{\text{adjacent}} = \frac{y}{h}.$$ 

Omit the middle step; we all know this and saying it just detracts from the readability of your presentation. Another example: instead of writing

\[
32\times^7(x + 2)^3 = \frac{6(x + 2)(x - 2)}{x^2} \quad \text{clear denominator}
\]
\[
32\times^9(x + 2)^3 = 6(x + 2)(x - 2) \quad \text{cancel the 2}
\]
\[
16\times^9(x + 2)^3 = 3(x + 2)(x - 2) \quad \text{cancel a factor of } (x + 2)
\]
\[
16\times^9(x + 2)^2 = 3(x - 2),
\]

simply write

we have

\[
32\times^7(x + 2)^3 = 6\frac{(x + 2)(x - 2)}{x^2}
\]
\[
16\times^9(x + 2)^2 = 3(x - 2).
\]

Or, if you really feel like the reader won’t follow you, write

we have

\[
32\times^7(x + 2)^3 = 6\frac{(x + 2)(x - 2)}{x^2}
\]

or, after clearing denominator and canceling like terms,

\[
16\times^9(x + 2)^2 = 3(x - 2).
\]

**Take Away:** *Clutter does not engender clarity.*