# **COMP2804: Discrete Structures**

#### Instructor: Pat Morin, 5177 HP, morin@scs.carleton.ca

Jump to Lecture Topics

#### **Learning Modality**

Since Carleton University administration has decided to suspend in-person classes until at least January 31, 2022, I will be using lectures I recorded during my last offering of this class, in Fall 2020 until at least February. Students may watch them at their own leisure.

I will have (online) office hours on Tuesday at 9:00–10:00 and 16:00–17:00 but these will only be for students who have questions about the material.

All lecture videos are available below. I will make an effort to integrate the assignments with lectures so that each question includes a link to the relevant lecture. The first two parts of Assignment 1 (which are based on Lectures 1 and 2) are now available.

#### **Course Objectives**

A second course that is designed to give students a basic understanding of Discrete Mathematics and its role in Computer Science. Computers handle discrete data rather than continuous data. The course presents an overview of some of the major theoretical concepts needed to analyze this type of data.

#### **Office Hours Schedule**

We will have lots of office hours during which TAs or myself can help you with studying course material and offer you guidance for assignments.

Day	Time	Staff	
Monday	10:00-11:00	<u>Haonan Sun</u>	
Monday	11:00-12:00	<u>Haonan Sun</u>	
Monday	13:00-14:00	Tom Mai	
Monday	14:00-15:00	Tom Mai	
Monday	15:00-17:00	Thinh Truong	
Monday	16:00 - 18:00	Jimmy Woo	
Tuesday	9:00-10:00	Pat Morin	
Tuesday	11:00-13:00	Alexa de Grandmont	
Tuesday	13:30 - 15:30	Félix Cardinal Tremblay	
Tuesday	14:00-16:00	Jason Dunn	
Tuesday	16:00-17:00	Pat Morin	
Wednesday	12:30 -14:30	Mehrnoosh Javarsineh	
Wednesday	10:30 - 12:30	<u>Xuejun Han</u>	
Wednesday	14:30-16:30	Tejash Patel	
Thursday	9:00 - 10:00	<u>Alma Arevalo</u>	
Thursday	11:00 - 12:00	David Katz	
Thursday	12:00-14:00	Masoud Khairi Atani	

To meet with one of these people during their office hours just click on their name to open a Google Meet or Zoom link.

#### **Important Dates**

Sunday	Jan 30	23:55	Assignment 1 due (in Brightspace)
Sunday	Feb 13	23:55	Assignment 2 due (in Brightspace)
Thursday	Feb 17	16:00-17:30	Mid-term evaluation/exam
Sunday	Mar 20	23:55	Assignment 3 due (in Brightspace)
Sunday	Apr 10	23:55	Assignment 4 due (in Brightspace)

**Note:** If you are enrolled in Sections B or D and have a conflict with the midterm exam time, then please contact me as soon as possible. You will be allowed to write the midterm exam on the same day at 8:30-10:00 (am).

#### Assignments

Assignments will be posted here as they become available.

• The first two questions in Assignment 1 are now available.

If you are looking for an example of excellent assignment solutions, here are the sample solutions (pdf) (tex) for Assignment 1 Fall 2019

Please note the following rules and requirements about assignments:

- Late assignments will not be accepted.
- Assignments emailed to me will not be accepted.
- I will not respond to emails sent shortly before or after assignment deadlines asking for exceptions to the preceding two rules.
- You can type your solutions, or write them by hand and scan them (for example, using a scan app on your phone or using a real scanner).
- Solutions written-up in LaTeX are preferred, but not strictly required. In case you want to learn LaTeX, here is a tutorial. Learning LaTeX is a useful exercise, since many programs (including Microsoft Word) now use LaTeX for typesetting formulas.
- Each assignment must be submitted as one single PDF file through Brightspace.

#### Exams

The midterm and final exams will take place online using Brightspace.

Here are exams for previous offerings of this course (for study purposes).

Here you can use use previous exams as practice exams.

#### **Academic Integrity**

As of 2020, there are new penalties in place for academic integrity violations. These will be issued by the Associate Dean (Undergraduate Affairs) of Science to students who copy, in whole or in part, work they submit for assignments.

- First offence: F in the course
- Second offence: One-year suspension from program
- Third offence: Expulsion from the University

These are standard penalties. More-severe penalties will be applied in cases of egregious offences. Failure to inform yourself of the expectations regarding academic integrity is not a valid excuse for violations of the policy. When in doubt, ASK your instructor or TA.

More information can be found at the ODS website

## **Grading Scheme**

This course will use the following grading scheme.

Assignments 25% Mid-term exam 25% Final exam 50%

If you fail to submit an assignment and provide me with a valid reason then I will shift the weight of the missed assignment onto the remaining assignments. If you fail to attend the midterm exam and provide me with a valid reason then I will shift the weight of the midterm exam onto the final exam.

#### Textbooks

We will be using the following free (*libre* and *gratis*) textbooks. The first one is the primary textbook for this course. The second contains supplementary and background material:

- Michiel Smid. Discrete Structures for Computer Science: Counting, Recursion, and Probability, 2019.
- Eric Lehman, F Thomson Leighton, and Albert R Meyer. Mathematics for Computer Science, 2018

#### **Accommodation Statement**

Carleton University is committed to providing access to the educational experience in order to promote academic accessibility for all individuals. Here is information on how to apply for academic accommodation.

## **Lecture topics**

You should already be familiar with the following topics from COMP 1805: basic logical reasoning, sets and functions, proof strategies (direct proof, proof by contradiction, proof by induction), Sigma-notation for summations, basic graph theory, Big-Oh, Big-Omega, Big-Theta. You may take a look at Chapter 2 of the textbook and do some of the exercises at the end of that chapter. Review the relevant parts of Lehman et al if you are still struggling.

The following schedule is from the Winter 2020 offering of COMP2804. Dates, videos, and topics will be updated as the course progresses.

Note: The entire collection of Fall 2020 lectures is available as a YouTube playlist

**Note:** If you want exactly the same material from a different lecturer, you can watch Michiel Smid's videos and I won't be offended.

- Lecture 1: Introduction
  - Course overview.
  - Chapter 1 in the textbook: Ramsey Theory, Quick-Sort, Sperner's Theorem.

COMP2804: Sep 9, 202	20	



- Lecture 2: Counting (1)
  - Product Rule, Section 3.1

COMP2804: September 14, 2020



- Lecture 3: Counting (2)
  - Bijection Rule, Complement Rule, Sum Rule, The Principle of Inclusion-Exclusion, Sections 3.2, 3.3, 3.4, 3.5.



- Lecture 4: Counting (3)
  - Binomial coefficients, Newton's Binomial Theorem, combinatorial proofs, Vandermonde's Identity, Pascal's Triangle, Sections 3.6, 3.7.



- Lecture 5: Counting (4)
  - Sections 3.7 and 3.8.
  - How many strings can be obtained from SUCCESS? Section 3.9.1

• Counting solutions of linear (in)equalities, Section 3.9.2



- Lecture 6: Pigeonhole Principle
  - Simon's Drinking Problem, Section 3.10.1
  - $\circ\;$  Every (n+1)-element subset of  $\{1,\ldots,2n\}$  contains a divisible pair, Section 3.10.2
  - The Erdös-Szekeres Theorem

• Infinity of primes, Section 3.10.4



- Fibonacci numbers, Section 4.2.
- $\circ~~$  Proof that  $f_n=(arphi^n-\psi^n)/\sqrt{5}$
- Counting 00-free bitstrings
- Counting *aa*-free strings over  $\{a, b, c\}$
- Counting *ab*-free strings over  $\{a, b, c\}$



- Lecture 8: Recursion (2)
  - Exercise 4.38

• Euclid's algorithm, Section 4.5. (gcd.py)



- Lecture 9: Recursion (3)
  - MergeSort, Section 4.6.

COMP2804: October 7, 2020	

- Lecture 10: Randomization and probability
  - Anonymous broadcasting: Dining Cryptographers, Section 5.1.
  - Probability Theory: Probability spaces, sample spaces, probability functions, Section 5.2.

• Basic rules of probability, Section 5.3.



- Lecture 11 Watch on your own:
  - Midterm review using the Fall 2015 Midterm

Feb 11, 2020	

- Lecture 12: Two surprising examples
  - The Birthday Paradox (section 5.5)

• Find the big box (section 5.6)



- Oct 21: Midterm exam on cuLearn
- Lecture 13:
  - Find Patti: The O'Reilley Triplets Problem, Section 5.7.
  - Conditional probability, Section 5.8.
  - Anil's kids, Exercise 5.40, the remarkable set B.



- Lecture 14:
  - Independent events, Section 5.11.

• Exercise 5.81: Annie, Boris, and Charlie write an exam.



- Lecture 15:
  - Section 5.12, in particular, the probability of a circuit failing, Section 5.12.3.
  - Choosing a random line in a file, Section 5.13.



- Lecture 16:
  - Infinite probability spaces, Section 5.15, Exercises 5.85 and 5.91.

•

• The law of total probability



- Random variables, Section 6.1.
- Independent random variables, Section 6.2.
- Expected value, Section 6.4.
- Linearity of expectation, Section 6.5.



- Lecture 18: (—)
  - Indicator random variables, Section 6.8, Exercise 6.57.
  - Expected running time of Insertion-Sort, Section 6.9
  - Largest elements in prefixes of random permutations, Section 6.8.2.



- Lecture 19: (—)
  - Quick-Sort and random binary search trees, Section 6.10 and Section 7.1 of ODS.



- Lecture 20:
  - Geometric distribution and its expected value, Section 6.6, Exercise 6.35.
  - Exercise 6.59 (the Coupon Collector's Problem)

• Binomial distribution and its expected value, Section 6.7.



- Lecture 21: Group testing
  - Single pooling and multiple pooling

COMP2804: November 30, 2020

- Lecture 22: The Probabilistic Method
  - Finding large bipartite subgraphs, Section 7.1
  - Graphs with no large clique or independent set, Section 7.2

• Jaccard distance satisfies triangle inequality, Section 7.4



- Lecture 23: Planar graphs and crossing lemma (Last class!)
  - Planar graphs, Section 7.5.1

• The crossing lemma, Section 7.5.2



- Final-exam review (no live class)
  - Solving the Winter 2019 Final Exam

Dec 3, 2019	

• Solving questions 19-25 on the Winter 2019 Final Exam



