

Discrete Mathematics

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discrete mathematics is the mathematics of structures that come in separate, countable pieces — integers, truth values, finite sets, graphs — as opposed to the smooth continuum of analysis. no limits, no derivatives; instead: induction, counting, and exact structure. it is the native mathematics of computation — every data structure, algorithm, database query and cryptographic protocol below this page is discrete mathematics wearing a lab coat (Epp, Susanna S., 2019).

the working test: if ε - δ arguments feel natural on it, it is not discrete

the field is less a single theory than a federation of subfields sharing a toolkit (induction, pigeonhole, bijection, recurrence). the map:

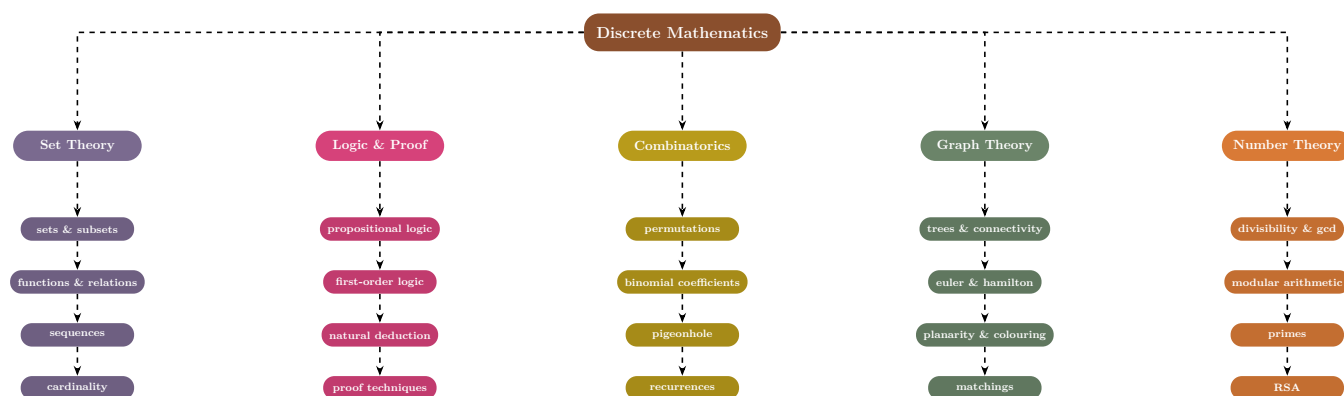


Figure 1: the discrete mathematics federation: five subfields, one toolkit. each branch is a child page of this one.

1 the subfields

1.1 sets, functions and sequences

the substrate everything else is written in. sets and subsets, cartesian products, the algebra of union/intersection/complement (de morgan's laws live here), functions as special relations, injections/surjections/bijections, and sequences as functions on $\mathbb{N}$. cardinality is where the subject briefly touches the infinite: countable versus uncountable, and cantor's diagonal argument. this page already has developed notes — start there.

1.2 logic

the rules of the game. propositional logic (connectives, truth tables, normal forms, satisfiability), first-order logic (quantifiers and models), natural deduction, and the proof techniques — direct, contrapositive, contradiction, induction — that the rest of mathematics quietly assumes. also where SAT solving and the soundness/completeness theorems live.

1.3 combinatorics

the art of counting without listing. permutations and combinations, the binomial theorem, pigeonhole, inclusion-exclusion, and recurrence relations (fibonacci, towers of hanoi, the master theorem's natural habitat). generating functions are the power tool: they turn counting problems into algebra (Graham, Ronald L. and Knuth, Donald E. and Patashnik, Oren, 1994).

1.4 graph theory

dots and lines, taken seriously. degree and the handshake lemma, trees and their five equivalent characterisations, eulerian and hamiltonian traversals, planarity and euler's formula $V - E + F = 2$, colouring, and matchings via hall's theorem. the algorithmic side (BFS, DFS, shortest paths, spanning trees) lives under [data structures & algorithms](#).

1.5 number theory

the integers under a microscope. divisibility and the euclidean algorithm, bezout's identity, unique factorisation, modular arithmetic and the chinese remainder theorem, fermat's little theorem and euler's totient — culminating in RSA, where 2300 years of “useless” mathematics turned into the lock on your bank account.

2 adjacent topics

three topics from the classical discrete-maths syllabus live elsewhere in this wiki or await their own pages:

- **recurrence relations** — set up in combinatorics; solved asymptotically by the master theorem over in [classical algorithms](#).
- **finite automata & formal languages** — really theory of computation; they belong with the computer-science pages.
- **discrete probability** — counting with weights; the combinatorics page is the prerequisite.

3 theorem index

the headline results, and where each one lives:

theorem	home
de morgan's laws	sets (set form), logic (propositional form)
pigeonhole principle	combinatorics
inclusion-exclusion principle	combinatorics
handshake lemma	graph theory
euler's formula $V - E + F = 2$	graph theory
chinese remainder theorem	number theory
fermat's little theorem	number theory
RSA correctness (via euler's theorem)	number theory
master theorem	classical algorithms

4 how to read this section

the dependency order is roughly the diagram left to right: sets and logic are pre-requisites for everything, combinatorics and graph theory are independent of each other, and number theory only needs induction and the well-ordering principle. epp (Epp, Susanna S., 2019) covers the whole federation at undergraduate pace; graham, knuth and patashnik (Graham, Ronald L. and Knuth, Donald E. and Patashnik, Oren, 1994) is the deeper cut on the counting and number-theoretic side.

*epp is the gentle on-ramp;
concrete mathematics is the
gym*

5 see also

- [data structures & algorithms](#) — discrete mathematics, executed
- [classical algorithms](#) — where the recurrences get solved

references

Epp, Susanna S. (2019). *Discrete Mathematics with Applications*, Cengage Learning.

Graham, Ronald L. and Knuth, Donald E. and Patashnik, Oren (1994). *Concrete Mathematics: A Foundation for Computer Science*, Addison-Wesley.