Category theory I. *Initial/final objects, (co)products.*

- Motivation and definitions.

Groups. *S_n, A_n, $GL(n, \mathbf{F}_p)$, $GL(n, \mathbf{R})$ U_n, free groups, p-groups.*

- Definitions, normal subgroups, actions, nilpotent, solvable, simple, extensions, semi-direct product, composition series, presentation, Cayley graphs.
- Isomorphism theorems, Lagrange, Jordan-Hölder, Sylow.

Rings and Modules. *Polynomial rings, power series, p-adics.*

- Definitions, ideals, integral domains, prime and maximal ideals, Noetherian rings, complexes, homology, exact sequences.
- Isomorphism theorems, snake lemma, Hilbert's basis theorem.

Factorization in rings. *Irreducibilty in polynomial rings, Eisenstein's criterion, Gaussian integers.*

- Prime and irreducible elements, PID's, UFD's, Euclidean domains.
- Polynomial rings over UFD's are UFD's, Chinese Remainder Theorem.

Linear algebra I. *Bases and dimension, torsion, presentations and resolutions, characteristic polynomials, canonical forms.*

- Classification of finitely generated modules over PID's, Cayley-Hamilton, Jordan canonical form.

Fields. *Rational functions, finite fields, cyclotomic fields, applications of Galois theory (e.g. solvability of polynomials).*

- Definitions, simple extensions, finite and algebraic extensions, algebraic closure, splitting field, normal and separable extensions, Galois extensions.
- Existence of algebraic closure, Galois correspondence.

Category theory II. *Functors, natural transformation, exact functors, adjoint functors, limits, colimits (and filtered colimits), relation with universal properties.*

- Preservation of limits/colimits by adjoint functors.

Linear algebra II. *Tensor product, extension of scalars, symmetric and exterior powers, flat modules, projective modules, injective modules, Tor, Ext.*

- A free module is projective. A projective module is flat. Existence and homotopy uniqueness of projective and injective resolutions of modules.

Commutative algebra. *Localization of rings and modules, integral homomorphism of rings, integral closure, normal domains, spectra of rings and Zariski topology, transcendental field exensions, Krull dimension.*

- Nakayama's Lemma, Going-up and Going-down, Noether normalization, Hilbert and Zariski Nullstellensatz, (transcendence degree equals Krull dimension for finitely generated algebras over a field).

Homological algebra. *Additive category, abelian category, complexes, homotopy category of complexes, derived category, derived functors and cohomology, spectral sequence.*

Noncommutative algebra. *Structure of semisimple rings, Jacobson radical, Wedderburn Theorem, division algebras.*