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Basics of constructive algebraic number theory

1.1. Introduction

Algebraic numbers are defined as complex numbers x satisfying an *algebraic equation* of the form

$$a_0x^n + a_1x^{n-1} + \dots + a_n = 0 \quad (n \in \mathbb{N}; a_i \in \mathbb{Z} \ (0 \leq i \leq n), a_0 \neq 0). \quad (1.1)$$

We are not satisfied merely with the existence of algebraic numbers such as, for instance,

- the natural numbers $1, 2, 3, \dots (\mathbb{N})$,
- rational integers $0, \pm 1, \pm 2, \dots (\mathbb{Z})$,
- rational numbers $0, \pm 1, \pm \frac{1}{2}, \pm 2, \pm \frac{1}{3}, \pm \frac{2}{3}, \pm 3, \dots (\mathbb{Q})$,
- surds $r^{1/n}$ ($r \in \mathbb{Q}, n \in \mathbb{N}, n \geq 2$);

we also inspect the means of constructing them. For this purpose we employ *algorithms*.

We shall not endeavour to give a definition of algorithms in terms of mathematical logics. Our algorithms consist of a stated input, a stated output and a finite number of well-defined steps. The input and output will usually be rational integers and quantities (such as fractions, algebraic integers, integral matrices) derived from rational integers by stated rules. The steps are numbered from 1 to n ($n \in \mathbb{N}$). They consist of statements which use the known data (from the input, or already calculated) to obtain new data by unique mathematical rules. The steps are usually carried out one after the other. But there can also be a jump from step i to step k ($k \neq i + 1$) depending on the value of some data. The mathematical rules for the computation of new data and for the decision, whether a jump occurs, are fixed throughout the whole algorithm. During the execution of the algorithm a certain step i ($1 \leq i \leq n$) may be carried out several times, say $N(i)$ times, depending on the input data. However, all numbers $N(i)$ ($1 \leq i \leq n$) must be finite.

Algorithmic Algebraic Number Theory

**Florian Hess, Sebastian Pauli, Michael
Pohst**



Algorithmic Algebraic Number Theory:

Algorithmic Algebraic Number Theory M. Pohst, H. Zassenhaus, 1997-09-25 Now in paperback this classic book is addressed to all lovers of number theory On the one hand it gives a comprehensive introduction to constructive algebraic number theory and is therefore especially suited as a textbook for a course on that subject On the other hand many parts go beyond an introduction and make the user familiar with recent research in the field For experimental number theoreticians new methods are developed and new results are obtained which are of great importance for them Both computer scientists interested in higher arithmetic and those teaching algebraic number theory will find the book of value Algorithmic Algebraic Number Theory M. Pohst, 1989

Algorithmic Algebra and Number Theory B. Heinrich Matzat, Gert-Martin Greuel, Gerhard Hiss, 2012-12-06 This book contains 22 lectures presented at the final conference of the German research program Schwerpunktprogramm Algorithmic Number Theory and Algebra 1991-1997 sponsored by the Deutsche Forschungsgemeinschaft The purpose of this research program and of the meeting was to bring together developers of computer algebra software and researchers using computational methods to gain insight into experimental problems and theoretical questions in algebra and number theory The book gives an overview on algorithmic methods and on results obtained during this period This includes survey articles on the main research projects within the program algorithmic number theory emphasizing class field theory constructive Galois theory computational aspects of modular forms and of Drinfeld modules computational algebraic geometry including real quantifier elimination and real algebraic geometry and invariant theory of finite groups computational aspects of presentations and representations of groups especially finite groups of Lie type and their Hecke algebras and of the isomorphism problem in group theory Some of the articles illustrate the current state of computer algebra systems and program packages developed with support by the research program such as KANT and LiDIA for algebraic number theory SINGULAR RED LOG and INVAR for commutative algebra and invariant theory respectively and GAP SYSPHOS and CHEVIE for group theory and representation theory Algorithmic algebraic number theory Michael Pohst, Hans J. Zassenhaus, 1989

Algorithmic Number Theory: Efficient algorithms Eric Bach, Jeffrey Outlaw Shallit, 1996 Volume 1

Algorithmic Number Theory Guillaume Hanrot, Francois Morain, Emmanuel Thomé, 2010-07-07 This book constitutes the refereed proceedings of the 9th International Algorithmic Number Theory Symposium ANTS 2010 held in Nancy France in July 2010 The 25 revised full papers presented together with 5 invited papers were carefully reviewed and selected for inclusion in the book The papers are devoted to algorithmic aspects of number theory including elementary number theory algebraic number theory analytic number theory geometry of numbers algebraic geometry finite fields and cryptography *Algorithmic Number Theory* Florian Hess, Sebastian Pauli, Michael Pohst, 2006-10-05 This book constitutes the refereed proceedings of the 7th International Algorithmic Number Theory Symposium ANTS 2006 held in Berlin July 2006 The book presents 37 revised full papers together with 4 invited papers

selected for inclusion The papers are organized in topical sections on algebraic number theory analytic and elementary number theory lattices curves and varieties over fields of characteristic zero curves over finite fields and applications and discrete logarithms

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Algorithmic Number Theory Wieb Bosma, 2006-12-30 This book constitutes the refereed proceedings of the 4th International Algorithmic Number Theory Symposium ANTS IV held in Leiden The Netherlands in July 2000 The book presents 36 contributed papers which have gone through a thorough round of reviewing selection and revision Also included are 4 invited survey papers Among the topics addressed are gcd algorithms primality factoring sieve methods cryptography linear algebra lattices algebraic number fields class groups and fields elliptic curves polynomials function fields and power sums

A Course in Computational Algebraic Number Theory Henri Cohen, 2013-04-17 With the advent of powerful computing tools and numerous advances in mathematics computer science and cryptography algorithmic number theory has become an important subject in its own right Both external and internal pressures gave a powerful impetus to the development of more powerful algorithms These in turn led to a large number of spectacular breakthroughs To mention but a few the LLL algorithm which has a wide range of applications including real world applications to integer programming primality testing and factoring algorithms sub exponential class group and regulator algorithms etc Several books exist which treat parts of this subject It is essentially impossible for an author to keep up with the rapid pace of progress in all areas of this subject Each book emphasizes a different area corresponding to the author's tastes and interests The most famous but unfortunately the oldest is Knuth's Art of Computer Programming especially Chapter 4 The present book has two goals First to give a reasonably comprehensive introductory course in computational number theory In particular although we study some subjects in great detail others are only mentioned but with suitable pointers to the literature Hence we hope that this book can serve as a first course on the subject A natural sequel would be to study more specialized subjects in the existing literature

Computational Algebraic Number Theory M.E. Pohst, 2012-12-06 Computational algebraic number theory has been attracting broad interest in the last few years due to its potential applications in coding theory and cryptography For this reason the Deutsche Mathematiker Vereinigung initiated an introductory graduate seminar on this topic in D sseldorf The lectures given there by the author served as the basis for this book which allows fast access to the state of the art in this area Special emphasis has been placed on practical algorithms all developed in the last five years for the computation of integral bases the unit group and the class group of arbitrary algebraic number fields Contents Introduction Topics from finite fields Arithmetic and polynomials Factorization of polynomials Topics from the geometry of numbers Hermite normal form Lattices Reduction Enumeration of

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Algorithmic Number Theory, 2002 **Algorithmic Number Theory** Duncan Buell, 2004-05-04 The sixth Algorithmic Number Theory Symposium was held at the University of Vermont in Burlington from 13-18 June 2004 The organization was a joint effort of number theorists from around the world There were four invited talks at ANTS VI by Dan Bernstein of the University of Illinois at Chicago Kiran Kedlaya of MIT Alice Silverberg of Ohio State University and Mark Watkins of Pennsylvania State University Thirty contributed talks were presented and a poster session was held This volume contains the written versions of the contributed talks and three of the four invited talks Not included is the talk by Dan Bernstein ANTS in Burlington is the sixth in a series that began with ANTS I in 1994 at Cornell University Ithaca New York USA and continued at Université de Bordeaux France 1996 Reed College Portland Oregon USA 1998 the University of Leiden Leiden The Netherlands 2000 and the University of Sydney Sydney Australia 2002 The proceedings have been published as volumes 877 1122 1423 1838 and 2369 of Springer Verlag's Lecture Notes in Computer Science series The organizers of the 2004 ANTS conference express their special gratitude and thanks to John Cannon and Joe Buhler for invaluable behind the scenes advice

Ants XIV Steven Galbraith, 2020-12-29 The Algorithmic Number Theory Symposium ANTS held biennially since 1994 is the premier international forum for research in computational and algorithmic number theory ANTS is devoted to algorithmic aspects of number theory including elementary algebraic and analytic number theory the geometry of numbers arithmetic algebraic geometry the theory of finite fields and cryptography This volume is the proceedings of the fourteenth ANTS meeting which took place 29 June to 4 July 2020 via video conference the plans for holding it at the University of Auckland New Zealand having been disrupted by the COVID-19 pandemic The volume contains revised and edited versions of 24 refereed papers and one invited paper presented at the conference

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