

ALGEBRAIC NUMBER THEORY

LECTURE 4 SUPPLEMENTARY NOTES

Material covered: Sections 2.6 through 2.9 of textbook.

I followed the book pretty closely in this lecture, so only a few comments.

Wherever Samuel states a theorem with the assumption that a field has characteristic zero or is finite, we can generalize to the field being perfect.

1. SECTION 2.6

To compute the determinant of the matrix

$$\begin{pmatrix} X & 0 & \cdots & a_0 \\ -1 & X & \cdots & a_1 \\ \cdots & -1 & X & a_{n-2} \\ \cdots & 0 & -1 & X + a_{n-1} \end{pmatrix}$$

first add X times the bottom row to the second last row, then X times the second last row to the third last, and so on. We get

$$\begin{pmatrix} 0 & 0 & \cdots & X^n + a_{n-1}X + \cdots + a_1X + a_0 \\ -1 & 0 & \cdots & X^{n-1} + a_{n-1}X^{n-2} + \cdots + a_1 \\ \cdots & -1 & 0 & X^2 + a_{n-1}X + a_{n-2} \\ \cdots & 0 & -1 & X + a_{n-1} \end{pmatrix}$$

Now Laplace expand along the first column, and so on, to get that the determinant is $f(X)$, the minimal polynomial of x , which is the top right entry of the above matrix.

Example. Suppose $A \subset B \subset C$ are rings, such that B is a free module over A and C is a free module over B . Let $x \in C$. Show that

$$\text{charpoly}_{B[X]/A[X]} \text{charpoly}_{C/B}(x) = \text{charpoly}_{C/A}(x)$$

Note that this is using that $B[X]$ is a free $A[X]$ module. In particular, check that this implies that traces and norms of elements are transitive.

2. APPENDIX: THE FUNDAMENTAL THEOREM OF ALGEBRA

Let's see a slightly different proof from that in the book (it's from Grillet's Abstract Algebra).

Algebraic Structures And Number Theory

S P Lam, Kar Ping Shum



Algebraic Structures And Number Theory:

Algebra and Number Theory Martyn R. Dixon, Leonid A. Kurdachenko, Igor Ya Subbotin, 2010-09-27 Explore the main algebraic structures and number systems that play a central role across the field of mathematics Algebra and number theory are two powerful branches of modern mathematics at the forefront of current mathematical research and each plays an increasingly significant role in different branches of mathematics from geometry and topology to computing and communications Based on the authors extensive experience within the field Algebra and Number Theory has an innovative approach that integrates three disciplines linear algebra abstract algebra and number theory into one comprehensive and fluid presentation facilitating a deeper understanding of the topic and improving readers retention of the main concepts The book begins with an introduction to the elements of set theory Next the authors discuss matrices determinants and elements of field theory including preliminary information related to integers and complex numbers Subsequent chapters explore key ideas relating to linear algebra such as vector spaces linear mapping and bilinear forms The book explores the development of the main ideas of algebraic structures and concludes with applications of algebraic ideas to number theory Interesting applications are provided throughout to demonstrate the relevance of the discussed concepts In addition chapter exercises allow readers to test their comprehension of the presented material Algebra and Number Theory is an excellent book for courses on linear algebra abstract algebra and number theory at the upper undergraduate level It is also a valuable reference for researchers working in different fields of mathematics computer science and engineering as well as for individuals preparing for a career in mathematics education

An Introduction to Essential Algebraic Structures

Martyn R. Dixon, Leonid A. Kurdachenko, Igor Ya Subbotin, 2014-11-17 A reader friendly introduction to modern algebra with important examples from various areas of mathematics Featuring a clear and concise approach An Introduction to Essential Algebraic Structures presents an integrated approach to basic concepts of modern algebra and highlights topics that play a central role in various branches of mathematics The authors discuss key topics of abstract and modern algebra including sets number systems groups rings and fields The book begins with an exposition of the elements of set theory and moves on to cover the main ideas and branches of abstract algebra In addition the book includes Numerous examples throughout to deepen readers knowledge of the presented material An exercise set after each chapter section in an effort to build a deeper understanding of the subject and improve knowledge retention Hints and answers to select exercises at the end of the book A supplementary website with an Instructors Solutions manual An Introduction to Essential Algebraic Structures is an excellent textbook for introductory courses in abstract algebra as well as an ideal reference for anyone who would like to be more familiar with the basic topics of abstract algebra

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Shum, 1990 First International Symposium on Algebraic Structures and Number Theory held in Hong Kong 1988 Pref

Algebraic Structures And Number Theory - Proceedings Of The First International Symposium S P Lam, Kar

Ping Shum,1990-12-31 In this proceedings recent development on various aspects of algebra and number theory were discussed A wide range of topics such as group theory ring theory semi group theory topics on algebraic structures class numbers quadratic forms reciprocity formulae were covered *Algebraic Structures and Number Theory* S. P. Lam,1990

Modern Algebra and the Rise of Mathematical Structures Leo Corry,2012-12-06 The book describes two stages in the historical development of the notion of mathematical structures first it traces its rise in the context of algebra from the mid nineteenth century to its consolidation by 1930 and then it considers several attempts to formulate elaborate theories after 1930 aimed at elucidating from a purely mathematical perspective the precise meaning of this idea First published in the series Science Networks Historical Studies Vol 17 1996 In the second rev edition the author has eliminated misprints revised the chapter on Richard Dedekind and updated the bibliographical index **Explorations in Number Theory** Cam

McLeman,Erin McNicholas,Colin Starr,2022-12-18 This innovative undergraduate textbook approaches number theory through the lens of abstract algebra Written in an engaging and whimsical style this text will introduce students to rings groups fields and other algebraic structures as they discover the key concepts of elementary number theory Inquiry based learning IBL appears throughout the chapters allowing students to develop insights for upcoming sections while simultaneously strengthening their understanding of previously covered topics The text is organized around three core themes the notion of what a number is and the premise that it takes familiarity with a large variety of number systems to fully explore number theory the use of Diophantine equations as catalysts for introducing and developing structural ideas and the role of abstract algebra in number theory in particular the extent to which it provides the Fundamental Theorem of Arithmetic for various new number systems Other aspects of modern number theory including the study of elliptic curves the analogs between integer and polynomial arithmetic p adic arithmetic and relationships between the spectra of primes in various rings are included in smaller but persistent threads woven through chapters and exercise sets Each chapter concludes with exercises organized in four categories Calculations and Informal Proofs Formal Proofs Computation and Experimentation and General Number Theory Awareness IBL Exploration worksheets appear in many sections some of which involve numerical investigations To assist students who may not have experience with programming languages Python worksheets are available on the book s website The final chapter provides five additional IBL explorations that reinforce and expand what students have learned and can be used as starting points for independent projects The topics covered in these explorations are public key cryptography Lagrange s four square theorem units and Pell s Equation various cases of the solution to Fermat s Last Theorem and a peek into other deeper mysteries of algebraic number theory Students should have a basic familiarity with complex numbers matrix algebra vector spaces and proof techniques as well as a spirit of adventure to explore the numbertverse **Algebraic structures and number theory. Proceedings of the International**

Symposium ; 1 ,1988 **Certain Number-Theoretic Episodes in Algebra** R Sivaramakrishnan,2019-08-30 Many basic

ideas of algebra and number theory intertwine making it ideal to explore both at the same time Certain Number Theoretic Episodes in Algebra focuses on some important aspects of interconnections between number theory and commutative algebra Using a pedagogical approach the author presents the conceptual foundations of commutative algebra arising from number theory Self contained the book examines situations where explicit algebraic analogues of theorems of number theory are available Coverage is divided into four parts beginning with elements of number theory and algebra such as theorems of Euler Fermat and Lagrange Euclidean domains and finite groups In the second part the book details ordered fields fields with valuation and other algebraic structures This is followed by a review of fundamentals of algebraic number theory in the third part The final part explores links with ring theory finite dimensional algebras and the Goldbach problem *An Introduction to Algebraic Structures* Joseph Landin, 2012-08-29 This self contained text covers sets and numbers elements of set theory real numbers the theory of groups group isomorphism and homomorphism theory of rings and polynomial rings 1969 edition

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