

Abstract Algebra

Chapter 13 - Field Theory

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Solutions Manual by postorius9902

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13 Field Theory

§13.1 Basic Theory and Field Extensions

Exercise 1. Show that $p(x) = x^3 + 3x + 8$ is irreducible in $\mathbb{Q}[x]$. Let θ be a root of $p(x)$. Find the inverse of $1 + \theta$ in $\mathbb{Q}(\theta)$.

Solution: $p(x) = x^3 + 3x + 8$ is irreducible in $\mathbb{Z}[x]$ by Eisenstein Criterion with $p = 2$. By Gauss Lemma, then it is irreducible in $\mathbb{Q}[x]$. To find $(1 + \theta)^{-1}$, we apply the Euclidean algorithm (long division) to $p(x)$ and $1 + x$. We find

$$x^3 + 3x + 8 = (1 + x)(x^2 - x + 10) - 4.$$

Evaluating at θ , we find $(1 + \theta)(\theta^2 - \theta + 10) = 4$. Therefore

$$(1 + \theta)^{-1} = \frac{\theta^2 - \theta + 10}{4}.$$

Exercise 2. Show that $x^3 - 2x - 2$ is irreducible over $\mathbb{Q}$ and let θ be a root. Compute $(1 + \theta)(1 + \theta + \theta^2)$ and $\frac{1 + \theta}{1 + \theta + \theta^2}$ in $\mathbb{Q}(\theta)$.

Solution: Let $f(x) = x^3 - 2x - 2$. f is irreducible over $\mathbb{Z}$ by Eisenstein Criterion with $p = 2$, hence over $\mathbb{Q}$ by Gauss Lemma. Now, if θ is a root of f , then $\theta^3 = 2\theta + 2$. Hence

$$(1 + \theta)(1 + \theta + \theta^2) = 1 + 2\theta + 2\theta^2 + \theta^3 = 3 + 4\theta + 2\theta^2.$$

For computing $\frac{1 + \theta}{1 + \theta + \theta^2}$, first we compute $(1 + \theta + \theta^2)^{-1}$. Applying the Euclidean algorithm, we obtain

$$x^3 - 2x - 2 = (x^2 + x + 1)(x - 1) - 2x - 3,$$

and

$$x^3 - 2x - 2 = (2x + 1)\left(\frac{x^2}{2} - \frac{x}{4} - \frac{3}{8}\right) - \frac{9}{8}.$$

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**Michael Sullivan, III, Janet
Mazzarella, Katherine Struve**



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Abstract Algebra Manual Ayman Badawi, 2004 This is the most current textbook in teaching the basic concepts of abstract algebra The author finds that there are many students who just memorise a theorem without having the ability to apply it to a given problem Therefore this is a hands on manual where many typical algebraic problems are provided for students to be able to apply the theorems and to actually practice the methods they have learned Each chapter begins with a statement of a major result in Group and Ring Theory followed by problems and solutions Contents Tools and Major Results of Groups Problems in Group Theory Tools and Major Results of Ring Theory Problems in Ring Theory Index **A Classical Introduction to Galois Theory** Stephen C. Newman, 2012-05-29 Explore the foundations and modern applications of Galois theory Galois theory is widely regarded as one of the most elegant areas of mathematics A Classical Introduction to Galois Theory develops the topic from a historical perspective with an emphasis on the solvability of polynomials by radicals The book provides a gradual transition from the computational methods typical of early literature on the subject to the more abstract approach that characterizes most contemporary expositions The author provides an easily accessible presentation of fundamental notions such as roots of unity minimal polynomials primitive elements radical extensions fixed fields groups of automorphisms and solvable series As a result their role in modern treatments of Galois theory is clearly illuminated for readers Classical theorems by Abel Galois Gauss Kronecker Lagrange and Ruffini are presented and the power of Galois theory as both a theoretical and computational tool is illustrated through A study of the solvability of polynomials of prime degree Development of the theory of periods of roots of unity Derivation of the classical formulas for solving general quadratic cubic and quartic polynomials by radicals Throughout the book key theorems are proved in two ways once using a classical approach and then again utilizing modern methods Numerous worked examples showcase the discussed techniques and background material on groups and fields is provided supplying readers with a self contained discussion of the topic A Classical Introduction to Galois Theory is an excellent resource for courses on abstract algebra at the upper undergraduate level The book is also appealing to anyone interested in understanding the origins of Galois theory why it was created and how it has evolved into the discipline it is today **Subject Guide to Books in Print** , 1975 [Introduction to Algebra Solution Manual](#) Richard Rusczyk, 2009 [Books in Print Supplement](#) , 2002 **Algebra** University of Chicago. School Mathematics Project, 1990 [Whitaker's Book List](#) , 1991 **Student Solutions Manual for Gallian's Contemporary Abstract Algebra** Joseph A. Gallian, 2025-05-12 Redesigned for the 11th edition of Contemporary Abstract Algebra Student Solutions Manual for Gallian's Contemporary Abstract Algebra written by the author has comprehensive solutions for all odd numbered exercises and a large number of even numbered exercises This Manual also offers many alternative solutions to those appearing in the text These will provide the student with a better understanding of the material This is the only available student solutions manual prepared by the author of Contemporary Abstract Algebra Eleventh Edition and the only

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