Algebra: Abstract and Concrete
Frederick M. Goodman
Edition 2.6 (last revised May 1, 2015)
`https://homepage.divms.uiowa.edu/~goodman/algebrabook.dir/download.htm`
Errata and comments by Darij Grinberg

The page numbers below refer to the printed page numbers in Edition 2.6. This list is not claimed to be exhaustive. Items marked "substantive" change a mathematical assertion or supply a missing hypothesis; other items are local corrections or clarifications. Formula-sensitive items have been checked against rendered pages of the PDF, since text extraction from this file occasionally loses minus signs.

The majority of errata in this list were found and written up by GPT-5.6 Sol. All have been verified by Darij Grinberg.

H. Corrections and mathematical clarifications

1. **Page 2, sentence below Figure 1.1.1:** Replace "An object is symmetric if it has symmetries" by "An object is symmetric in a nontrivial sense if it has a symmetry other than the nonmotion." Once the nonmotion is counted as a symmetry on page 3, every object has at least this trivial symmetry.

2. **Page 20, paragraph defining the order of a permutation:** Replace "no lower power of π is the identity" by "no lower positive power of π is the identity". The zeroth power is always the identity.

3. **Page 22, Theorem 1.5.3 (uniqueness of disjoint-cycle notation):** *Clarification.* This theorem, as stated, relies on the convention that each cycle has length ≥ 2 (that is, it permutes at least two elements). If 1-cycles (i.e., cycles of length 1) were allowed, then the representation of a permutation as a product of disjoint cycles would no longer be unique, since 1-cycles are just the identity permutation (after all, cycling through a single element obviously leaves this element fixed!) and thus can be inserted into a product at will without affecting the product.

   Later on – e.g., in Example 5.1.17 and Exercise 5.1.17 – this convention is abandoned; there, you allow cycles of length 1, and in fact require them in certain cases. Namely, in Chapter 5, you include a 1-cycle (i) for each fixed point i of the permutation, so as to ensure that each element of $\{1, 2, \ldots, n\}$ appears exactly once in the cycle notation. For example, the permutation in S_9 that would be written as $[(2\ 5)\ (4\ 6\ 9\ 8)]$ according to the convention of Chapter 1 would be written as $[(1)\ (2\ 5)\ (3)\ (4\ 6\ 9\ 8)\ (7)]$ in Chapter 5 (with the redundant 1-cycles being included in order to ensure that each

element of $\{1, 2, \ldots, n\}$ appears exactly once). With this convention, the representation is again unique.

4. **Page 22, proof of Theorem 1.5.3:** Replace "If $|X| = 1$, there is nothing to do" by "If $|X| \leq 1$, there is nothing to do." Also, after the induction hypothesis, replace "Let π be a nonidentity permutation of X" by "If π is the identity, there is nothing to prove. Otherwise, let π be a nonidentity permutation of X." The theorem includes the empty set and the identity permutation on sets of cardinality greater than 1.

5. **Page 26, paragraph before Definition 1.6.3:** Replace "Natural numbers that are not prime are called *composite*" by "Natural numbers greater than 1 that are not prime are called *composite*". Otherwise, the sentence incorrectly classifies 1 as composite.

6. **Page 30, Euclidean algorithm:** Replace "after no more than n steps" by "after no more than $|n|$ steps". The integer n has not been assumed positive.

7. **Page 40, Example 1.7.6:** Replace "the sum of a positive number and a negative number can be either positive or negative" by "the sum of a positive number and a negative number can be negative or nonnegative". The sum can also be 0.

8. **Page 52, proof of Theorem 1.8.16:** Replace "after at most $\deg(f)$ steps" by "after at most $\deg(f) + 1$ steps". For example, when f is a nonzero constant, one division is needed although $\deg(f) = 0$.

9. **Page 54, Definition 1.8.23:** After "if $x - \alpha$ appears exactly k times in the irreducible factorization of p", add "(or, to be more precise, exactly k scalar multiples of $x - \alpha$ appear in this factorization)". For example, the multiplicity of 3 in $(x - 2)(x - 3)(2x - 6)$ is 2, since $2x - 6$ is a scalar multiple of $x - 3$.

10. **Page 55, Exercise 1.8.13 (b):** Replace "is an element of I of smallest degree" by "has smallest degree among the nonzero elements of I". The zero polynomial belongs to I and has degree $-\infty$ under the convention of Definition 1.8.3.

11. **Page 56, Exercise 1.8.18 (b):** Replace "is irreducible if and only if it has no integer root" by "is irreducible in $\mathbb{Q}[x]$ if and only if it has no integer root". Irreducibility has so far been defined only for polynomial rings over a field.

12. **Page 60, Corollary 1.9.6:** Parts (b) and (c) are only true for $n \geq 1$.

13. **Page 61, Example 1.9.7:** Replace "while evaluating at $x = -1$ gives" by "while, if $n > 1$, evaluating at $x = -1$ gives". For $n = 1$, the left-hand side of the differentiated identity evaluates to 1, not to 0.

14. **Page 61, proof of Proposition 1.9.9:** Replace "Reducing modulo n gives $[a][s] = [0]$, so $[a]$ is a zero divisor in $\mathbb{Z}_n$, and therefore not invertible" by "Reducing modulo n gives $[a][s] = [0]$. Since $1 \leq s < n$, we have $[s] \neq [0]$; hence $[a]$ cannot be invertible". If $[a] = [0]$, then $[a]$ is not a zero divisor according to the definition on page 41, so the printed intermediate assertion need not hold.

15. **Page 63:** It is worth mentioning that 1 means the function $\mathbf{1}_U : U \to \{0, 1\}$, which sends every $u \in U$ to 1.

16. **Page 65, approximation of the derangement number:** Replace both occurrences of "$\leq$" in the two displayed remainder estimates by "$<$". The strict alternating-series estimate makes the conclusion that D_n is the integer closest to $n!/e$ immediate also when $n = 1$.

17. **Page 65, Definition 1.9.15:** Replace "natural numbers $k < n$" by "natural numbers $k \leq n$". This gives the standard value $\varphi(1) = 1$ and makes the definition agree with the group of units of $\mathbb{Z}_1$ used later.

18. **Page 74, Exercise 1.10.7:** Replace "A C^1 diffeomorphism of $\mathbb{R}^3$ is a bijective map $T : \mathbb{R}^3 \to \mathbb{R}^3$ having continuous first-order partial derivatives" by "A C^1 diffeomorphism of $\mathbb{R}^3$ is a bijective map $T : \mathbb{R}^3 \to \mathbb{R}^3$ such that both T and T^{-1} have continuous first-order partial derivatives". Without the condition on the inverse, the asserted closure under inverses is false; for example, $x \mapsto x^3$ on $\mathbb{R}$ is bijective and C^1, but its inverse is not C^1 at 0.

19. **Pages 74–75, Exercise 1.10.10:** As it stands, this exercise relies on the reader correctly inferring how to interpret the definition of T in the presence of infinities – e.g., understanding $\dfrac{a\infty + b}{c\infty + d}$ as $\dfrac{a}{c}$. Also, there is an unwritten condition that not all of a, b, c, d are 0, since otherwise nothing can make T well-defined.

20. **Page 75, matrix-ring examples:** After "In the first three examples, multiplication is commutative, but in the fourth example, it is not", add "(unless $n \leq 1$)".

21. **Page 76, Example 1.11.2 (d):** After "The set of n-by-n matrices with integer entries is a noncommutative ring", add "(unless $n \leq 1$, in which case it is a commutative ring)".

22. **Page 77, Example 1.11.6 (b):** Replace

$$a_0 + a_1 x + \cdots + a_s x^s \longmapsto a_0 + a_1 T + \cdots + a_s T^s$$

by

$$a_0 + a_1 x + \cdots + a_s x^s \longmapsto a_0 I_n + a_1 T + \cdots + a_s T^s,$$

where I_n is the n-by-n identity matrix. The scalar constant term has to be interpreted as a scalar matrix.

23. **Page 81, Lemma 1.12.1:** Replace "For all integers a and h" by "For every integer a and every positive integer h". Negative powers of an arbitrary integer a are not defined in the setting of the lemma.

24. **Page 83, Exercise 1.12.1 (b):** Replace "Let $n = pq$ the product of two primes" by "Let $n = pq$ be the product of two distinct primes." The displayed isomorphism $\Phi(pq) \cong \Phi(p) \times \Phi(q)$ requires p and q to be relatively prime.

25. **Page 91, proof of Proposition 2.1.19:** Replace "$(a_1 \cdots a_{k+1})(a_{k+1} \cdots a_n)$" by "$(a_1 \cdots a_{k+1})(a_{k+2} \cdots a_n)$". The former repeats a_{k+1} and therefore does not equal p_{k+1}.

26. **Page 96, constructive description of $\langle S \rangle$:** After "all possible products $g_1 g_2 \cdots g_n$, where $g_i \in S$ or $g_i^{-1} \in S$", add "(including the empty product, which is understood to be e)".

27. **Page 96, footnote 1:** The definition of a partial order needs a third requirement: *reflexivity* ($x \leq x$ for all x). Also, the second requirement should be called *antisymmetry*, not *asymmetry*.

28. **Page 100, proof of Proposition 2.2.21 (a):** Replace "by part (a), d and d' divide one another" by "by part (c), d and d' divide one another".

29. **Page 101, proof of Corollary 2.2.26 (a):** Replace "the least of positive integers s such that $s \in H$" by "the least of positive integers s such that $[s] \in H$". Here H is a subgroup of $\mathbb{Z}_n$, so its elements are congruence classes.

30. **Page 114, proof of Proposition 2.4.11:** Replace the first reference to "Proposition 2.1.1(a)" by "Corollary 2.1.7", and replace the reference to "Proposition 2.1.1(b)" by "Proposition 2.1.2".

31. **Page 117, Example 2.4.20:** This is literally true if all elements of G have finite order. Otherwise, it requires the understanding that ∞ divides 0 but does not divide any nonzero integers.

32. **Page 117, Corollary 2.4.23:** Replace "The set of odd permutations in S_n is $(1\,2)A_n$" by "For $n \geq 2$, the set of odd permutations in S_n is $(1\,2)A_n$". For $n = 1$, the transposition $(1\,2)$ is not an element of S_n.

33. **Page 120, Exercise 2.4.15:** Replace "Show that ϵ is the unique homomorphism from S_n onto $\{1, -1\}$" by "For $n \geq 2$, show that ϵ is the unique homomorphism from S_n onto $\{1, -1\}$". For $n = 1$, no such surjective homomorphism exists.

34. **Page 121, Exercise 2.4.21:** Replace "if n is relatively prime to the order of G" by "if G is finite and n is relatively prime to $|G|$".

35. **Page 127, Exercise 2.5.16:** Replace "the symmetric group S_n has a unique subgroup of index 2" by "for $n \geq 2$, the symmetric group S_n has a unique subgroup of index 2". The assertion is false for $n = 1$.

36. **Page 131, Example 2.6.10 (b):** Replace "The equivalence relation $x \sim y$ for all $x, y \in X$ has just one equivalence class, namely X" by "If $X \neq \varnothing$, the equivalence relation $x \sim y$ for all $x, y \in X$ has just one equivalence class, namely X; if $X = \varnothing$, it has no equivalence classes".

37. **Page 134, first paragraph of Section 2.7:** Replace "Consider the permutation group S_n with its normal subgroup of even permutations" by "Let $n \geq 2$, and consider the permutation group S_n with its normal subgroup of even permutations". The displayed coset $O = (1\,2)E$ is not defined for $n = 1$.

38. **Page 136, Example 2.7.3:** The domain $\mathbb{Z}_n$ is written additively, while the target group G is written multiplicatively. Make the following replacements.

    Replace "$\varphi(a) - \varphi(b) = \varphi(a - b) = 0$" by "$\varphi(a)\varphi(b)^{-1} = \varphi(a - b) = e_G$".

    Replace
    $$\widetilde{\varphi}([a][b]) = \widetilde{\varphi}([ab]) = \varphi(ab) = \varphi(a)\varphi(b)$$
    by
    $$\widetilde{\varphi}([a] + [b]) = \widetilde{\varphi}([a + b]) = \varphi(a + b) = \varphi(a)\varphi(b).$$

    Finally, replace "If $\widetilde{\varphi}([k]) = 0$, then $\varphi(k) = 0$, so $k \in n\mathbb{Z} = [0]$, so $[k] = [0]$" by "If $\widetilde{\varphi}([k]) = e_G$, then $\varphi(k) = e_G$, so $k \in n\mathbb{Z}$, and hence $[k] = [0]$".

39. **Page 153, Example 3.1.11:** There are three Dalmatian dogs, so their permutation group D is isomorphic to S_3, not to S_4.

    Moreover, the displayed copy of A inside
    $$P = A \times B \times C \times D \times E$$
    should be
    $$\widetilde{A} = A \times \{e\} \times \{e\} \times \{e\} \times \{e\},$$
    with four trivial factors $\times\{e\}$, not three.

40. **Page 155, Definition 3.1.16:** In both formulas defining the coordinatewise operations, replace the final entry r'_s of the second tuple by r'_n.

41. **Page 155, Proposition 3.1.18:** "For any integers $x_1, x_2, \ldots, x_s$" should be "For any integers $x_1, x_2, \ldots, x_n$".

42. **Page 162, Exercise 3.2.2:** The automorphism

$$j : [x] \longmapsto [-x]$$

does not always have order 2: it is the identity for $n = 1$ and $n = 2$. It does satisfy $j^2 = \mathrm{id}$ for every n, which is all that is needed to define the indicated homomorphism from $\mathbb{Z}_2$. Thus, either replace "an order 2 automorphism" by "an automorphism satisfying $j^2 = \mathrm{id}$", or add the hypothesis $n > 2$ to the assertion about its order.

43. **Page 172, proof of Proposition 3.3.25:** "there is a nonzero $\boldsymbol{\alpha} = \begin{bmatrix} \alpha_1 \\ \vdots \\ \alpha_n \end{bmatrix} \in K^n$"

should be "there is a nonzero $\boldsymbol{\alpha} = \begin{bmatrix} \alpha_1 \\ \vdots \\ \alpha_s \end{bmatrix} \in K^s$".

44. **Page 172, proof of Corollary 3.3.26:** The second application of Proposition 3.3.25, with the roles of X and Y reversed, gives $|X| \leq |Y|$, not a second copy of $|Y| \leq |X|$.

45. **Page 175, proof of Proposition 3.3.33:** The proof cites Proposition 3.5.1, which has not yet appeared. It would be natural to switch the order of these two results.

46. **Page 176, Proposition 3.3.35:** The preceding argument assumes that $T : V \to W$ is surjective, whereas the proposition is stated for an arbitrary linear map. To obtain the stated result, apply the preceding argument to the surjective map $T : V \longrightarrow \mathrm{range}(T)$.

47. **Page 176, warning after Corollary 3.3.37:** The word "never" in "Complements of a subspace are never unique" is an overstatement: For example, the zero subspace has the unique complement V, and V has the unique complement $\{0\}$. Replace "are never unique" by "need not be unique" or "are usually not unique".

48. **Page 177, Exercise 3.3.10 (a):** The row $[v_1, \ldots, v_n]$ belongs to V^n, not to K^n.

49. **Page 182, paragraph after Theorem 3.4.5:** The assertion that the canonical map $V \to V^{**}$ is not surjective when V is infinite-dimensional is true, but is nontrivial and is neither proved nor assigned as an exercise.

50. **Pages 184–185, Proposition 3.4.10:** The convention introduced immediately before the proposition denotes the matrix of $T : V \to W$ by $[T]_{C,B}$, where B is the basis of V and C the basis of W. Thus, in part (a), replace "$T \longmapsto [T]_{B,C}$" by "$T \longmapsto [T]_{C,B}$". Make the same correction in the final sentence of the proof of part (a).

51. **Page 188, Exercise 3.4.4:** In the displayed inner product, the second vector should be
$$\begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix},$$
not
$$\begin{bmatrix} \beta_2 \\ \beta_2 \\ \beta_3 \end{bmatrix}.$$

52. **Page 189, Exercise 3.4.10 (b):** The "integration" map $P_6 \to P_7$ is not determined until a choice of integration constant has been specified. For example, one can define it to be $f(x) \longmapsto \int_0^x f(t)\,dt$, equivalently the unique antiderivative with constant term 0.

53. **Page 190, first paragraph of Section 3.5:** After "the order of an element x is the smallest natural number s such that $sx = 0$", add "(or ∞ if no such s exists)".

54. **Page 194, Proposition 3.5.9:** The integer s in
$$\operatorname{diag}(d_1, \ldots, d_s, 0, \ldots, 0)$$
is not introduced. One should specify that $0 \leq s \leq \min\{m, n\}$ and that $d_1, \ldots, d_s$ are the nonzero diagonal entries.

55. **Page 200, derivation of the invariant-factor decomposition:** In the direct product
$$\mathbb{Z}/d_i\mathbb{Z} \times \cdots \times \mathbb{Z}/d_s\mathbb{Z} \times \mathbb{Z}^{n-s},$$
the first factor should be $\mathbb{Z}/d_1\mathbb{Z}$, not $\mathbb{Z}/d_i\mathbb{Z}$.

56. **Page 203, proof of uniqueness in Theorem 3.6.2:** The proof should dispose separately of the case $G_{\text{tor}} = \{0\}$ before writing
$$a_s = b_t = a.$$
In that case $s = t = 0$, so neither a_s nor b_t exists, and uniqueness is immediate. Add, for example: "If $G_{\text{tor}} = \{0\}$, then $s = t = 0$, and there is nothing left to prove. Hence assume $G_{\text{tor}} \neq \{0\}$."

57. **Page 204, proof of uniqueness in Theorem 3.6.2:** After "Let k' be the last index such that $a_{k'} = p$", add "(or 0 if no such index exists)". Make a similar change when k'' is defined.

58. **Page 204, Example 3.6.6:** Under the convention in Theorem 3.6.2 that the invariant factors satisfy $a_1 \mid a_2 \mid \cdots$, the final decomposition should be written
$$\mathbb{Z}_{30} \times \mathbb{Z}_{24} \cong \mathbb{Z}_6 \times \mathbb{Z}_{120},$$
and the invariant factors should be listed as $6, 120$, rather than $120, 6$. (The two displayed direct products are of course isomorphic; the issue is the ordering convention.)

59. **Page 205, Definition 3.6.9 (b):** If the partition is denoted $(n_1, n_2, \ldots, n_k)$, then the displayed decomposition should end in $\mathbb{Z}_{p^{n_k}}$, not in $\mathbb{Z}_{p^{n_s}}$.

60. **Page 207, proofs of Theorem 3.6.15 and Corollary 3.6.16:** In both prime factorizations, replace
$$p_1^{k_1} p_s^{k_2} \cdots p_s^{k_s}$$
by
$$p_1^{k_1} p_2^{k_2} \cdots p_s^{k_s}.$$

61. **Pages 210–212, Examples 3.6.22–3.6.24:** The invariant factors are systematically listed in the reverse of the order stipulated in Theorem 3.6.2, where $a_1 \mid a_2 \mid \cdots \mid a_s$.

    For instance, the decomposition on page 210 should be written
    $$\mathbb{Z}_2 \times \mathbb{Z}_{10} \times \mathbb{Z}_{2100},$$
    rather than
    $$\mathbb{Z}_{2100} \times \mathbb{Z}_{10} \times \mathbb{Z}_2.$$
    Likewise, the algorithm on pages 210–211 produces the invariant factors from largest to smallest, so the resulting list should be reversed before it is put into the convention of Theorem 3.6.2.

    On page 212, the six decompositions should accordingly be written as
    $$\begin{gathered}\mathbb{Z}_{4200}, \\ \mathbb{Z}_5 \times \mathbb{Z}_{840}, \\ \mathbb{Z}_2 \times \mathbb{Z}_{2100}, \\ \mathbb{Z}_{10} \times \mathbb{Z}_{420}, \\ \mathbb{Z}_2 \times \mathbb{Z}_2 \times \mathbb{Z}_{1050}, \\ \mathbb{Z}_2 \times \mathbb{Z}_{10} \times \mathbb{Z}_{210}.\end{gathered}$$
    The displayed groups are of course unchanged up to isomorphism; the problem is only the stated ordering convention.

62. **Page 213, proof of Proposition 3.6.27 (b):** Exercise 2.2.30 correctly shows that the order of $[3]$ in $\Phi(2^n)$ is 2^{n-2}, not 2^{n-1}. Consequently, replace "order 2^{n-1}" by "order 2^{n-2}", and replace each of the three "$\mathbb{Z}_{2^{n-1}}$"s by "$\mathbb{Z}_{2^{n-2}}$.

63. **Page 215, Exercise 3.6.17:** If $(m_1, \ldots, m_k)$ are invariant factors with $m_1 \mid m_2 \mid \cdots \mid m_k$, then a finite abelian group G has an element of order s if and only if $s \mid m_k$, not if and only if $s \mid m_1$. The exponent of G is the largest invariant factor m_k.

64. **Page 249, Exercise 5.1.20:** The proposed description

$$\mathbb{Z}_4 = \langle (1\ 2\ 3\ 4), (1\ 2)(3\ 4) \rangle$$

is wrong: the displayed generators generate the dihedral group D_4, exactly as in the preceding bullet point. Replace this by

$$\mathbb{Z}_4 = \langle (1\ 2\ 3\ 4) \rangle\,.$$

65. **Page 250, proof of Proposition 5.2.2:** The characteristic function $\mathbf{1}_F$ was defined on $G \times X$, not on $X \times G$. Thus, in both displayed double sums, replace $\mathbf{1}_F(x, g)$ by $\mathbf{1}_F(g, x)$.

66. **Page 259, paragraph following the proof of Theorem 5.4.11:** In the summary of the Sylow theorems, replace "the number of such subgroups divides $|G|$ and is conjugate to 1 mod p" by "the number of such subgroups divides $|G|/p^n$ and is congruent to 1 modulo p." The statement that it divides $|G|$ is true but weaker than the third Sylow theorem (although easily seen to be equivalent in view of the $\equiv 1 \mod p$ property), whereas the word "conjugate" is simply wrong.

67. **Page 260, Example 5.4.14:** "Hence $n_r \in \{1, 10\}$" should be "Hence $n_3 \in \{1, 10\}$".

68. **Page 261, Example 5.4.14:** The assertion that the map

$$[k] \longmapsto [-k]$$

is an automorphism of order 2 of $\mathbb{Z}_n$ "for any n" is false for $n = 1$ and $n = 2$; in these cases it is the identity. Replace "for any n" by "for any $n > 2$". Only $n = 3, 5$ is needed here.

69. **Page 263, Exercise 5.4.10, converse assertion:** The relations

$$a^7 = b^4 = 1, \qquad bab^{-1} = a^{-1}$$

do not by themselves force a group generated by a, b to be the indicated semidirect product; they only make it a quotient of that group. For example, one may take $a = 1$. Add, for instance, that a and b have orders exactly 7 and 4, respectively (or that the generated group has order 28), or rephrase the assertion as a presentation of the semidirect product.

70. **Page 264, first non-italicized paragraph of Section 5.5:** The subgroup

$$\langle (1\ 2\ 3\ 4\ 5), (1\ 2) \rangle$$

is S_5, not D_5. For example, conjugating $(1\ 2)$ by powers of $(1\ 2\ 3\ 4\ 5)$ produces enough transpositions to generate S_5. Replace $(1\ 2)$ by, for example,

$$(2\ 5)(3\ 4),$$

as in Proposition 5.5.3.

71. **Page 265, paragraph immediately before Proposition 5.5.3:** Since the common normalizer of the three displayed subgroups has order 20, its index in S_5 is

$$[S_5 : \langle \sigma, \rho \rangle] = 120/20 = 6,$$

not 5. Thus replace "the number of conjugates of each of the groups is 5" by "...is 6". In Proposition 5.5.3, "and its five conjugates" is consistent with this if it means five *other* conjugates; "and its five other conjugates" would be clearer.

72. **Page 266, Definition 5.6.1:** Replace "if for all $x \in X$," by "if for all $g \in G$ and all $x \in X$, we have".

73. **Page 267, Exercise 5.6.6:** Add the hypothesis $n \geq 3$. For $n = 2$, the point stabilizer $H = \mathrm{Stab}(2)$ is the trivial subgroup of S_2, whose normalizer is all of S_2, not H.

74. **Page 268, Exercise 5.6.18:** This exercise is false. Let

$$V = \left\{ (x_1, \ldots, x_5) \in \mathbb{F}_2^5 \;\middle|\; x_1 + \cdots + x_5 = 0 \right\} \cong (\mathbb{Z}_2)^4,$$

and let $\mathbb{Z}_5$ act nontrivially on V by cyclically permuting the five coordinates. Then

$$G = V \rtimes \mathbb{Z}_5$$

has order $2^4 \cdot 5 = 80$, but the displayed complement $\mathbb{Z}_5$ is not normal. Indeed, G has multiple 5-Sylow subgroups (since any $(v, c) \in V \rtimes \mathbb{Z}_5 = G$ for which c is nonzero has order 5 in G), which are all conjugate by the Second Sylow Theorem, and thus none of them is normal.

A simple repair is to assume $1 \leq n \leq 3$. In that case the number of 5-Sylow subgroups divides 2^n and is congruent to 1 modulo 5, and hence must equal 1.

75. **Page 270, etc.:** It might also be worthwhile to point out that polynomials usually "know" the names of their variables; i.e., the polynomial $x + 1 \in K[x]$ is not identified with $y + 1 \in K[y]$ (or else things would go awry when

$K[x]$ and $K[y]$ are embedded into $K[x,y]$). The definition of polynomials as sequences (or families, in the multivariate case) of coefficients obscures this point, as it suggests that the monomials x^2y in $K[x,y]$ and y^2z in $K[y,z]$ both are just the multi-index $(2,1)$. To avoid this ambiguity, it should be clarified that a monomial is not *just* the multiindex, but also the list of names of variables involved – e.g., the monomial x^2y in $K[x,y]$ is the multi-index $(2,1)$ with the list of names $(\text{“}x\text{”},\text{“}y\text{”})$, whereas the monomial y^2z in $K[y,z]$ is the multi-index $(2,1)$ with the list of names $(\text{“}y\text{”},\text{“}z\text{”})$.

76. **Page 274, Exercise 6.1.12:** The claim that “R is isomorphic to the subring of constant functions on X” is only true if X is nonempty.

77. **Page 284, Proposition 6.2.27 (a):** The displayed description of $R\mathcal{S}R$ should specify all three families of conditions:

$$R\mathcal{S}R = \left\{ \sum_{i=1}^{n} a_i s_i b_i : \ n \geq 0, \ a_i, b_i \in R, \ s_i \in \mathcal{S} \right\}.$$

As printed, only $a_n, b_n \in R$ are mentioned, and no condition at all is placed on the s_i.

78. **Page 295, Definition 6.4.2:** *Missing hypothesis.* To agree with the standard convention and with subsequent uses, require an integral domain to be nontrivial, equivalently to satisfy $1 \neq 0$. Otherwise the zero ring satisfies the printed condition vacuously.

79. **Page 298, Definition 6.4.10 and Proposition 6.4.11:** *Missing hypothesis.* A prime ideal is required to be proper. Thus Definition 6.4.10 should add the requirement $J \neq R$. Correspondingly, Proposition 6.4.11 should say that J is prime if and only if R/J is a nonzero ring with no zero divisors (and, in the unital commutative case, an integral domain in the corrected sense).

80. **Page 298, Example 6.4.13:** Every ideal of $\mathbb{Z}$ has the form $d\mathbb{Z}$ for a unique $d \geq 0$, not necessarily for $d > 0$. With the usual definition of prime ideal, (0) is also a prime ideal of $\mathbb{Z}$. Thus the positive ideals $d\mathbb{Z}$ are prime exactly when d is a prime number, and (0) is the additional prime ideal.

81. **Page 300, definition of a Euclidean domain:** The condition “$d(fg) \geq \max\{d(f), d(g)\}$” is not used until Lemma 8.4.7 (and possibly the solution to Exercise 6.5.3, where it allows for a simpler proof). Several authors omit it from the definition of a Euclidean domain.

82. **Page 317, Lemma 6.7.4 and its proof:** First dispose separately of the case $J = (0)$, since otherwise the “minimum of the degrees of nonzero elements of J” is undefined. In the induction step, “choose $g \in J_0$ such that $\deg(f - g) < \deg(g)$” should read “choose $g \in J_0$ such that $\deg(f - g) < \deg(f)$”.

83. **Page 324, display (7.2.1):** The first elementary-symmetric relation should be
$$\alpha_1 + \alpha_2 + \alpha_3 = 0,$$
not $\alpha_1 + \alpha_3 + \alpha_3 = 0$.

84. **Page 324, Cardano formula near the bottom of the page:** The second root is labeled a_2; it should be α_2. More importantly, the claim that the square-root choice is immaterial needs an exception: When $p = 0$, one of the two square-root choices can make $A^3 = 0$, after which the displayed expression $p/(3A)$ is undefined. Choose the sign so that $A \neq 0$ when possible, and handle the case $p = q = 0$ separately (where the sole root is 0 with multiplicity 3).

85. **Page 356, Definition 8.1.28:** In my view, this is a bad definition, as it lacks the flexibility that is later needed (and silently assumed). It makes a lot more sense to define linear independence for *families* or *tuples* (rather than *sets*), and similarly to say that a *family* or a *tuple* (not a *set*) is a basis of an R-module. This does not mean that it is always wrong to speak of the linear independence of a set (it is a particular case of the linear independence of a family: namely, the family $(s)_{s \in S}$, where S is the set in question), but *most of the time* when people say "the set $\{x_1, \ldots, x_n\}$ is linearly independent", they really mean "the tuple $(x_1, \ldots, x_n)$ is linearly independent". This sort of language often causes statements to mean different things than the author meant to say. For example, on page 328, in the proof of Proposition 7.3.4, you say that the powers $1, \alpha, \alpha^2, \alpha^3, \ldots$ cannot be linearly independent over K. You definitely mean that the family $(\alpha^n)_{n \geq 0}$ is not linearly independent, rather than the set $\{1, \alpha, \alpha^2, \alpha^3, \ldots\}$. (The latter would be false for $\alpha = 1$, because in this case the set $\{1, \alpha, \alpha^2, \alpha^3, \ldots\} = \{1\}$ is linearly independent.) On page 384, in Exercise 8.4.1 (b), the set $\{v_1, v_2, \ldots, v_n\}$ does not change if we duplicate some of the v_i's, but the claim of the exercise becomes wrong. In Example 8.5.4, you speak of "the set of $n+1$ elements $\{v, T(v), T^2(v), T^3(v), \ldots, T^n(v)\}$", but this doesn't have to be a set of $n+1$ elements; it is a *tuple* of $n+1$ elements. On page 398, you say that "the n^2+1 linear transformations $\mathrm{id}, T, T^2, \ldots, T^{n^2}$ are not linearly independent", and again this only holds if you take their tuple rather than their set. (On the other hand, Proposition 9.5.7 is one of the few places where it really matters that the set is a set. Here I'd replace "collection" by "set" to stress this.)

86. **Page 375, Lemma 8.4.1:** Here you should assume that R is not the zero ring. Otherwise, the zero ring over itself is a counterexample, having a basis of any size (as I said, bases are naturally tuples or families, not sets; but even if you restrict yourself to sets, then there is still a basis of size 0 and a basis of size 1). In his paper *Nontrivial uses of trivial rings* (Proc. Amer. Math.

Soc. **103** (1988), pp. 1012–1014), Fred Richman makes a highly convincing case that the "right" way to state the correct lemma is to say that if R is a commutative ring with unity, and M is an R-module equipped with two bases of distinct finite cardinalities, then $R = 0$.

87. **Page 387, Example 8.5.3:** Replace "there is an $n \in \mathbb{Z}$" by "there is a nonzero $n \in \mathbb{Z}$".

88. **Page 448, Definition 9.6.5:** Algebraic independence means that there is no *nonzero* polynomial $f \in K[x_1, \ldots, x_n]$ satisfying $f(u_1, \ldots, u_n) = 0$. The zero polynomial always gives such a relation, so the word "nonzero" is essential.

    Also, it is better to define this notion over rings instead of fields; i.e., let K be a commutative ring with unity, and let $u_1, \ldots, u_n$ lie in a commutative K-algebra with unity. This way, the first statement in Theorem 9.6.6 applies to every commutative ring K. (Also, again, I am not keen on speaking of "algebraically independent sets" as opposed to "algebraically independent families".)

89. **Page 449:** Your definition of partitions misses one ingredient: two partitions that only differ in trailing zeroes should be identified. For example, $(3,2,2) = (3,2,2,0) = (3,2,2,0,0) = \cdots$. Otherwise, the conjugate partition λ^* would not be uniquely defined (or would fail to satisfy $(\lambda^*)^* = \lambda$) due to too much freedom in choosing its length.

90. **Page 450, definition of the monomial symmetric function m_λ:** The formula
$$m_\lambda = (1/f) \sum_{\sigma \in S_n} \sigma(x^\lambda)$$
    is not defined over an arbitrary field K when the stabilizer size f is zero in K. Instead, m_λ should be defined as
$$m_\lambda = \sum_{u \in S_n \cdot x^\lambda} u,$$
    the sum of the distinct monomials in the orbit of the monomial x^λ under the symmetric group S_n permuting the variables.

91. **Pages 450–451, Lemma 9.6.7 (c):** The inverse coefficients $S_{\lambda\mu}$ need not be nonnegative. For example,
$$m_{(2)} = \epsilon_1^2 - 2\epsilon_2.$$
    Replace "nonnegative integer" in part (c) by "integer". The proof by inverting a unitriangular integer matrix establishes integrality, not positivity.

92. **Page 450, proof of Lemma 9.6.7:** "number of λ_k" should be "number of k" (we must count the k's, not the λ_k's; for example, if $\lambda_2 = \lambda_3$, then both 2 and 3 are counted).

93. **Page 453, Exercise 9.6.15:** This needs a requirement that $\operatorname{char} K \neq 2$. (Alternatively, retain the condition $\sigma(f) = \epsilon(\sigma)f$ and additionally require f to vanish whenever two of its indeterminates are set equal. With these two conditions, the conclusion holds in every characteristic.)

94. **Page 461, beginning of Section 9.8:** *Missing hypothesis.* The substitution $x = y - a/4$ and formulas (9.8.3) require at least $\operatorname{char} K \neq 2$. This assumption should be made before the substitution, rather than only later in the discussion.

95. **Page 461, formula (9.8.2):** Replace both "x"s on the right-hand side of (9.8.2) by y's. That is, the formula should be

$$f(x) = g(y) = y^4 + py^2 + qy + r.$$

96. **Page 462, Case 1A:** If the resolvent cubic h is irreducible and its discriminant is a square, then its splitting field has degree 3, not 6. Indeed its transitive Galois group is a subgroup of A_3, hence is $A_3 \cong C_3$. Thus the argument should say that 3 divides $|G|$, which still distinguishes A_4 from the Klein four group and yields $G = A_4$.

97. **Page 463, Lemma 9.8.1, first two sentences:** The variables are inconsistent. Write, for example,

$$g(x) = x^4 + px^2 + qx + r$$

and let $h(y)$ denote its resolvent cubic (or consistently use y for the quartic variable throughout), rather than writing $g(x) = y^4 + py^2 + qy + r$.

98. **Page 479, alternative proof of simplicity of A_n:** *Substantive terminology and notation.* The stabilizer of a subgroup N under conjugation is its *normalizer*, not its centralizer. Thus "centralizer" should be replaced by "normalizer" throughout this page, and "$\operatorname{Cent}_{S_n}(N)$" should be likewise replaced by "$N_{S_n}(N)$".

99. **Page 485, Lemma 10.6.3:** This is false unless the extension L/K is separable. (The classical example $K = \mathbb{F}_p(x^p)$ and $L = \mathbb{F}_p(x)$ of an inseparable finite extension is a counterexample.)

100. **Pages 485–487, proof of Theorem 10.6.2:** Even aside from the problem with Lemma 10.6.3 noted above, this proof does not work in arbitrary positive characteristic. If $p = \operatorname{char} K$ divides $n = n_1 n_2 \cdots n_r$, then no primitive n-th root of unity exists in any extension field of K. Thus the instruction to adjoin such a root cannot be carried out.

101. **Page 492, definition of the Euclidean norm:** The displayed formula

$$\|\boldsymbol{a}\| = \langle \boldsymbol{a}, \boldsymbol{a} \rangle = \sum_i a_i^2$$

should read

$$\|\boldsymbol{a}\|^2 = \langle \boldsymbol{a}, \boldsymbol{a} \rangle = \sum_i a_i^2, \qquad \text{or equivalently} \qquad \|\boldsymbol{a}\| = \sqrt{\langle \boldsymbol{a}, \boldsymbol{a} \rangle}.$$

102. **Page 493, proof of Lemma 11.1.1:** Both displayed equalities have the wrong sign in front of the inner product. They should be

$$\|\boldsymbol{a} - \boldsymbol{b}\|^2 = \|\boldsymbol{a}\|^2 + \|\boldsymbol{b}\|^2 - 2\langle \boldsymbol{a}, \boldsymbol{b} \rangle$$

and the analogous identity for $\tau(\boldsymbol{a}), \tau(\boldsymbol{b})$. The desired conclusion still follows after making this correction.

103. **Page 497, Lemma 11.1.9:** The formula "$\sigma\tau_{\boldsymbol{b}}\sigma^{-1} = \tau_{\sigma(\boldsymbol{b})}$" should instead be

$$\sigma\tau_{\boldsymbol{b}}\sigma^{-1} = \tau_{\boldsymbol{Ab}}, \qquad \text{where } \sigma \text{ is given by } \sigma(\boldsymbol{x}) = \boldsymbol{Ax} + \boldsymbol{c}.$$

104. **Page 501, proof of Theorem 11.2.6:** The induction begins with graphs having exactly one edge, but the theorem also includes the connected graph with one vertex and no edges. Add this base case: $v = 1$, $e = 0$, $f = 1$, so $v - e + f = 2$.

    The tree step also invokes the existence of a vertex of valence 1, a fact deferred to Exercise 11.2.4; it would be clearer to state this as a preceding lemma.

105. **Page 502, proof of Euler's theorem for polyhedra:** If "polyhedron" denotes the solid convex body, the radial projection $\boldsymbol{x} \mapsto \boldsymbol{x}/\|\boldsymbol{x}\|$ does not map the whole polyhedron bijectively onto the sphere. It maps the *boundary* of a convex polyhedron containing the origin bijectively onto the sphere. Replace "maps the polyhedron bijectively" by "maps the boundary of the polyhedron bijectively" (or state explicitly that "polyhedron" here means its boundary surface).

106. **Page 550:** The notation M^j for the j-th column of a matrix M is rather confusing, even if the matrix M is (in general) rectangular and thus has no j-th power.

107. **Page 551, Definition E.9:** Replace "$\{T(\boldsymbol{x}) : \boldsymbol{x} \in K^n\}$" by "$\{T(\boldsymbol{x}) : \boldsymbol{x} \in V\}$".

I. Minor typographical and editorial corrections

1. **Page 9, paragraph following Figure 1.3.5:** Replace "in this table, order in which symmetries are multiplied" by "in this table, the order in which symmetries are multiplied".

2. **Page 16:** Replace "Let τ be symmetry" by "Let τ be a symmetry", and replace "the third in the place of the first; There are" by "the third in the place of the first; there are".

3. **Page 19:** Replace "sends 1 to 4, 2, to 3" by "sends 1 to 4, 2 to 3".

4. **Page 25, first paragraph:** Replace "probably most familiar algebraic system" by "probably the most familiar algebraic system".

5. **Page 26, first paragraph:** Replace "every natural numbers has" by "every natural number has".

6. **Page 27, proof of Theorem 1.6.6:** Replace "We show than" by "We show that".

7. **Page 28, Proposition 1.6.7:** Replace "such $a = qd + r$" by "such that $a = qd + r$".

8. **Page 32, paragraph after proof of Proposition 1.6.18:** "it is a only a short way" should be "it is only a short way".

9. **Page 35, paragraph after proof of Proposition 1.6.24:** Replace "integers $s_1, s_2, \ldots, s_n$ such" by "integers $s_1, s_2, \ldots, s_n$ such that".

10. **Page 41, Proposition 1.7.7 (f):** Replace "The distributive law hold" by "The distributive law holds".

11. **Page 42, Example 1.7.8 (b):** Replace "the conjugacy class of 237 modulo 3" by "the congruence class of 237 modulo 3".

12. **Page 44, Exercise 1.7.16:** Replace "Find and integer x" by "Find an integer x".

13. **Page 45, paragraph following Example 1.8.1:** Replace "K can be regarded as subset of $K[x]$" by "K can be regarded as a subset of $K[x]$".

14. **Page 55, Exercise 1.8.12:** There is an extraneous closing parenthesis at the end of this exercise.

15. **Page 61, proof of Lemma 1.9.8:** Replace "$(n-k)!$" by "$(p-k)!$".

16. **Page 62, Inclusion–Exclusion:** "but then uncounted once in $|A \cap B| - |A \cap C| - |B \cap C|$" should be "but then uncounted once in $-|A \cap B| - |A \cap C| - |B \cap C|$".

17. **Page 64, Example 1.9.13:** Replace "$A_1' \cap A_2 \cap \cdots \cap A_n'$" by "$A_1' \cap A_2' \cap \cdots \cap A_n'$" (mind the prime over the A_2).

18. **Page 65, simplification of D_n:** Replace "$D_n = =$" by "$D_n =$".

19. **Page 65, Example 1.9.14:** Replace "$D_{10} = 1{,}333{,}961$" by "$D_{10} = 1{,}334{,}961$". (See the OEIS for more values of D_n.)

20. **Page 66, computation of $\varphi(n)$:** Replace "$A_1' \cap A_2' \cap \cdots \cap A_n'$" by "$A_1' \cap A_2' \cap \cdots \cap A_s'$".

21. **Page 66, proof of Corollary 1.9.17:** Replace "the number of natural numbers $j \leq n$" by "the number of natural numbers $j \leq p^k$".

22. **Page 67, Example 1.9.21:** Replace

$$7^8 - 1 = 5764801$$

by

$$7^8 - 1 = 5764800.$$

23. **Page 68, Exercise 1.9.8 (b):** Replace "In how many ways the men and women form pairs" by "In how many ways can the men and women form pairs".

24. **Pages 71 and 74, comparison of $\mathcal{R}$ with the fourth roots of unity:** Replace both occurrences of "H" by "C_4".

25. **Page 72, homomorphism paragraph:** Replace "if f take products to products" by "if f takes products to products".

26. **Page 73, Exercises 1.10:** Replace "Show that set of symmetries" by "Show that the set of symmetries", and replace "1.10.3. . Consider" by "1.10.3. Consider".

27. **Page 74, Exercise 1.10.3:** Again, replace "H" by "C_4".

28. **Page 75, first paragraph of Section 1.11:** Replace "the set is group under the operation of addition" by "the set is a group under the operation of addition".

29. **Page 76:** Replace "with with polynomial entries" by "with polynomial entries", and replace "*inverses*; A multiplicative inverse" by "*inverses*: A multiplicative inverse".

30. **Page 78, Proposition 1.11.7:** Replace "Z_b" by "$\mathbb{Z}_b$". Make the same change in the proof of the proposition.

31. **Page 78, proof of Proposition 1.11.7:** Replace "we have to check that If" by "we have to check that if".

32. **Page 79, Exercise 1.11.2:** Replace "the only units are the constant polynomials" by "the only units are the nonzero constant polynomials".

33. **Page 79, Exercise 1.11.3:** Replace the mismatched quotation marks around "polynomial" by matching quotation marks.

34. **Page 86, Proposition 2.1.4:** Insert a period after the formula $(ab)^{-1} = b^{-1}a^{-1}$.

35. **Page 90, discussion of the general associative law:** Replace "three different product of four elements" by "three different products of four elements", and replace "four or less elements" by "four or fewer elements". In the list of four candidate products of five elements, insert a comma after $(ab)(cde)$.

36. **Page 91:** Replace "no more that $n-1$ elements" by "no more than $n-1$ elements".

37. **Page 91, Exercise 2.1.3:** delete the redundant sentence "Suppose e' and g are elements of G".

38. **Page 95, proof of Example 2.2.4:** Replace "the set of complex number of modulus 1" by "the set of complex numbers of modulus 1".

39. **Page 96:** Replace "The family of subgroups of a group G are partially ordered" by "The family of subgroups of a group G is partially ordered".

40. **Page 96, proof of Proposition 2.2.9:** Replace "is always is closed" by "is always closed".

41. **Page 97, proof of Example 2.2.13:** Replace "root or unity" by "root of unity".

42. **Page 101, Example 2.2.27:** Replace "The inclusion relations among the subgroups of $\mathbb{Z}_{12}$ is pictured" by "The inclusion relations among the subgroups of $\mathbb{Z}_{12}$ are pictured".

43. **Page 105, Exercise 2.2.11:** Replace "the product of a 2-cycle and a 3-cycle (disjoint) is 6,while" by "the order of the product of a 2-cycle and a 3-cycle disjoint from it is 6, while".

44. **Page 105, Exercise 2.2.23:** "therein $\mathbb{Z}_{200000}$" should be "there in $\mathbb{Z}_{200000}$".

45. **Page 113, Example 2.4.7:** Replace "the cyclic subgroup of G generated by g" by "the cyclic subgroup of G generated by a".

46. **Page 117, paragraph preceding Definition 2.4.21:** Replace "there is a homomorphisms" by "there is a homomorphism".

47. **Page 118, proof of Corollary 2.4.24:** Replace "a k cycle" by "a k-cycle".

48. **Page 119, Exercise 2.4.10:** Insert a period after "for all σ and $\tau \in S_n$".

49. **Page 119, Exercise 2.4.14:** Replace "k cycle" and "k cycles" by "k-cycle" and "k-cycles", respectively.

50. **Page 120, Exercise 2.4.16:** Replace "Show that two answers always agree" by "Show that the two answers always agree".

51. **Page 121, Definition 2.5.1:** Replace "Let H be subgroup of a group G" by "Let H be a subgroup of a group G".

52. **Page 127, first paragraph of Section 2.6:** Replace "$a \sim b \bmod H$)" by "$a \sim b \bmod H$", and replace "if, and only if, if $b^{-1}a \in H$" by "if, and only if, $b^{-1}a \in H$" (in the same sentence).

53. **Page 128, Example 2.6.3 (g):** Replace "an bijective map" by "a bijective map".

54. **Page 129, last paragraph:** Replace "we can define an relation on X" by "we can define a relation on X".

55. **Page 131, Example 2.6.10 (e):** Replace "an bijective map" by "a bijective map".

56. **Page 132, Proposition 2.6.13:** Replace "determine the same equivalence relation X" by "determine the same equivalence relation on X".

57. **Page 133, paragraph preceding Definition 2.6.14:** Replace "a canonical surjective map on G" by "a canonical surjective map from G".

58. **Page 135, proof of Theorem 2.7.1:** Replace "the definition of the product on G/H makes sense" by "the definition of the product on G/N makes sense".

59. **Pages 136–137, Example 2.7.4:** Replace "in the same coset modulo $\mathbb{Z}$" by "in the same coset of $\mathbb{Z}$ in $\mathbb{R}$". Replace each occurrence of "cosets of $\mathbb{R}$ modulo $\mathbb{Z}$" by "cosets of $\mathbb{Z}$ in $\mathbb{R}$". On page 137, replace "bijections between set $\mathbb{R}/\mathbb{Z}$" by "bijections between the set $\mathbb{R}/\mathbb{Z}$".

60. **Page 138, Example 2.7.5:** Replace "cosets of $\mathrm{Aff}(n)$ modulo N" by "cosets of N in $\mathrm{Aff}(n)$".

61. **Page 141, Example 2.7.12:** Replace "Morover" by "Moreover", and replace "homorphism theorem" by "homomorphism theorem".

62. **Page 144, Example 2.7.18:** Replace "The cyclic subgroup group generated by $[a]$" by "The cyclic subgroup generated by $[a]$".

63. **Page 146, Example 2.7.21:** Replace "then we have $X = \lambda X'$" by "Then we have $X = \lambda X'$".

64. **Page 147, Exercise 2.7.6 (a):** Replace "Show that $\mathrm{Aut}(G)$ of G is also a group" by "Show that $\mathrm{Aut}(G)$ is also a group".

65. **Page 157, Exercise 3.1.2:** "$\{e_a\}$" should be "$\{e_A\}$".

66. **Page 158, Exercise 3.1.7:** "Show that π_i surjective homomorphism" should be "Show that π_i is a surjective homomorphism".

67. **Page 164:** "The *kernel* of linear transformation" should be "The *kernel* of a linear transformation". Also, in Lemma 3.3.3, "then" at the beginning of the second sentence should be capitalized.

68. **Page 165, quotient-vector-space paragraph:** Delete the repeated word in "check that this this is well-defined", and replace "if $v + W = v' + W$ and, then" by "if $v + W = v' + W$, then".

69. **Page 166:** "straighforward" should be "straightforward", and "indclude" should be "include".

70. **Page 169, discussion of the empty set:** The statement that the empty set is linearly independent because there are no sequences of its elements is correct if "sequence" means a sequence of positive length, as in the book's convention. If sequences of length 0 are allowed (which is the standard convention in mathematics), there is exactly one such sequence, namely the empty sequence; its coefficient vector is the unique element of K^0, so the conclusion about linear independence remains correct.

71. **Page 172, Proposition 3.3.25:** "Let V a finite dimensional vector space" should be "Let V be ...".

72. **Page 172, proof of Corollary 3.3.26:** "Propostion" should be "Proposition".

73. **Page 174:** "several vectors spaces" should be "several vector spaces".

74. **Page 178:** "linear maps from V and W" should be "linear maps from V to W", and "preceeding" should be "preceding".

75. **Pages 179–180, dual-basis discussion and Proposition 3.4.2 (b):** Replace both occurrences of "is a a basis" by "is a basis".

76. **Page 183:** "subpace" should be "subspace", and the stray period after "Corollary 3.4.9" should be deleted.

77. **Page 187:** "Similarly is an equivalence relation" should be "Similarity is an equivalence relation".

78. **Page 190:** "ususal" should be "usual".

79. **Page 194:** "post–mulitplication" should be "post–multiplication".

80. **Page 195:** "it's own inverse" should be "its own inverse".

81. **Page 195, Smith-normal-form algorithm:** "If there is a element β" should be "If there is an element β".

82. **Page 198, proof of Theorem 3.5.13:** "a basis of Z^n" should be "a basis of $\mathbb{Z}^n$".

83. **Pages 202–204:** Replace "is a also an $\mathbb{Z}_p$-vector space" by "is also a $\mathbb{Z}_p$-vector space"; replace "an $\mathbb{Z}_p$-vector space" by "a $\mathbb{Z}_p$-vector space"; replace "irreducible" by "prime"; and replace "occuring in an prime factorization" by "occurring in a prime factorization".

84. **Page 209:** "We have already have observed" should be "We have already observed", and "decompostion" should be "decomposition".

85. **Page 212, Remark 3.6.26:** "the group of units of K^*" should be "the multiplicative group K^*" or "the group of units of K".

86. **Page 213:** Replace both references to "Lemma 3.6.25" by references to "Theorem 3.6.25".

87. **Page 216, first paragraph:** The paper models are in Appendix F, not Appendix E. Also replace "patterns for making paper model" by "patterns for making paper models".

88. **Page 239, first paragraph of Section 4.5:** Delete one occurrence of "by" in "implemented by by a linear isometry".

89. **Page 243, Definition 5.1.5:** The two proposed formulations of transitivity are equivalent only when X is nonempty. If $X = \varnothing$, there are no orbits, whereas "for any two elements $x, x' \in X$" is vacuously true. Add the hypothesis $X \neq \varnothing$, or choose one of the two formulations as the definition.

90. **Page 245, Definition 5.1.16:** Replace "$\mathrm{Cent}_G(x)$" by "$\mathrm{Cent}_G(g)$".

91. **Page 253, Remark 5.3.2:** "The rather unexpected answer that it is true" should be "The rather unexpected answer is that it is true".

92. **Page 254, Exercise 5.3.5:** "determined by rational 2-by-2 matrix" should be "determined by a rational 2-by-2 matrix".

93. **Page 258, Theorem 5.4.9:** "there is a $a \in G$" should be "there is an $a \in G$".

94. **Page 265, proof of Lemma 5.5.1:** "the intersections of the stabilizers" should be "the intersection of the stabilizers".

95. **Page 265, Remark 5.5.2:** "A_n is the only nontrivial normal subgroup of S_n" should read "A_n is the only nontrivial *proper* normal subgroup of S_n", since S_n itself is also a nontrivial normal subgroup.

96. **Page 284, Proposition 6.2.27 (b):** "interesection" should be "intersection".

97. **Page 289, quotient-ring discussion:** Delete one occurrence of "this" in "check that this this is well defined", and insert a space in "degree of f,the product".

98. **Page 305, Lemma 6.5.18:** "properties of an nonzero nonunit element" should be "properties of a nonzero nonunit element".

99. **Page 310, Corollary 6.6.5 and Example 6.6.6:** Replace "unique factorization domain domain" by "unique factorization domain", "an nonzero" by "a nonzero", and "In an UFD" by "In a UFD".

100. **Page 355, Definition 8.1.26:** The subscript "s" on the left hand side of the first equality should be "n".

101. **Page 363, Lemma 8.3.3:** "acts S_n" should be "S_n acts".

102. **Page 363, proof of Lemma 8.3.3:** In the long computation, replace "$x_{\sigma(\tau(1))}, \ldots, x_{\sigma(\tau(1))}$" by "$x_{\sigma(\tau(1))}, \ldots, x_{\sigma(\tau(n))}$".

103. **Page 375, proof of Lemma 8.4.1:** In "Each w_j has a unique expression as an Râ€"linear combination of the basis elements v_j", it would be better to replace"v_j" by "v_i". Replace "as an Râ€"linear combinations" by "as an Râ€"linear combination". In the formula for v_j (between (8.4.1) and (8.4.2)), replace "$b_{n,j}w_n$" by "$b_{m,j}w_m$". Finally, in the last sentence of the proof, "two basis" should be "two bases".

104. **Page 379, definition of length:** The period before "where u is a unit and the p_i's are irreducibles" should be a comma.

105. **Page 382, proof of Lemma 8.4.11:** "as an Râ€"linear combinations" should be "as an Râ€"linear combination".

106. **Page 399, paragraph after the block-diagonal display:** Delete one occurrence of "subspace" in "the invariant subspace subspace V_i".

107. **Page 410, Definition 8.6.14:** "an *nonzero* vector" should be "a *nonzero* vector".

108. **Page 417, Definition 8.7.7:** "similar A" should be "similar to A".

109. **Page 435, proof of Proposition 9.4.4:** There is a closing parenthesis too much in "$k_n\sigma(\alpha^n))$".

110. **Page 453, Exercise 9.6.15:** The "g" should be a mathmode "g".

111. **Page 457:** Replace "(b_j/b_n)" by "(b_j/b_m)" (shortly after (9.7.2)). In the next sentence, replace "and the total degree as a polynomial in the (b_j/b_m) is m" by "and the total degree as a polynomial in the (b_j/b_m) is n".

112. **Page 466, proof of Lemma 9.8.5:** "By by the Galois correspondence" should be "By the Galois correspondence".

113. **Page 498, Exercise 11.1.1:** "there is an most one point" should be "there is at most one point".

114. **Page 547, Definitions E.1 and E.2:** "A linear combination of set S" should be "A linear combination of a set S", and "A set S vectors" should be "A set S of vectors".

115. **Page 548, first sentence:** "a linear independent set" should be "a linearly independent set".

116. **Page 548, second sentence:** "The empty set is linearly independent, since there are no sequences of its elements". There are! But only the empty one, so the conclusion still holds.

117. **Page 550, first paragraph after Definition E.6:** The map is printed as $x \mapsto= Mx$; delete the extraneous equals sign.

118. **Page 551, first line:** The identity matrix E_n acts on K^n, not on the undefined K^N.

119. **Page 551, second paragraph:** "$\mathrm{Hom}_k(K^n, K^m)$" should be "$\mathrm{Hom}_K(K^n, K^m)$".

120. **Page 552, second paragraph:** Replace "$T(\boldsymbol{x}) = \sum \alpha_i T(\boldsymbol{e}_i)$" by "$T(\boldsymbol{x}) = \sum \alpha_i T(\widehat{\boldsymbol{e}}_i)$".

121. **Page 555, second paragraph:** "A matrix has a left inverse" should be "A matrix M has a left inverse".

122. **Page 556, definition of an inner product:** The third property "$\langle \boldsymbol{x}, \boldsymbol{x} \rangle \geq 0$ and $\langle \boldsymbol{x}, \boldsymbol{x} \rangle = 0$ if, and only if $\boldsymbol{x} = \boldsymbol{0}$" is confusingly worded. Of course, what is meant is that $\langle \boldsymbol{x}, \boldsymbol{x} \rangle \geq 0$ holds for each vector $\boldsymbol{x}$, whereas $\langle \boldsymbol{x}, \boldsymbol{x} \rangle = 0$ holds if and only if $\boldsymbol{x} = \boldsymbol{0}$.

123. **Page 556, Section E.3:** "Cauchy–Schwartz" should be "Cauchy–Schwarz" (twice).

124. **Page 557, first paragraph:** "$v_i, \ldots, v_s$" should be "$v_1, \ldots, v_s$".

125. **Page 557, third paragraph:** "$\{v_i, \ldots, v_n\}$" should be "$\{v_1, \ldots, v_n\}$".

126. **Page 557, fourth paragraph:** Delete one occurrence of "to" in "w_j is orthogonal to to B_j".