**ERRATA**

GRAPH THEORY: Modeling, Applications, and Algorithms,
by Geir Agnarsson and Ray Greenlaw
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- 2nd printed page (Library of Congress, etc.): line 3: "Senionr Editor" should be "Senior Editor".
- Page **xii**, line 4: "Almost all proofs other than of some exceptionally technical theorems" (the crucial words "other than" are missing!).
- Page **xvi**, line -12: "ot thak" should be "to thank".
- Page 9, line -13: "$g : Y \mapsto Z$" should be "$g : Y \to Z$".
- Page 9, line -3: "$h(x) = 1 - \frac{x}{3}$" should be "$h(x) = (1 - x)/3$".
- Page 12, line "$e_6$ is adjacent both to itself and to $e_5$" should be "$e_6$ is adjacent to $e_5$".
- Page 28, Exercise 1.23: "less than relation ($<$)" should be "less than or equal relation ($\leq$)".
- Page 29, Exercise 1.27: "$G_{\gcd(k,n)}$" should be "$\vec{G}_{\gcd(k,n)}$".
- Page 30, line 3: should read $E(...) = ...$, not $V(...) = ....$
- Page 45, line 2: "is satisfied by the graph on the right, but not by the one on the left."
- Page 51, line 15: "$G_{\sigma(n)}$" should be "$G_{\sigma(k)}$".
- Page 54, Definition 2.37: In the 2nd itemized condition "$i \in \{1, \ldots, k-1\}$" should be "$i \in \{0, \ldots, k-1\}$".
- Page 56, Figure 2.18: "$\phi_1$" should be "$f_1$".
- Page 61, Exercise 2.3: add assumption that $G$ is simple.
- Page 61, Exercise 2.11: add assumption that $G$ and $G'$ are simple.
- Page 63, Exercise 2.22: should read "... every regular simple graph is regular.".
- Page 63, Exercise 2.23: should read "Show that if a simple graph $G$ on $n > 1$ vertices..." (since 0 is not a natural number, so 1 is not of the given form).

- Page 63, Exercise 2.30: should read "simple contraction" instead of "contraction" in both places.
- Page 64, Exercise 2.26: the second sentence should read "Viewing these paths as subgraphs of $G$, show that $p_1 \triangle p_2$ constitutes an edge-disjoint union of one or more cycles, possibly along with some isolated vertices.".
- Page 70, Theorem 3.7, 1st line: the assumptions can be weakened by deleting "simple".
- Page 85, line -5: "$T_\ell l$" should be "$T_\ell$".
- Page 92, line 3: "$i \in \{0, 1, \ldots, n-1\}$" should be "$i \in \{0, 1, \ldots, k-1\}$".
- Page 94, Exercise 3.7: note that the exercise can be improved by asking that the bound from the previous exercise be proved tight for all $n \geq 2$.
- Page 95, Exercise 3.18: should start "For all $k \geq 0$, show ...".
- Page 99, Definition 4.1: The definition of $\tau$ is here wrong. Item number 3 should read as follows: "For a fixed labeling of the vertices of $G$, the number of distinct spanning trees of $G$ is denoted by $\tau(G)$ and the number of spanning forests of $G$ is denoted by $\tau_f(G)$."
- Page 99, Remark 4.2: with the the above fix of Definition 4.1 in mind, the first bullet should read as follows: "If a graph $G$ is connected, then $\tau_f(G) = \tau(G)$ is the number of spanning trees in $G$."
- Page 99, Observation 4.3: in the second item, $\tau(G)$ should be replaced by $\tau_f(G)$ in the displayed formula.
- Page 100, Theorem 4.4, as it stands, is not entirely correct: $\tau(G)$ is defined in Definition 4.1 as the number of spanning forests of $G$, so the note right after Theorem 4.4 is wrong, since $\tau(G - e) \neq 0$. However, if we in Definition 4.1 define $\tau(G)$ to be the number of spanning trees of $G$, so $\tau(G) = 0$ if $G$ is not connected, then Theorem 4.4 is correct.
- Page 102, lines 16, 25, 27, 30: "Tree to Prüfer code" should be "Tree from Prüfer code".
- Page 122, line 12: "$V(e) \geq 0$" should be "$W(e) \geq 0$".
- Page 125, line 2 (Proof of Theorem 4.40): "$T$" should be "$T_1$".
- Page 128, Exercise 4.19: restrict to loopless general graphs for the second and third questions. The third question should read "... two adjacent vertices ..." instead of "... two distinct pairs of vertices ...".
- Page 128, Exercise 4.22: replace "all entries" by "all off-diagonal entries". Alternatively, (a) limit the assertion to graphs with $n \geq 3$ vertices, or (b) insist the sum defining $\mathsf{Y}$ starts with $\mathsf{A}(G)^0 = \mathsf{I}_n$.

- Page 129, Exercise 4.33: should read "... for any $n \geq 2$, ...".
- Page 129, Exercise 4.34: add "... , for $n \geq 3$." at the end of the first sentence.
- Page 130, Exercise 4.38: add assumption that G is loopless.
- Page 130, line -2 (in Exercise 4.39): should read "$W(e)$", not "$E(e)$".
- Page 133, Definition 5.1: line 1: "if there are $X$ and $Y$..." should read "if there are nonempty $X$ and $Y$...".
- Page 136, Corollary. 5.8: needs to read "A connected non-Eulerian graph $G$ has ..." (since a trail is allowed to be closed).
- Page 140, Theorem 5.16: the assumptions can be weakened by deleting "simple".
- Page 148, The second line in the displayed formula should be: "$N^-(u) \cup N^+(u) = V(\vec{G}) \setminus \{u\}$.".
- Page 154, Figure 5.12: in the first graph the directed edge $(u_1, u_6)$ is missing.
- Page 156, Exercise 5.11: "...contain $2k$ vertices..." should read "contain exactly $2k$ vertices...".
- Page 156, Exercise 5.12: the penultimate sentence of the exercise should read "... the last edge ..." instead of "... the least edge ...".
- Page 157, Exercise 5.20: This problem doesn't make sense as is. It should be as follows:

  "Let $G$ be a simple graph on $n$ vertices and $k$ components. Show that

  $$d_G(u) + d_G(v) \leq 2n - k - 1,$$

  for all $u, v \in V(G)$. Show further that the upper bound of $2n - k - 1$ can be reached for all $n$ and $k$. Also show that if we assume $u$ and $v$ to be in distinct components, then the upper bound is $n - k$, and that this is also sharp."
- Page 159, Exercise 5.43: the second line should read "contain a directed cycle.".
- Page 159, Exercise 5.46: the problem is not correct as stated. It should read " Let $\vec{G}$ be a digraph on $n$ vertices, and let $\mathsf{I}_n$ be the $n \times n$ identity matrix. Show that if $\vec{G}$ is acyclic, then $\mathsf{I}_n - \mathsf{A}(\vec{G})$ is an invertible matrix. Give an example of an simple non-acyclic digraph $\vec{G}$ where $\mathsf{I}_n - \mathsf{A}(\vec{G})$ is invertible. [*Hint:* A simple digraph on $n = 3$ vertices and 4 directed edges will work.]".

- Page 167, Theorem 6.20: should read "For a simple graph $G$ on two or more vertices, we have...".
- Page 167, Note 6.21: should read "... for all $n \geq 2$.".
- Page 167, Example 6.22: should read "... integers with $n-1 \leq m \leq n(n-1)/2$. ...". (This is so that the Harary graph will be simple.)
- Page 169, Corollary. 6.28: add assumption that $G$ has no isolated vertices.
- Page 171, Theorem 6.33: condition 3 should read "... there are two paths in $G$ connecting them which are vertex-disjoint except at the endvertices."
- Page 187, Corollary 6.54: add assumption that $u \neq v$.
- Page 187, Theorem 6.55: add assumption that $u \neq v$.
- Page 188, Theorem 6.56: add assumption that $u \neq v$ and there is no edge in $G$ from $u$ to $v$.
- Page 189, Theorem 6.57: add assumptions that $u \neq v$ and $u$ not adjacent to $v$.
- Page 190, Exercise 6.5: add at the end "and there is some $u, v$-path in $G$.".
- Page 190, Exercise 6.6: add the hypothesis that $G$ has $n \geq 2$ vertices.
- Page 190, Exercise 6.7: add the hypothesis that $G$ has $n \geq 2$ vertices.
- Page 191, Exercise 6.13: should read: "any connected simple graph...". Also, correct the hypothesis to $n \geq 2$.
- Page 191, Exercise 6.15: add the hypotheses that $\Delta \geq 2$ and $n \geq \Delta+1$.
- Page 192, Exercise 6.26: the hint should read that $0 \leq f(e) \leq c(e)$ for every edge $e$ of the network.
- Page 192, Exercise 6.30: the last sentence should read "In general, is it possible to have an arbitrary number of maximum flows ...".
- Page 194, Exercise 6.40: the 2nd line should read "Show that for any distinct vertices $u$ and $v$, the minimum number ...".
- Page 194, Exercise 6.41: the 10th line should read "...path in $\vec{G} - M_d$,...", and not "... path in $G$, ...".
- Page 197, Definition 7.3: as it stands, this definition is too relaxed. The following edited versions of the definition should fix this.

  Let $G$ be a graph and $S$ a surface. We say that $G$ is *embeddable* in $S$ if $G$ has a representation in $S$, by injections $V(G) \hookrightarrow S$; $u \mapsto \tilde{x}_u$ and $E(G) \hookrightarrow \mathbf{P}(S)$; $e \mapsto C_e$ respectively, in the following way:

1. Each edge $e \in E(G)$ is represented by a continuous curve $\xi_e : [0;1] \to S$, so $\xi_e([0;1]) = C_e$, where the endpoints $\xi_e(0)$ and $\xi_e(1)$ represent the endvertices of $e$. The restricted open curve $\xi_e : ]0;1[ \to S$ is always injective.
2. Two curves $C_e$ and $C_f$, representing distinct edges $e, f \in E(G)$, intersect if, and only if they are adjacent in $G$, in which case their intersection points are precisely the endpoints representing the common endvertices of $e$ and $f$.
3. The sets in $\{\{\tilde{x}_u\} : u \in V(G)\} \cup \{\xi_e(]0;1[) : e \in E(G)\}$ are pairwise disjoint pointsets in $S$.

- Page 200, Note 7.8: "can made" should be "can be made".
- Page 201, line 10: "We conclude this chapter" should be "We conclude this section".
- Page 202, Cor. 7.15: add assumption that $n \geq 3$.
- Page 208, Note 7.29, 1st line: should read "...homeomorphic to a given graph $H$ with no vertices of degree 2, then ...".
- Page 214, 2nd sentence of 1st paragraph after Note 7.34: should read "A property of graphs which is preserved under taking minors is called hereditary."
- Page 226, Cor. 7.54: add assumption that $n \geq 3$.
- Page 226, Theorem 7.55: should read "... on $n \geq 3$ vertices, ...".
- Page 228, Exercise 7.1: "$r_2$, $r_3$ and $r_4$" should be "$r_1$, $r_2$ and $r_3$".
- Page 229, Exercise 7.5: should read "Let $G$ be a plane graph ...".
- Page 229, Exercise 7.6: should read "Show that a simple plane graph ...".
- Page 230, Exercise 7.23: should read "Eulerian" instead of "Euler" in four places.
- Page 230, Exercise 7.26: 2nd line should read "vertex disjoint paths from $u$ to $v$.".
- Page 231, Exercise 7.28: Theorem 7.59 is not correct as stated. Condition 2 should read "No subgraph of $G$ can be obtained from $K_4$ or $K_{2,3}$ by subdividing edges.".
- Page 231, Exercise 7.34: should read "... in a simple graph with ...".
- Page 241, last line of proof of Theorem 8.19 should be "$(\Delta+1)$-vertex coloring...".

- Page 242, line -2: should read "adjacent" instead of "connected" in both places.
- Page 248, Theorem 8.28: should read "For a loopless planar graph ...".
- Page 249, Theorem 8.29: should read "For a loopless planar graph ...".
- Page 249, Theorem 8.30: should read "For a loopless graph G ...".
- Page 250, Theorem 8.31: should read "For a loopless graph G ...".
- Page 251, line 10 (first displayed formula): "$2e$" should be "$2m$".
- Page 252, Definition 8.35: should read "... for all distinct $e, f \in E(G)$ ...".
- Page 253, line 1: "$V(E)$" should be "$E(G)$".
- Page 259, line 18: "...when $n$ is odd..." should be "...when $n$ is even...".
- Page 259, line 19: "...when $n$ is even." should be "...when $n$ is odd.".
- Page 262, Exercise 8.20: "$d_G(u) \geq \chi(G)$" should be "$d_G(u) \geq \chi(G')$" and "$d_{\overline{G}}(u) \geq \chi(\overline{G})$" should be "$d_{\overline{G}}(u) \geq \chi(\overline{G'})$".
- Page 262, Exercise 8.21, part (b): $\ell - 2$ should be $\ell - 1$, and part (c): $\ell(G) - 1$ should be $\ell(G) + 1$.
- Page 263, Exercise 8.30: "$n\binom{k}{2}$" should read "$m\binom{k+1}{2}$".
- Page 264, Exercise 8.37: 1st line should read "... a simple graph $G$ ... if $\chi(G) \leq 4$?". 2nd line should read "... a simple planar graph ...".
- Page 282, Theorem 9.24: Strictly speaking, this theorem should be attributed to Koebe [1] and Andreev [2] in addition to Thurston. Koebe's original proof only covered the case for fully triangulated planar graphs. Thurston rediscovered the theorem and reduced the proof to a theorem by Andreev. His proof works for all planar graphs. Thurston never formally published his proof, but a sketch of his proof is in his cited lecture notes. For additional citations and history see [3, p. 118].
- Page 298, Exercise 9.26 part (b): "$C_2^7$" should be "$C_7^2$".
- Page 306, line -2: "$D = \{u_1, u_5, u_8\}$" should be "$D = \{u_1, u_5, u_7\}$" (as depicted in Figure 10.5.)
- Page 318, line -6: "$a \in A \setminus \{x\}$" should be "$a \in S \setminus \{x\}$".
- Page 352, Exercise 11.12, line 4: "$F_1 = 0$, $F_1 = 1$" should be "$F_1 = 1$, $F_2 = 1$".

- Page 368, lines 5 and 6: "... $+2x^2$" should be "... $-2x^2$" in both places.
- Page 417, Exercise 13.7: should read "Is it true that $\lg(O(f(n))) = O(\lg(f(n)))$? Justify your answer.".
- Page 444, Index: "Seymour, Paul" and "Seymour, Paul D." are the same person and should be listed once as "Seymour, Paul D.". Similarly, "Slater, Peter J." should be listed once.

## References


[1] Paul Koebe; Kontaktprobleme der konformen Abbildung, *Ber. Verh. Sächs. Akademie der Wissenshaften Leipzig*, Math.-Phys. Klasse **88**, 141 – 164, (1936).

[2] E. M .Andreev; Convex polyhedra in Lobačevskiĭspaces. (Russian), *Matematicheskiĭ Sbornik. Novaya Seriya*, **81 (123)**, 445 – 478, (1970).

[3] Günter M. Ziegler: Lectures on Polytopes, *Graduate Texts in Mathematics*, **GTM 152**, Springer-Verlag New York Inc. (1995).


I will do my best to maintain this errata sheet for further printings and for possible additional editions of the book. Please drop me a line at `geir@math.gmu.edu` if you find a typo/mistake. On behalf of the authors, Ray and me, I thank you all collectively for your input and help.

Yours, Geir Agnarsson