ERRATA 1.2
for
Introduction to Algorithms
by Cormen, Leiserson, and Rivest
July 28, 1994

This list describes the known bugs in the second and subsequent printings of the first edition of Introduction to Algorithms. An errata sheet for the first printing is available separately.

Typically, page and line numbers are given to localize the error. A negative line number indicates numbering from the bottom up. The finder of each bug is credited on the right margin. Actual text from the book is surrounded by ⟨⟨ ⟩⟩. Replacement text, where provided, is surrounded by ⟨⟨ ⟩⟩.

A PostScript version of this errata sheet is available via an Internet electronic mail server. To receive instructions on how to use this service, send electronic mail to algorithms@theory.lcs.mit.edu with “Subject: help” in the message header. The instructions also describe how to submit bug reports by email and how to obtain errata for the first printing. We regret that we cannot personally respond to all mail.

Page xvi, line 28

Hershel Safer

Change ⟨⟨ Herschel Safer ⟩⟩ to ⟨⟨ Hershel Safer ⟩⟩.

Page 11, Exercise 1.2-3

Julie Sussman

Exercise 1.2-3 depends on material introduced later in Chapter 1. Move it to Section 1.4.

Page 15, Exercise 1.3-3

Stanley Selkow

Change ⟨⟨ Use mathematical induction to show that the solution of the recurrence ⟩⟩ to ⟨⟨ Use mathematical induction to show that when n is an exact power of 2, the solution of the recurrence ⟩⟩.

Page 24, lines 22–24

Charles E. Leiserson

Replace the text ⟨⟨ every member of Θ(g(n)) ⟩⟩ with ⟨⟨ every member f(n) ∈ Θ(g(n)) ⟩⟩. After the end of the sentence, insert the sentence ⟨⟨ An asymptotically positive function is one which is strictly positive for all sufficiently large n. ⟩⟩. As a result of this change, on page 33, line 9, the words ⟨⟨ asymptotically positive ⟩⟩ should no longer be boldfaced.
The text ((on or above g(n).)) should be changed to ((on or above cg(n)).).

The condition ((b \neq 0)) should be changed to ((b > 0)).

The statement ((Thus, any positive exponential function grows faster than any polynomial.) should be restated ((Thus, any exponential function with a base strictly greater than 1 grows faster than any polynomial function.).)

The text ((\lim_{n \to \infty} \frac{\log^b n}{2^{\log^a n}})) should be replaced by ((\lim_{n \to \infty} \frac{\log^b n}{(2^a)^{\log^b n}})).

The upper bound for n! is incorrect for n \leq 7, but is correct, although loose, for n \geq 8. The upper bound should be changed to read as follows: ((n! \leq \sqrt{2\pi n}(n/e)^n e^{1/12n}).

The symbol ((\leq)) should be replaced by ((>).

The constraint ((c \geq 2)) should be changed to ((c \geq 1)).

The text ((\text{height log}_a n)) should be changed to ((\text{height log}_8 n)).

The symbol ((\leq)) should be replaced by ((=)).

Change ((n \leq 2)) to ((n \leq 8)).
Page 82, line 11

Lon Sunshine

Change \((\text{equivalent to } A.)\) to \((\text{equivalent to } a.)\).

Page 87, line 14

Charles Leiserson

The term isolated is not defined. Add the sentence \(\langle A \text{ vertex whose degree is } 0, \text{such as vertex } 4 \text{ in Figure 5.2(b), is isolated.}\rangle \) after \(\langle \text{has degree } 2.\rangle\).

Page 88, lines 12–13

Bruce Maggs

The text \(\langle \text{In an undirected graph, a path } \langle v_0, v_1, \ldots, v_k \rangle \text{ forms a cycle if } v_0 = v_k \text{ and } v_1, v_2, \ldots, v_k \text{ are distinct.}\rangle \) should be replaced by \(\langle \text{In an undirected graph, a path } \langle v_0, v_1, \ldots, v_k \rangle \text{ forms a (simple) cycle if } k \geq 3, v_0 = v_k, \text{ and } v_1, v_2, \ldots, v_k \text{ are distinct.}\rangle\).

Page 90, Exercise 5.4-2

Bruce Maggs

The exercise should be eliminated, because the bug fix to the definition of a cycle in an undirected graph on page 88, lines 12–13 obviates it.

Page 92, line 10

Julie Sussman

The text \(\langle \text{one path}\rangle \) should be changed to \(\langle \text{one simple path}\rangle\).

Page 115, Exercise 6.3-9

Bobby Blumofe

The equation to prove should read \(\langle \text{Var}[aX] = a^2\text{Var}[X]\rangle\), not \(\langle \text{Var}[aX] = a^2\text{Var}[x]\rangle\) bug fixed

Page 121, line –3

Julie Sussman

The expression \(\langle \ldots(1-p)^{(n-k-1)}\rangle\) has an extra right parenthesis. It should be replaced by \(\langle \ldots(1-p)^{(n-k-1)}\rangle\).

Page 124, line –1, and page 125, line 1

Tom Cormen

Replace the inequalities \(\langle q \leq 1, e^{\alpha q} \leq e^\alpha, \text{and } e^{-\alpha y} \leq 1 \rangle\) by \(\langle q_i \leq 1, e^{\alpha q_i} \leq e^\alpha, \text{and } e^{-\alpha y} \rangle\).

Page 130, line 11

David Wolfe

The last inequality in bounding \(E[n]\) should be an equality.
The “fact” given on page 132, line 2, is false (e.g., for $n = 2^{10}$). The text is modified to read:

\[
(1 - 1/\sqrt{n})^{2n/\lfloor \lg n \rfloor} \leq (1 - 1/\sqrt{n})^{2n/\lg n - 1} \\
\leq e^{-(2n/\lg n - 1)/\sqrt{n}} \\
= O(e^{-\frac{\lg n}{\sqrt{n}}} ) \\
= O(1/n) .
\]

For this argument, we used inequality (2.7), $1 + x \leq e^x$.

Thus, the probability that the longest streak exceeds $\lfloor \lg n \rfloor/2$ is at least $1 - O(1/n)$. Since the longest streak has length at least 0, the expected length of the longest streak is at least

\[
(\lfloor \lg n \rfloor/2)(1 - O(1/n)) + 0 \cdot (1/n) = \Omega(\lg n) .
\]

Page 133 (Problem 6-2), line -8 to -6

The problem statement now gives a simpler assumption about the input, which guarantees that the input numbers are distinct: \(\text{Assume that the numbers in } A \text{ are a random permutation of } n \text{ distinct numbers.}\) In part (a), the element $x$ is also now specified to be randomly chosen from a set of \(\{n\} \text{ distinct numbers, instead of a set of } \binom{n}{n} \text{ distinct numbers.}\)

Page 140, first sentence of Section 7.1

Add the word \(\text{nearly}\) before the phrase \(\text{(complete binary tree)}\).

Page 142, Exercise 7.1-3

Change the exercise to read \(\text{Show that in any subtree of a heap, the root of the subtree contains the largest value occurring anywhere in that subtree.}\).

Page 142, Exercise 7.1-4

Change the exercise to read \(\text{Where in a heap might the smallest element reside, assuming that all elements are distinct?}\).

Page 145, lines 20–22

The text \(\text{Our tighter analysis relies on the properties that in an } n\text{-element heap there are at most } \left\lfloor \frac{n}{2^h+1} \right\rfloor \text{ nodes of any height } h \text{ (see Exercise 7.3-3).}\) is replaced to read \(\text{Our tighter analysis relies on the properties that an } n\text{-element heap has height } \lfloor \lg n \rfloor \text{ (see Exercise 7.1-2) and at most } \left\lfloor \frac{n}{2^h+1} \right\rfloor \text{ nodes of any height } h \text{ (see Exercise 7.3-3).}\)
Page 147, Exercise 7.3-3  
This exercise should be starred.

Page 150, Exercise 7.5-1  
Since inserting 3 into the heap is trivial, the exercise is changed to insert the value 10 instead.

Page 159, line 22  
The text ([asks to you show]) should be replaced by ([asks to you show]).

Page 160, Exercise 8.2-2  
Change ([when the array A is sorted in nonincreasing order]) to ([when the array A contains distinct elements and is sorted in decreasing order]).

Page 170, part (c) of Problem 8-4  
Append the sentence ([Maintain the O(n lg n) expected running time of the algorithm]) to the end of the problem part.

Page 183, Problem 9-1  
There are several minor errors in parts (b)-(d). They should be replaced by

b. Let \( D(T) \) denote the external path length of a tree \( T \); that is, \( D(T) \) is the sum of the depths of all the leaves of \( T \). Let \( T \) be a tree with \( k \geq 1 \) leaves, and let \( LT \) and \( RT \) be the left and right subtrees of \( T \). Show that \( D(T) = D(LT) + D(RT) + k \).

c. Let \( d(k) \) be the minimum value of \( D(T) \) over all decision trees \( T \) with \( k \geq 1 \) leaves. Show that \( d(k) = \min_{1 \leq i \leq k-1} \{ d(i) + d(k-i) + k \} \). (Hint: Consider a decision tree \( T \) with \( k \) leaves that achieves the minimum. Let \( i \) be the number of leaves in \( LT \) and \( k-i \) the number of leaves in \( RT \).)

d. Prove that for a given value of \( k \geq 1 \) and \( i \) in the range \( 1 \leq i \leq k-1 \), the function \( i \lg i + (k-i) \lg (k-i) \) is minimized at \( i = k/2 \). Conclude that \( d(k) = \Omega(k \lg k) \).

Page 185, first paragraph  
To remove ambiguity and needless later verbiage, the definition of “median” is changed so that the phrase “the median” of a set is always well-defined. This change also causes some small changes to be made on pages 190 and 193. The revised introductory paragraph to the chapter now reads as follows. ([The ith order statistic of a set of \( n \) elements is the \( i \)th smallest element.])
For example, the minimum of a set of elements is the first order statistic \((i = 1)\), and the maximum is the \(n\)th order statistic \((i = n)\). A median, informally, is the "halfway point" of the set. When \(n\) is odd, the median is unique, occurring at \(i = (n + 1)/2\). When \(n\) is even, there are two medians, occurring at \(i = n/2\) and \(i = n/2 + 1\). Thus, regardless of the parity of \(n\), medians occur at \(i = \lfloor (n + 1)/2 \rfloor\) (the lower median) and \(i = \lceil (n + 1)/2 \rceil\) (the upper median). For simplicity in this text, however, we consistently use the phrase "the median" to refer to the lower median.

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Page 186, last paragraph  
Dick Johnsonbaugh

The bound claimed in this paragraph is tightened to \(3 \lfloor n/2 \rfloor - 2\), and a sentence justifying this is added: "The first pair needs only one comparison to establish the initial values for the current minimum and current maximum, which accounts for the -2 term." Also, the word "necessary" is changed to "sufficient" in the first sentence.

Page 189, line 3 (2nd line of equations)  
Julie Sussman

This should read \(\leq\) rather than \(\leq\).

Page 190  
Ron Rivest

The description of SELECT is improved to include a description of the base case \((n = 1)\) of the recursion; the following sentence is added: "If \(n = 1\) then SELECT merely returns its only input value as the ith smallest."

Page 190, step 2 of procedure SELECT  
Ronald Greenberg

To maintain consistency with the revised definition of median (see bug report for page 185), and for simplicity in the algorithm, step 2 is revised to read as follows: "Find the median of each of the \(\lceil n/5 \rceil\) groups by insertion sorting the elements of each group (of which there are \(5\) at most) and then picking the median from the sorted list of group elements."

Page 191, Exercise 10.3-1  
Ron Rivest

To make the problem a little easier, the last part of the exercise, "How about groups of \(3^2\)?" is replaced by the text "Argue that SELECT will not run in linear time if groups of \(3\) are used."

Page 193, Problems 10-1 (a) and (b)  
Ronald Greenberg

Commas should be inserted before the word "and" in both parts.

Page 193, Problem 10-2  
Ronald Greenberg

To achieve consistency with the revised definition of median (see bug report for page 185), the introductory paragraph of this problem was revised as follows:
For $n$ distinct elements $x_1, x_2, \ldots, x_n$ with positive weights $w_1, w_2, \ldots, w_n$ such that $\sum_{i=1}^{n} w_i = 1$, the **weighted median** is the element $x_k$ satisfying

$$\sum_{x_i < x_k} w_i < \frac{1}{2}$$

and

$$\sum_{x_i > x_k} w_i \leq \frac{1}{2}.$$  

(This is actually the **weighted lower median**; the **weighted upper median** would be defined similarly.)

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**Page 194, line -5**  
*Julie Sussman*

The words, "linear-time" are added after the phrase "worst-case.”

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**Page 208, Exercise 11.2-8, line 3**  
*Julie Sussman*

The word ((index)) should be changed to ((pointer)).

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**Page 212, 4 lines after the code for Free-Object**  
*Dale Russell*

The word ((three)) should be replaced by ((two)).

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**Page 217, Problem 11-3, line 6**  
*Julie Sussman*

The word “in” has been left out of the sentence. The sentence can be further improved by replacing the phrase ((much faster than linear time.)) with ((in $o(n)$ time.).)

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**Page 217, Problem 11-3**  
*John Gateley*

The code for Compact-List-Search does not work properly when searching for the first element of the list. The test ((key[i] < k)) in line 3 of the code should be replaced by ((key[i] \leq k)).

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**Page 228, line -16**  
*Margrit Betke*

The text ((a = 2000/3)) should be replaced with ((2000/3)).

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**Page 234, lines 6-7 of first paragraph**  
*Disk Johnsonbaugh*

The sentence, ((We would then modify the procedure HASH-SEARCH so that it keeps on looking when it sees the value DELETED, while HASH-INSERT would treat such a slot as if it were empty so that a new key can be inserted,)) is replaced by the text, ((We would then modify the procedure HASH-INSERT to treat such a slot as if it were empty so that a new key can be inserted. No modification of HASH-SEARCH is needed, since it will pass over DELETED values while searching.))
Page 234, line -11

The text \((\{h(k, 1), h(k, 2), \ldots, h(k, m)\})\) is replaced by \((\{h(k, 0), h(k, 1), \ldots, h(k, m-1)\})\).

Page 236, lines -9 to -6

To clarify the example, the value of \(m'\) is given, so that the sentence now reads, \(\langle\) For example, if \(k = 123456, m = 701,\) and \(m' = 700,\) we have \(h_1(k) = 80\) and \(h_2(k) = 257,\) so the first probe is to position 80, and then every 257th slot (modulo \(m\)) is examined until the key is found or every slot is examined. \(\rangle\)

Page 238, lines -7 and -6

Add the words “at most” in two places, so these two lines now read as follows: \(\langle\) number of probes in an unsuccessful search is at most \(1/(1 - .5)/2.\) If it is 90 percent full, the average number of probes is at most \(1/(1 - .9) = 10.\rangle\).

Page 239, line 4

The text \((\{\text{number of probes is } 1/(1 - \alpha)\})\) should be replaced with \((\{\text{number of probes is at most } 1/(1 - \alpha)\})\).

Page 239, Theorem 12.7

The bound in Theorem 12.7 is not very good for smallish \(\alpha\) because of the unnecessary term \(1/\alpha.\) \(\langle\) Note that the bound in the theorem actually decreases as \(\alpha\) increases from 0 to . 7! \rangle\) Replace the text \((\langle\) \(1/\alpha \ln \frac{1}{1 - \alpha} + 1/\alpha\rangle\) in the statement of the theorem with the text \((\langle\) \(1/\alpha \ln \frac{1}{1 - \alpha}\rangle\). Replace lines -4 to -2 of the proof with \(\langle\)

\[
\frac{1}{\alpha}(H_m - H_{m-n}) = \frac{1}{\alpha} \sum_{k=m-n+1}^{m} 1/k \\
\leq \frac{1}{\alpha} \int_{m-n}^{m} (1/x) \, dx \\
= \frac{1}{\alpha} \ln(m/(m-n)) \\
= \frac{1}{\alpha} \ln(1/(1 - \alpha))
\]

\(\rangle\) The constants on lines -2 and -1 of page 239 change from \((\langle\) 3.387\rangle\) to \((\langle\) 1.387\rangle\) and from \((\langle\) 3.670\rangle\) to \((\langle\) 2.559\rangle\).

Page 239, line -3

Add the words \((\langle\) in a successful search\rangle\) after the phrase \((\langle\) expected number of probes\rangle\).
Dick Johnsonbaugh

Page 240, Exercise 12.4-4

Replace the second sentence by \((\text{Give upper bounds on the expected number of probes in an unsuccessful search and on the expected number of probes in a successful search.})\)

Ron Rivest

Page 240, Exercise 12.4-6

This exercise becomes irrelevant once the improvement to Theorem 12.7 noted in the erratum for page 239 has been made. Delete the exercise.

Julie Sussman

Page 242, part (d) of Problem 12-3

In order to be usable in part (3), the statement of part (d) is modified to read:
\((\text{Conclude that } P_k < 1/n^2 \text{ for } k \geq k_0 = c \lg n / \lg \lg n.}\)

Bug fixed

Page 243, line 3

The dot product notation in Exercise 12-5(c) is replaced by the equivalent summation notation, for clarity. Also, it now says “modm” at the end of definition of \(h\): 
\[
h_{a,b}(x) = \sum_{i=0}^{r} a_i x_i + b \mod m ,
\]

Bug fixed

Julie Sussman

Pages 244 and 251–253

Ronald Greenberg

Referring to the “contents” of a node in a binary search tree is ambiguous, since it is unclear whether the contents includes the parent and child pointers. Use explicit reference to satellite data instead, entailing the following changes:

- On page 244, line –5, change \((\text{In addition to a key field,})\) to \((\text{In addition to a key field and satellite data,})\).

- On page 251, lines –2 and –3, change \((\text{and replace the contents of } z \text{ with the contents of } y,))\) to \((\text{and replace } z\text{'s key and satellite data with } y\text{'s key and satellite data.})\).

- On page 252, Figure 13.4 caption, change \((\text{(and then replace the contents of } z \text{ with the contents of } y,))\) to \((\text{(and then replace } z\text{'s key and satellite data with } y\text{'s key and satellite data.})\).

- On page 253, line 16 of TREE-DELETE, change the line to read \((\text{P Copy } y\text{'s satellite data, too.)})\).

- On page 253, lines 8–9 of the paragraph following the TREE-DELETE pseudocode, change \((\text{the contents of } z \text{ are moved from } y \text{ to } z, \text{ overwriting the previous contents})\) to \((\text{y's key and satellite data are moved to } z, \text{ overwriting the previous key and satellite data.})\).

Bug fixed
Page 250, Exercise 13.2-6

*Julie Sussman*

Replace Exercise 13.2-6 with: Let $T$ be a binary search tree whose keys are distinct, let $x$ be a leaf node, and let $y$ be its parent. Show that $key[y]$ is either the smallest key in $T$ larger than $key[x]$ or the largest key in $T$ smaller than $key[x]$.

Page 262, Problem 13-4

*Mark Kantrowitz*

Bug fixed

In the equation giving the Taylor expansion of $f(x)$, change $\langle f^{(k)}(x - a) \rangle$ in the numerator to $\langle f^{(k)}(a) \rangle$.

Page 263, line -2

*Ronald Greenberg*

Change $\langle$ to a leaf $\rangle$ to $\langle$ down to a leaf $\rangle$.

Page 266, caption for Figure 14.2, lines 2 and 5

*Julie Sussman*

In line 2, the text $\langle$ RIGHT-ROTATE$(T, x)$ $\rangle$ should be changed to $\langle$ RIGHT-ROTATE$(T, y)$ $\rangle$, and in line 5, the text $\langle$ LEFT-ROTATE$(T, y)$ $\rangle$ should be changed to $\langle$ LEFT-ROTATE$(T, x)$ $\rangle$.

Page 267, Exercise 14.2-3

*Julie Sussman*

The exercise is already pretty much answered in the text. It should be eliminated.

Page 267, Exercise 14.2-4, line 3

*Rosario Gennaro*

The text $\langle$ a left rotation is performed on node $x$ $\rangle$ should be replaced by $\langle$ a right rotation is performed on node $y$ $\rangle$.

Page 267, Exercise 14.2-5

*Rosario Gennaro*

The exercise should be amended to refer to binary search trees, instead of just trees. The new text is $\langle$ Show that any arbitrary $n$-node binary search tree can be transformed into any other arbitrary $n$-node binary search tree using $O(n)$ rotations. (Hint: First show that at most $n - 1$ right rotations suffice to transform the tree into a right-going chain.) $\rangle$.

Page 268, line 15 of RB-INSERT

*Hubert Wagener*

A right bracket is missing: $\langle$ color$p[p[x]]$ $\leftarrow$ RED $\rangle$.

Page 273, line 15 of RB-DELETE

*Hirendu Vaishnav*

This comment is ambiguous. Replace it with $\langle$ $\triangleright$ Copy y’s satellite data, too. $\rangle$. 
The claim is false unless the root was black before RB-DELETE executes. The exercise should be rewritten (Argue that if a red-black tree has a black root before RB-DELETE executes, then it has a black root afterwards.).

That assumption that there is no parent field, which is explicit in parts (b) and (c) needs to be explicit in the problem text preceding part (a). The text ((Assume that each tree node has the fields key, left, and right but no parent field. (See also Exercise 14.3-6.)) should be moved from part (b) to just before part (a).

Change (an insertion) to (a deletion).

Change references to (Figure 15.2) to (Figure 15.1).

Change (to to count) to (to count).

Change (the the parenthesization) to (the parenthesization).

The number of extra space characters should be constrained to be nonnegative, and it should be specified that $i \leq j$. Change the sentence beginning ((If a given line)) to read ((If a given line contains words $i$ through $j$, where $i \leq j$, and we leave exactly one space between words, the number of extra space characters at the end of the line is $M - j + i - \sum_{k=i}^{j} l_k$, which must be nonnegative so that the words fit on the line.))

Change (3-cost(insert)) to (4-cost(insert)).

Change the reference ([106]) for the Hu and Shing article to the two references listed in the erratum for page 992.
Page 339, line 4 of figure 17.4 caption

The equation \( f = 100 \) is replaced by the correct text \( f = 101 \).

Page 346, line 20

The text ((the addition of \( x \) to \( A \)) should read ((the addition of \( e \) to \( A \))

Pages 428–429, Figure 21.3

The auxiliary array \( A \) in Figure 21.3 should run from 0 to 3, not 0 to 4. The Fibonacci heap in part (a) has \( n[H] = 15 \) nodes. By Exercise 21.2-3, \( D(n[H]) \leq \lfloor \log n[H] \rfloor \). Array \( A \) runs from 0 to \( D(n[H]) \) and \( \lfloor \log 15 \rfloor = 3 \).

Page 439, line 5 of Chapter notes

Change ((Driscoll, Sarnak, Sleator, and Tarjan)) to ((Driscoll, Gabow, Shrairman, and Tarjan))

Page 440, line –2

Change ((is pointed to by \( x \)) to ((is \( x \))

Pages 443–446, Section 22.2

The linked-list representation of disjoint sets requires that each list also include a pointer to its last element. Otherwise, the append operation does not take \( O(1) \) time.

Page 443, lines –7 and –5

There are \( q - 1 \) UNION operations being executed, so replace \( \{ q = m - n = \lfloor m/2 \rfloor - 1 \} \) in line –7 with \( \{ q = m - n + 1 = \lfloor m/2 \rfloor \} \) and replace \( \{ m = n + q \} \) in line –5 with \( \{ m = n + q - 1 \} \).

Page 444, Figure 22.3 caption

Change ((\( O(m^2) \)) to ((\( \Theta(m^2) \))

Page 446, Exercise 22.2-3

Change ((Argue on the basis of Theorem 22.1 that we can obtain)) to ((Adapt the proof of Theorem 22.1 to obtain))

Page 450, Exercise 22.3-4

Because the pseudocode for the UNION operation calls FIND-SET, a sequence of more than one UNION operation must contain some calls to FIND-SET
before a call to Union. Change the two appearances of \{ Union \} to \{ Link \} in the exercise.

Page 457, computation of $N(j)$ and $P(n)$

Since there are at most $n$ nodes, we have $N(0) \leq n$, which in turn implies that $N(j) \leq n/B(j)$ for all $j \geq 0$. The constant $3/2$ in the computation of $P(n)$ can therefore be eliminated.

Page 467, line 19

The phrase \{the the transpose\} should have the extra “the” removed.

Page 474, line 8

The sentence, \{ Line 14... \}, which contains “only” twice, is modified to contain it only once: \{ Line 14 is therefore executed only for vertices with finite $d$ values. \}

Page 475, line 3

Replace \{lemma\} with \{theorem\}.

Page 475, line -6

The phrase \{reachable from $v$\} should read \{reachable from $s$\}.

Page 479, line 6 of text

The phrase \{lines 1–2\} should read \{lines 1–3\}.

Page 479, line -2

The phrase \{lines 2–5\} should read \{lines 3–6\}.

Page 480, line 11

The text \{parenthesis “$u$,” then\} should read \{parenthesis “$u$,” then\}

Page 482, line -8

To avoid possible confusion (as might occur in trying to solve Problem 23-1(a), the definition of a back edge is expanded to help remind the reader that self-loops are not of concern in undirected graphs. The new text reads: \{ Back edges are those edges $(u,v)$ connecting a vertex $u$ to an ancestor $v$ in a depth-first tree. Self-loops, which may occur in directed graphs, are considered to be back edges. \}
This exercise should be modified to include the following phrase at the end: 
under the assumption of Exercise 23.3-2.

This exercise should be deleted, as the first part is incorrect as stated.

The given definition of semiconnected, \((A\text{ directed graph } G = (V, E)\text{ is said to be semiconnected if, for any two vertices } u, v \in V, \text{ we have } u \sim v \text{ or } v \sim u.\) can be made clearer, as follows: \((A\text{ directed graph } G = (V, E)\text{ is said to be semiconnected if, for all pairs of vertices } u, v \in V, \text{ we have } u \sim v \text{ or } v \sim u.\)

Part (b) of the problem is buggy as stated, and should be changed to read as follows: \((\text{Let } v \text{ be a nonroot vertex of } G_v. \text{ Prove that } v \text{ is an articulation point of } G \text{ if and only if } v \text{ has a child } s \text{ such that there is no back edge from } s \text{ or any descendant of } s \text{ to a proper ancestor of } v.\))

The sentence \((\text{At each step, a light edge connecting a vertex in } A \text{ to a vertex in } V - A \text{ is added to the tree.})\) does not type check. It should be replaced by the sentence \((\text{At each step, a light edge is added to the tree } A \text{ that connects } A \text{ to an isolated vertex of } G_A = (V, A).\).

The reference to the best min spanning tree algorithm is time \(O(E \lg \beta),\) not \(O(E\beta).\) The reference is “Efficient algorithms for finding minimum spanning trees in undirected and directed graphs”, H.N. Gabow, Z. Galil, T.H. Spencer and R.E. Tarjan, Combinatorica 6, 2, 1986, pp. 109-122.

The procedure RELAX takes three parameters. Add the parameter \(w\) to the calls to RELAX in the figure, and change the first sentence of the caption from \((\text{Relaxation of an edge } (u, v).)\) to \((\text{Relaxation of an edge } (u, v) \text{ with weight } w(u, v) = 2.)\).

Replace \((\leq d[v]; \text{ thus, so})\) to \((\leq d[v], \text{ and thus})\).
Page 529, Figure 25.6 caption, line 3

Change \( V - S \) to \( S \).

Julie Sussman

Page 530, line -17

Change \( \{ \text{lines 4-8} \} \) to \( \{ \text{lines 7-8} \} \).

Julie Sussman

Page 534, Theorem 25.14

In the last line of the theorem statement, change \( \{ \text{reachable from } S \} \) to \( \{ \text{reachable from } s \} \).

Bug fixed

Page 536, line -6

Change \( \{ \text{Unlike Dijkstra's algorithm, however, we use only } O(1) \text{ time per edge.} \} \) to \( \{ \text{Unlike Dijkstra's algorithm, there is no priority queue, and so we use only } O(1) \text{ time per edge.} \} \).

Bug fixed

Page 537, line 6 of Figure 25.8 caption

Change \( \{ \text{was used as } v \} \) to \( \{ \text{was used as } u \} \).

Bug fixed

Page 547, Problem 25-4

Add the sentence \( \{ \text{We assume that all vertices are reachable from the source.} \} \) to the end of the second paragraph.

Bug fixed

Page 551, line 11

Change \( \{ \text{and otherwise } \pi_{ij} \text{ is some predecessor of } j \text{ on a shortest path from } i \} \) to \( \{ \text{and otherwise } \pi_{ij} \text{ is the predecessor of } j \text{ on some shortest path from } i \} \).

Bug fixed

Page 555, Improving the running time

An exercise should be added at the end of the section to show that the multiplication performed by Extend-Shortest-Paths is associative and corresponds to extending shortest paths.

Bug not fixed

Page 560, line 6 of FLOYD-WARSHALL

Add the keyword \( \{ \text{do} \} \).

Bug fixed

Page 560, first line after code for FLOYD-WARSHALL

Change sentence to read \( \{ \text{Figure 26.4 shows the matrices } D^{(k)} \text{ computed by the Floyd-Warshall algorithm for the graph in Figure 26.1.} \} \).

Bug fixed
Page 562, line -10

Julie Sussman

Change \((\text{the logical operations } \lor \text{ and } \land)\) to \((\text{the logical operations } \lor \text{ (logical OR) and } \land \text{ (logical AND)})\).

Page 565, Exercise 26.2-8

Ronald Greenberg

Change the exercise to read as follows: \(\langle\text{Suppose that the transitive closure of a directed acyclic graph can be computed in } f(|V|, |E|) \text{ time, where } f \text{ is a monotonically increasing function of } |V| \text{ and } |E|. \text{ Show that the time to compute the transitive closure } G^* = (V, E^*) \text{ of a general directed graph } G = (V, E) \text{ is } f(|V|, |E|) + O(V + E^*).\rangle\).

Page 572, line -1

Tom Cormen

Replace the last line of the display with the following: \(\langle\lambda(p_1) \odot (1 \oplus \lambda(c) \oplus (\lambda(c) \odot \lambda(c)) \oplus (\lambda(c) \circ \lambda(c) \circ \lambda(c)) \oplus \cdots) \odot \lambda(p_2)\rangle\).

Page 585, line 1

Ruben Glueck

The two occurrences of the variable \((t_j)\) should be replaced by \((t_i)\).

Page 591, line -8

Julie Sussman

The term \textit{minimum cut} is never defined. Its definition should be added after the definition of \textit{capacity}: \(\langle\text{A minimum cut of a network is a cut whose capacity is minimum over all cuts of the network.}\rangle\).

Page 593, line -12

Rosario Gennaro

The variable \((T)\) should be lower case: \(\langle\text{no path from } s \text{ to } t \text{ in } G_f\rangle\).

Page 598, line -5

Julie Sussman

Change \((\text{at least } 1)\) to \((\text{at least } 0)\).

Page 600, Exercise 27.2-10

Julie Sussman

Prepend the following sentence to the beginning of the exercise: \(\langle\text{Suppose that a flow network } G = (V, E) \text{ has symmetric edges, that is, } (u, v) \in E \text{ if and only if } (v, u) \in E.\rangle\). Also, in line 2 of the exercise, replace \((\delta(u, t))\) by \((\delta(v, t))\).

Page 600, line -17

Michael Ernst

Change \((\text{a maximum-flow problem})\) to \((\text{maximum-flow problems})\).
Page 600, line -2

Julie Sussman

After \{between \textit{L} and \textit{R.}\}, the text \{We further assume that no vertex in \textit{V} is isolated.\} should be inserted.

Page 602, line -11

Julie Sussman

The variable \{m\} should be upper case. \{M\}.

Page 603, line -5

Nabil Kahale

Replace \{so is \textit{f'}.\} with \{we can assume that \textit{f'} is integer-valued.\}.

Page 621, line -4

Thomas Lengauer

The text \{in \textit{L} must\} should be changed to \{in \textit{L} (except possibly the first, which has no excess) must\}.

Page 628, Problem 27-5, part (d)

Julie Sussman and Ron Rivest

The problem part should be amended to read \{Show that the capacity of a minimum cut of the residual graph \(G_f\) is at most 2\(K|E|\) each time line 4 is executed.\}.

Page 628, Problem 27-6

Charles Leiserson

The problem is confused between the notion of net flow and positive flow. The problem should be rewritten as follows:

27-6 Maximum flow with negative capacities

Suppose that we allow a flow network to have negative (as well as positive) edge capacities. In such a network, a feasible flow need not exist.

\textbf{a.} Consider an edge \((u, v)\) in a flow network \(G = (V, E)\) with \(c(u, v) < 0\).

Briefly explain what such a negative capacity means in terms of the positive flow between \(u\) and \(v\).

Let \(G = (V, E)\) be a flow network with negative edge capacities, and let \(s\) and \(t\) be the source and sink of \(G\). Construct the ordinary flow network \(G' = (V', E')\) with capacity function \(c'\), source \(s'\), and sink \(t'\), where \(V' = V \cup \{s', t'\}\) and

\[ E' = E \cup \{(u, v) : (v, u) \in E\} \]
\[ \cup \{(s', v) : v \in V\} \]
\[ \cup \{(u, t') : u \in V\} \]
\[ \cup \{(s, t), (t, s)\} \].

We assign capacities to edges as follows. For each edge \((u, v) \in E\), we set \(c'(u, v) = c'(v, u) = (c(u, v) + c(v, u))/2\). For each vertex \(u \in V\), we
set \( c'(s', u) = \max(0, (c(V, u) - c(u, V))/2) \) and \( c'(u, t') = \max(0, (c(u, V) - c(V, u))/2) \). We also set \( c'(s, t) = c'(t, s) = \infty \).

b. Prove that if a feasible flow exists in \( G \), then all capacities in \( G' \) are non-negative and a maximum flow exists in \( G' \) such that all edges into the sink \( t' \) are saturated.

c. Prove the converse of part (b). Your proof should be constructive, that is, given a flow in \( G' \) that saturates all the edges into \( t' \), your proof should show how to obtain a feasible flow in \( G \).

d. Describe an algorithm that finds a maximum feasible flow in \( G \). Let \( MF(n, m) \) denote the worst-case running time of an ordinary maximum flow algorithm on a graph with \( n \) vertices and \( m \) edges. Analyze your algorithm for computing the maximum flow of a flow network with negative capacities in terms of \( MF \).

Page 637, line -5

The size of a comparison network is not defined. Replace ((physical size )) with ((size, the number of comparators that it contains,)).

Page 642, first line of Section 28.3

The definition of bitonic sequence is wrong. The first two sentences of the section should be changed to read ("The first step in our construction of an efficient sorting network is to construct a comparison network that can sort any bitonic sequence: a sequence that monotonically increases and then monotonically decreases, or can be circularly shifted to become so. For example, the sequences (1, 4, 6, 3, 2), (6, 9, 4, 2, 3, 5), and (9, 8, 3, 2, 4, 6) are all bitonic.”).

Page 645, Exercise 28.3-1

The length of the sequences is not specified. The exercise should be rephrased ("How many zero-one bitonic sequences of length \( n \) are there?").

Page 645, Exercise 28.3-4

The exercise is wrong for the definition of bitonic sequence given on page 642. The exercise is correct after the definition is corrected as specified in the erratum for page 642.

Page 646, line -14

The text ("the the second") should be replaced by ("the second").
Page 648, Exercise 28.4-3

The exercise should state that the \( n - 1 \) items are already sorted. Replace the words \{ \( n - 1 \) items \} with the words \{ \( n - 1 \) sorted items \}.

Page 651, Problem 28-1, line -5

The range \{ \( i = 2, 3, \ldots, n - 1 \) \} should be replaced by \{ \( i = 1, 2, \ldots, n \) \}.

Page 652, line -5

The notation for permutations used in this problem has not been sufficiently introduced. Replace \( (\pi = \{4, 7, 3, 5, 1, 6, 8, 2\}) \) with \( (\pi = \{\pi(1), \pi(2), \ldots, \pi(8)\} = \{4, 7, 3, 5, 1, 6, 8, 2\}) \).

Page 663, line -6

Change \( \{ \text{We can think of } y_i \text{ as a “prefix” of } x_0 \odot x_1 \odot \cdots \odot x_n, \} \) to \( \{ \text{We can think of } y_i \text{ as a “prefix” of the “product” } x_0 \odot x_1 \odot \cdots \odot x_n, \} \).

Page 666, line 1

Change \( \{ [i, k] \} \) to \( \{ [i, j - 1] \} \).

Page 667, Figure 29.9

The label \( \{ y_i \} \) at the top of each tree should be \( \{ y_8 \} \).

Page 672, line 3 of Figure 29.13 caption

Change \( \{ \text{Here, } n = 8. \} \) to \( \{ \text{Here, } n = 4. \} \).

Page 677, line 5

Change \( \{ [2n/3] \} \) to \( \{ [n/3] \} \).

Page 696, line 16

Replace \( \{ \text{for } 0 \leq i \leq j < k \leq n. \} \) with \( \{ \text{for } 1 \leq i \leq j < k \leq n. \} \).

Page 700, line 15

Replace \( \{ \text{the the} \} \) with \( \{ \text{the} \} \).

Page 702, line 7 of FIND-ROOTS

The root fields are assigned to improperly. Replace line 7 with the following two lines of code: \( \{ \)
then if \( \text{parent}[\text{parent}[i]] = \text{NIL} \)
then \( \text{root}[i] \leftarrow \text{root}[\text{parent}[i]] \)

\( \text{The lines must be renumbered, which affects some of the references in the subsequent text.} \)

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**Page 718, line -4**

*Michael Ernst*

*Replace \( ( \text{of processors} ) \) with \( ( \text{of the processors} ) \).*

**Page 752, line -9**

*Anthony Martin Hill*

*Replace \( ( \text{work backward to} ) \) with \( ( \text{work backward to} ) \).*

**Page 759, line 4 of LUP-DECOMPOSITION**

*Tom Cormen*

*Replace \( ( n-1 ) \) with \( ( n ) \).*

**Page 760, caption of Figure 31.2**

*Tom Cormen*

*In conjunction with the bug fix for line 4 of LUP-DECOMPOSITION on page 759, replace \( ( (g)-(i) \) The third step finishes the algorithm.\) with \( ( (g)-(i) \) The third step. No further changes occur on the fourth and final step.\).*

**Page 764, Theorem 31.12**

*Hal Gabow*

*The conditions on \( M(n) \) in the statement of the theorem are incorrect. Change the statement of the theorem to \( ( \text{Suppose we can multiply two } n \times n \text{ real matrices in time } M(n), \text{ where } M(n) = \Omega(n^3) \text{ and } M(n) \text{ satisfies the two regularity conditions } M(n + k) = O(M(n)) \text{ for any } k \text{ in the range } 0 \leq k \leq n \text{ and } M(n/2) \leq c M(n) \text{ for some constant } c < 1/2. \text{ Then we can compute the inverse of any real nonsingular } n \times n \text{ matrix in time } O(M(n)). ) \) \( ( \text{The proof should explicitly reference these conditions where needed.} ) \).*

**Page 773, line 13**

*Jeff Shallit*

*Replace \( \langle A_{ij} = 1 \rangle \) with \( \langle a_{ij} = 1 \rangle \).*

**Page 783, Exercise 32.1-4**

*Rosario Gennaro*

*The hint as given is incorrect and misleading. The problem is revised to read: \( ( \text{Show how to use equation (32.5) to interpolate in time } \Theta(n^2). \text{ (Hint: First compute } \prod_{j}(x-x_j) \text{ and then divide by } (x-x_k) \text{ as necessary for the numerator of each term. See Exercise 32.1-1. ) } ) \)\*
Page 791, line 2 of Exercise 32.2-8

In Exercise 32.2-8, page 791 (chirp transform), the expression (\( y_k = \sum_{j=0}^{n-1} z^j \)) should read (\( y_k = \sum_{j=0}^{n-1} z^{kj} \)).

Page 798, Problem 32-4, last line on page

The remainder of \( 3x^3 + x^2 - 3x + 1 \) when divided by \( x^3 + x + 2 \) is not \( 5x - 3 \), but \( -7x + 5 \).

Page 799, line 4

The variable (\( p_{ij} \)) should be (\( P_{ij} \)).

Page 812, line 1 (not counting caption)

The phrase (\( \langle \text{an arbitrary pair of integers} \rangle \)) is replaced by (\( \langle \text{an arbitrary pair of nonnegative integers} \rangle \)).

Page 816, line -8

The multiplicative group over \( \mathbb{Z}_n \) should be denoted as (\( \langle (\mathbb{Z}_n^*, \cdot) \rangle \)) instead of (\( \langle (\mathbb{Z}_n, \cdot) \rangle \)).

Page 817, Theorem 33.14

The statement of the theorem and the following comment are modified to include the condition that the set \( S' \) must be nonempty, as follows:

Theorem 3.1 (A nonempty closed subset of a finite group is a subgroup)

If \( (S, \oplus) \) is a finite group and \( S' \) is any nonempty subset of \( S \) such that \( a \oplus b \in S' \) for all \( a, b \in S' \), then \( (S', \oplus) \) is a subgroup of \( (S, \oplus) \).

Page 829, Proof of Corollary 33.35

The corollary is stated correctly, but the proof is not, since the contrapositive to Theorem 33.34 is stronger than the corollary. (Indeed the contrapositive
is just the second sentence in the proof supplied.) The proof is modified to read: \( \text{"Theorem 33.34 implies that if there exists a nontrivial square root of 1, modulo } n, \text{ then } n \text{ can't be a prime or a power of a prime. Furthermore, we must have } n > 1 \text{ for a nontrivial square root of 1 to exist. Therefore, } n \text{ must be composite.} \)

Page 834, line 7 

The use of absolute value notation to denote the length of numbers (in binary) is changed to use the binary logarithm function instead.

Page 837, line 9 

The equation \( \{ \pi(n) = 50,847,478 \} \) for \( n = 10^3 \) is incorrect. The correct value is \( \{ \pi(n) = 50,847,534 \} \). (Reference: “Computing \( \pi(x) \): The Meissel-Lehmer Method”, by J. C. Lagarias, V. S. Miller, and A. M. Odlyzko, Mathematics of Computation 44, 170(April 1985), 537–560.)

Page 838, lines 15–17 

This sentence is rewritten to read, \( \{ \text{When it works, trial division has the advantage that it not only determines whether } n \text{ is prime or composite, but also determines one of } n\text{'s prime factors if } n \text{ is composite.} \}\)

Page 840, line 5 

The expression \( \{ a^{n-1} \pmod{1} \} \) should read \( \{ a^{n-1} \pmod{n} \} \).

Page 844, Exercise 33.8-1 

The phrase \( \{ \text{an integer } n \} \) is replaced to read \( \{ \text{an odd integer } n \} \).

Page 850, Problem 33-3(c) 

The matrix given in the hint should be: \( \{ \)
\[
\begin{pmatrix}
    0 & 1 \\
    1 & 1
\end{pmatrix}
\]

Page 853, line 9 

The text \( \{ \text{of length } m \} \) is replaced by \( \{ \text{of length } m \leq n \} \).

Page 862, line 8 (Exercise 34.2-4) 

The set \( \{ \{0,1,\ldots,n-1\} \} \) should be \( \{ \{0,1,\ldots,q-1\} \} \).
Page 881, line 3

Tian Yuxing

The statement \( \langle \lambda[a] = 0 \rangle \) should be \( \langle \lambda[a] - 0 \rangle \)

Pages 895–898

Hal Gabow and Danny Sleator

The ANY-SEGMENTS-INTERSECT procedure can miss intersections in which the right endpoint of one segment coincides with the left endpoint of another. To correct the procedure, forget about \( y \)-coordinates when breaking ties in line 2. Instead, break ties by putting left endpoints before right endpoints. That way, the left endpoint is still in the sweep-line status when a coincident right endpoint becomes the event point.

Also, the pseudocode, as is, works even when three or more segments intersect at a common point despite the assumption in the text that this case does not occur. In fact, the pseudocode can even handle vertical segments if we call the top endpoint the left endpoint and the bottom endpoint the right endpoint. Exercise 35.2-8 on page 898 is then obviated.

Page 902, line 10 of GRAHAM-SCAN

Thomas Lengauer

Change \( \langle \text{Push}(S,p_i) \rangle \) to \( \langle \text{Push}(p_i,S) \rangle \).

Page 908, line 4 of Section 35.4

Dick Johnsonbaugh

Change \( \langle \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \rangle \) to \( \langle \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \rangle \).

Page 912, Exercise 35.4-2

Dick Johnsonbaugh

Delete the last sentence of the exercise.

Page 917, lines 2–3 of Section 36.1

Tian Yuxing

Change \( \langle \text{These problems are generally regarded as tractable. The reason why is a philosophical, not a mathematical, issue.} \rangle \) to \( \langle \text{These problems are generally regarded as tractable, but for philosophical, not mathematical, reasons.} \rangle \).

Page 919, line 6

Hoon Choi

Change \( \langle \text{must must be represented} \rangle \) to \( \langle \text{must be represented} \rangle \).

Page 919, second paragraph under subheading Encodings

Thomas Hofmeister

Before the sentence beginning “A concrete problem . . .”, add the footnote \( \langle \) We assume that the algorithm’s output is separate from its input. Because it takes at least one time step to produce each bit of the output and there are \( O(T(n)) \) time steps, the size of the output is \( O(T(n)) \).\rangle \).
Thomas Hofmeister

Change $\langle \lceil \lg k \rceil \rangle$ to $\langle \lceil \lg k + 1 \rceil \rangle$.

Dale Russell

Change $\langle \text{where } n = \lceil e_1(i) \rceil \rangle$ to $\langle \text{where } n = \lceil e_2(i) \rceil \rangle$.

Dick Johnsonbaugh

The definitions should be made more precise. Change the paragraph to read as follows:

"Even if language $L$ is accepted by an algorithm $A$, the algorithm will not necessarily reject a string $x \notin L$ provided as input to it. For example, the algorithm may loop forever. A language $L$ is \textit{decided} by an algorithm $A$ if every binary string in $L$ is accepted by $A$ and every binary string not in $L$ is rejected by $A$. A language $L$ is \textit{accepted in polynomial time} by an algorithm $A$ if there is a constant $k$ such that for any length-$n$ string $x$, the algorithm accepts $x$ in time $O(n^k)$ if and only if $x$ is in $L$. A language $L$ is \textit{decided in polynomial time} by an algorithm $A$ if there is a constant $k$ such that for any length-$n$ string $x \in \{0,1\}^*$, the algorithm correctly decides whether $x \in L$ in time $O(n^k)$. Thus, to accept a language, an algorithm need only worry about strings in $L$, but to decide a language, it must correctly accept or reject every string in $\{0,1\}^*$."
Page 930, line 6 of running text

*Thomas Hofmeister*

Change “In Section 36.5, shall use” to “In Section 36.5, we shall use”.

Page 932, Theorem 36.4

*Thomas Hofmeister*

Change the theorem statement and proof to “

Theorem 36.4

If any NP-complete problem is polynomial-time solvable, then $P = NP$. Equivalently, if any problem in NP is not polynomial-time solvable, then no NP-complete problem is polynomial-time solvable.

Proof Suppose that $L \in P$ and also that $L \in NPC$. For any $L' \in NP$, we have $L' \leq_p L$ by property 2 of the definition of NP-completeness. Thus, by Lemma 36.3, we also have that $L' \in P$, which proves the first statement of the theorem.

To prove the second statement, note that it is the contrapositive of the first statement.

\]

Page 932, line –5

*Thomas Hofmeister*

Change “NP-complete” to “NP-complete”.

Page 942, line 11

*Thomas Hofmeister*

Change “Why is the circuit $\phi$” to “Why is the circuit $C$”.

Page 945, line 10

*Thomas Hofmeister*

Change “as clauses of $f(\phi)$” to “as clauses of $\phi'''$”.

Page 949, line –1

*Thomas Hofmeister*

Change “graph $G$ has vertex cover of size $k$” to “graph $G$ has a vertex cover of size $k$”.

Page 953, paragraph beginning “Now suppose …”

*Dale Russell*

Change “Let $S = \{x_i, x_{i_2}, \ldots, x_{i_m}\} \cup \{y_j, y_{j_2}, \ldots, y_{j_k}\}$.” to “Let $S' = \{x_i, x_{i_2}, \ldots, x_{i_m}\} \cup \{y_j, y_{j_2}, \ldots, y_{j_k}\}$ and change “(there are three 1’s in set $S$ in the $e_j$ position;” to “(set $S$ contains three integers with 1’s in the $e_j$ position;”.

Bug fixed
Page 959, lines -7 and -8  

Dale Russell  

Change "(The formal language for the traveling-salesman problem) to (The formal language for the corresponding decision problem)."

Page 960, Exercise 36.5-1  

Dick Johnsonbaugh  

Change "whether \( G_1 \) is a subgraph of \( G_2 \)" to "whether \( G_1 \) is isomorphic to a subgraph of \( G_2 \)."

Page 967, caption to Figure 37.1  

Dale Russell  

The caption is modified to remove all references to the set \( A \), and replace these with references to the set \( C \) of vertices in the vertex cover being constructed.

Page 974, Exercise 37.2-3  

Hal Gabow  

The hint says to use a minimum spanning tree. It should be to use a bottleneck spanning tree, since the bottleneck property is what is used in the proof of correctness of the algorithm. The text implies that a minimum spanning tree is a bottleneck tree, but does not state it explicitly. Anyway, since a bottleneck tree can be found faster than a min sp tree, \( O(E) \) versus nonlinear\) saying "bottleneck" is the best hint. (Cross-reference to Exercise 24.2-6 on page 510?)

Page 983, line -2  

Dick Johnsonbaugh  

The text "(the the) should be (the)."

Page 984, Problem 37-2  

Luisa Gargano  

The definition of \( G^{(k)} \) was given incorrectly (in particular, the definition of the edge set was wrong). The corrected definition now reads: For any \( k \geq 1 \), define \( G^{(k)} \) to be the undirected graph \( (V^{(k)}, E^{(k)}) \), where \( V^{(k)} \) is the set of all ordered \( k \)-tuples of vertices from \( V \) and \( E^{(k)} \) is defined so that \( (v_1, v_2, \ldots, v_k) \) is adjacent to \( (w_1, w_2, \ldots, w_k) \) if and only if for each \( i, 1 \leq i \leq k \), either vertex \( v_i \) is adjacent to \( w_i \) in \( G \), or else \( v_i = w_i \)."

Page 992, reference [106]  

James Park  

Replace reference [106] with two references:


Page 995, reference [176]  
Michael Formann

Change \( (16\text{th}) \) to \( (17\text{th}) \) and \( (1975) \) to \( (1976) \).

Page 1006, column 2, line 11  
Ronald Greenberg

Change \( (562-563) \) to \( (562-565) \).

Page 1026, index entry for transitive closure  
Ronald Greenberg

Change \( (562-563) \) to \( (562-565) \).