THE STATE OF THE ART OF COMPUTER PROGRAMMING

by

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This report lists all corrections and changes to volumes 1 and 3 of The Art of Computer Programming, as of May 14, 1976. The changes apply to the most recent printings of both volumes (February and March, 1975); if you have an earlier printing there have been many other changes not indicated here. Volume 2 has been completely rewritten and its second edition will be published early in 1977. For a summary of the changes made to volume 2, see SIGSAM Bulletin 9, 4 (November 1975), p. 10f -- the changes are too numerous to list except in the forthcoming book itself.

On any given day the author likes to feel that the last bug has finally disappeared, yet it appears likely that further amendments will be made as time goes by. Therefore a family of computer programs has been written to maintain a collection of errata, in the form printed here, but encoded as an ad-hoc sequence of ASCII characters. The author wishes to thank Juan Ludlow-Saldivar for the enormous amount of help he provided in order to get this system rolling. (Some readers who have access to the Stanford A.I.-Lab computer may wish to consult the change file before they report a "new" error; the file name is ACP.MAS [ART,DEK]. Entries for page nnn of volume k begin with @k0lnnn (but change the 01 to 00 if nnn is the Arabic equivalent of a Roman numeral); since "β" is the control character "ńC", you may rather search for simply the string "k0lnnn". The text of the correction usually includes special codes following the symbol "|", for things like font changes, etc.)

The author thanks all the bounty hunters who have reported difficulties they spotted. The reward to first finder of each error is still $1 for the first edition and $2 for the second, gratefully paid. Volume 4 remains rather far from completion, so there is plenty of time to work all the exercises in volumes 1-3 and to catch all the remaining errors therein.

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The Art of Computer Programming
Errata et Addenda May 14 1976

2.XVIII line 5 forcing himself being encouraged

2.XIX line 10 answer answers

2.XIX new quote for bottom of page

We can face our problem. We can arrange such facts as we have with order and method.

--HERCULE POIROT, in Murder on the Orient Express (1934)

2.4 line 23

EO. EO. (boldface)

2.26 line 3 prove A6 prove that A6

2.25 line -1 3n0 3n

2.25 lines -3 and -2 T < 3n0, where n0 is the original value of n. T < n,
1.26 ex 25

delete step L5 and move the 1 to the end of step L4

1.26 ex 25, change step L3 to:

L3. [Shift.] If $x-z < 1$, set $z \leftarrow z$ shifted right 1, $k \leftarrow k+1$, and repeat this step.

1.26 line 15, new sentence

hardware, hardware. The idea goes back in essence to Henry Briggs, who used it (in decimal rather than binary form) to compute logarithm tables, published in 1624.

1.27 line 23

example, example --

1.26 exercise 40

.a period (.) should appear after the displayed equation

1.44 line 2 two changes

(i) the (q/p) and (p/q) don't match each other. (ii) the first two lines of p44 should have moved back top p43, otherwise the reader will think exercise 47 is incomplete without turning the page.

1.46 line 20

$1/2n \sim 1/(2n)$

1.50 ex 15

put spaces in the first matrix, i.e.

ah! \sim a b c
def \sim d e f
ghi \sim g h i
2.52 line 7 after Table 1

Shih-chich — Shih-Chich

2.56 left side of eq (17)

move the k a little left, to center it

2.58 line 7 after (26)

Shih-chich — Shih-Chich

2.58 line 8 after (26)

the boldface 3 appears to be in wrong font (too small)

1.71 14 places

change \( R \) to \( B \) (Roman type) in the notation for Beta function, namely in line 1, line 2, line 3 (twice), line 4 (thrice), line 5 (twice), line 7, line 10 (twice), line 12, line 15.

1.71 exercise 47

in displayed formula: change upper indices \( c r a m \ n, n+1/2, 2n+1, 2n+1-k \) to \( r, r-1/2, 2r, 2r-k \) respectively

line 3: \( n \cdot -1 \).  \( \leftrightarrow \ r = -1/2 \).

1.78 lines -3 and -2

before the Renaissance  \( \leftrightarrow \) during the Middle Ages.

1.80 line 2

1963-  \( \leftrightarrow \) 1963-

1.90 between (23) and (24)

series  \( \leftrightarrow \) series (cf. (17))
1.90 insert new sentence just after (26):


1.90 replace (25) by new equation (25):

\[
\frac{1}{(1-z)^{m+1}} \ln \left( \frac{1}{1-z} \right) \cdot \sum_{k \geq 0} \left( \frac{1}{(m+k-1)\cdot m!} \right) z^k, m \geq 0.
\]

1.95 lines 4-8

move the copy for each step to the left next to the step numbers (standard format, see e.g. Algorithm F on p2)

1.98 line -4

\[ \sum \rightarrow \sum_k \]

1.101 lines 3 and 4 after Fig. 11

\[ x \; \text{that} \; \sum x = \text{that values, we} \; \sum \text{values} = \text{we} \]

1.102 line 5

distribution, the \( \sum \) distribution, we can improve significantly on Chebyshev's inequality: The

1.105 line after (13)

\[ f^{(2k+1)}(x) \text{tends} \rightarrow f^{(2k+1)}(x) \text{and} f^{(2k+3)}(x) \text{tend} \]

1.150 line 11

\[ C \rightarrow C \text{ (Roman, not italics)} \]

1.155 line 20

records \( \sum \) blocks
record block

row 5 column 4 of the table

Fig. 14 in both steps P7 and P6

PRIME[K] → PRIME[K]

fix broken type in the of PRIME[M]

delete the exclamation point (!)

ex 3, first line of program

X+1 → X+1 (0)

last line of ex 18

assume → assume that

insert more space after the period, this line's too narrow

line no. 21 of the program

PERM+1 . . . → PERM+1, . . .
1.230 line 8
itself " ~ itself."

1.230 top of page
the "1" is broken in "1.3.3"

1.230 line 14
the 0 is broken

1.230 line 16
O.J. ~ O.J.

1.230 line -10
print) ~ print,

1.230 Fig. 3(a)
delete the funny little box which appears between "third from top" and "fourth from top"

1.230 just after (1)
remove black speck

1.230 lines -3 and -2
delete the sentence "Is there... obtainable?"

1.243 bottom line

TOP ~ TOP (twice)
1.244 line 3  

\[ \sum \text{ after step names G1 and G2} \]

brokentypo Γ for [ 

1.248 line -1  

\( \text{BASE, BASE+1, BASE+2, } \sum \text{BASE+1, BASE+2, BASE+3} \)

1.255 in (10)  

move the heavy bar to the right so that it is aligned vertically with the heavy bar in (11) 

1.264 comment for line 18 of the program  

T3 \( \sum \) T4 

1.265 new paragraph before the exercises  

In spite of the fact that Algorithm T is so efficient, we will see an even better algorithm for topological sorting in Section 7.4. 

1.275 changes to Program A  

line 04: 6 H \( \sum \) 1H  
line 05: becomes line 06  
line 06: becomes line 07  
line 07: becomes line 05, and delete the "1H" and change \( \sum \) \( 1+m \).  
line 12: becomes the following two lines  
12 LO2 1:3 (LINK) \( q \) Q-LINK(Q1).  
13 JMP 2B \( q \) Repeat.  
lines 13 - x become lines 14-36  

change 6B \( \sum \) 1B in what was line 17 (now line 18)
\( h_3 \sim h_{3-1} \)

\( b_4 \sim \text{line } -4 \)
\( \text{exceed } h \sim \text{exceed } h - 1 \)

\( \text{line } 12 \)
\( 29 \sim 27 \) (twice)

Table 1, left column
the line for time 0200 is out of place, it belongs just before the line for time 0256

Fig. 12
the shading in this figure mysteriously disappeared from the 3rd column of nodes, in the second edition. (First edition was OK!)

\( \text{line } 7 \)
\( 2419200 \sim 2419200 \)

\( \text{two lines before (11)} \)
* is the lowest value \( \sim \) points to the bottom-most value

Exercise 20 line 3
\( A(I,J) \sim A[I,J] \)
new exercise

21. [20] Suggest a storage allocation function for $n \times n$ matrices where $n$ is variable. The elements $A[i, j]$ for $1 \leq i, j \leq n$ should occupy $n^2$ consecutive locations, regardless of the value of $n$.

- tree illustration near bottom of page

the number "(9)" must be inserted at the right of this diagram

line -13

$P^* \leftrightarrow P^*$

between (2) and (3)

tilt the diagram $45^\circ$ and we have $\leftrightarrow$
tilt the diagram and bend it slightly, obtaining

Fig. (7)

the photographer has lined up the two parts of this figure improperly in this edition; the left-hand half of the illustration should be lowered so that the trees are flush at the bottom -- this means that corresponding letters will be on the same line in both left and right parts of the illustration

line -9

of (7) $\leftrightarrow$ of the left-hand tree in (7)

line 16

node to $\leftrightarrow$ node with

line 9

only upward links are sufficient $\leftrightarrow$ upward links are sufficient by themselves
1.557 in (17)
delete "." outside the boxes (for consistency in style)

1.560 exercise 11
change script \( I \) to italic \( I \) in five places (lines 5, 6, 6, 23, 25)

1.563 Theorem A part (a)

1.575 line 4
remove hairline between "fin" and "("

1.575 line -3
or it or

1.576 line -2
Exercise exercise

1.505 exercise 12
Suppose [20] Suppose

1.506 line -14
particular particular

1.527 line -4
3). 3).
the shape of the box containing B6, should have rounded sides (like that of B2); on the other hand, the box that says "Error" should be rectangular.

this displayed line should be raised half a space so that it is separated from line -4 by the same amount as it is separated from line -6.

audition \( \mapsto \) condition
emergencies \( \mapsto \) emergencies.
hence \( \mapsto \) Hence

two level \( \mapsto \) two-level

\( N(n,m) \mapsto N(n,m)/n \)

first line of quote
me that \( \mapsto \) me... that
1.465 exercise 3

line 3: let \( r \) be \( \wedge \) let \( m \) b c
line 4: if \( r \neq 0 \), \( \wedge \) if \( m \neq 0 \),
line 5: \( n/r \) \( \wedge \) \( n/m \)
   \( r \) and let \( m \) ho \( \wedge \) m and let \( n \) ha
lines 6 and 7 (steps F4 and F5) deleted
line 8: F6. \( \wedge \) F 4 ,

1.468 better answer to exercise 3

3. \(-1/2\), but the text hasn't defined it.

1.468 exercise 13

first sentence should become:
Add "\( T \leq 3(n-d)+k \)" to assertions A3, A4, A5, A6, where \( k \) takes the respective values 2, 3, 3, 1.

1.468 line 16

elements \( a \) and \( b \) \( \wedge \) elements, \( a < b \),

1.470 exercise 3

the value 3 i n two \( n^2 \). \( \wedge \) \( n^2 = 3 \) occurs for no \( n \), and in the second place \( n^2 = 4 \)
occur for two \( n \).

1.470 line 10

388. \( \wedge \) 388; V.S. Linskiǐ, Zh. Vych. Mat. i Mat. Fiz. 2 (1957), 90-119.

1.470 new answer replacing answer 10

9.10. No. the applications of rule (d) assume that \( n \geq 0 \). (The result is correct for \( n = -1 \)
but the derivation isn't.)
exercise 41 line 4

1/4 \sim 1/ R (twice)

exercise 31

We have \[ \text{[This sum was first obtained in closed form by J. F. Pfaff, Nova acta}
\]
\[ \text{scient. Petr. 11 (1797), 38-57.]} \] We have

and extending to page 487

change I to R (Roman type) in the solutions to exercises 40, 41 (twice), 42, 48 (twice).

exercise 14

n+4 \sim n+1

exercise 10 line 2

(25) \sim (17)

exercise 15

line 1: \(2G_{n-2}(x) \sim 2G_{n-2}(x) + \delta_n\)

line 3 (the displayed formula): delete the period, then add a new line:

when \(x \neq -1/4; G_n(-1/4) \rightarrow (n+1)/2^n \text{ for } n \geq 0.

bottom of page, a new answer to exercise 1.2.11.2-3:

3. \( |R_{2k}| < |H_{2k}|/(2k)! \int_1^n |f^{(2k)}(x)| dx. \) [C. H. Reinsch observes that \(R_{2k} \sim \int_1^n (B_{2k+2} - H_{2k+2}(x)) f^{(2k+2)}(x) dx/(2k+2)!!, and that \(H_{2k+2} - H_{2k+2}(x)) \text{ always lies between 0 and } \frac{2-2^{2k+1}}{2^{2k+2}}. \) Therefore if \(f^{(2k+1)}(x) \text{ but not } f^{(2k+3)}(x) \text{ tends monotonically to zero}, \text{ still holds for some } \theta \text{ with } 0 < \theta < 2 - 2^{2k+1}.]

exercise 6

\(O(n^{-3}) \sim O(n^{-3})\)
exercise 14

line 3: MOVE ← MOVE
line 4: JSJ*+1 ← JSJ*+1

exercise 17(b)

(A slightly faster, but quite preposterous, program uses STZ: JMP 3995; STZ 1, 2; STZ 2, 2; ...; STZ 993, 2; J2N 3999; DEC 993; J2NN 3001; ENNI 0, 2; JMP 3000, 1.)

exercise 18 add new sentence:

(Under the program itself appears in locations 0000-0015.)

exercise 20

exercise 16 line 1

(49): ← (49);

new line just before answer no. 23:

For small byte size, the entries ±6 would not appear.

exercise 6 line 3

\sqrt{N} ← \sqrt{N}

line -13

e.g. the ← e.g., the
exercise 22(d) 114

Since the \( a \)'s are independently chosen, the

exercise 23 115

line 1: \( \int_0^1 \ldots (1/n) \) \( \rightarrow \int_0^\infty \exp(-t)E_1(t)dt \), where \( E_1(x) = \int_x^\infty e^{-t}dt/t \).

line 4: \( \ln n \rightarrow n^{-\gamma} \ln n \)

line 6: 8310... \( \rightarrow \) 83100 83724 41796 [Math. Comp. 22 (1968), 411-415];

line 6 116

de\( v/\sqrt{m} \), \( \rightarrow \) dev \( \sqrt{v/m} \), when \( n \geq 2m \).

line 5 117

process would loop indefinitely; \( \rightarrow \) algorithm breaks down (possibly refers to huffer while I/O is in progress);

exercise 9 118

in reverse, we can get the inverse \( \rightarrow \) backwards, we can get the reverse of the inverse of the reverse

exercise 12 119

\( 0 < \alpha < 1 \) \( \rightarrow \) |\( a \)| < 1

line 12 120

\( r_2(z) \rightarrow r_2(z) \cdot \frac{z}{z} \)

exercise 4(ii) should have the following answer instead: 121

(ii) LDA \( X, 7:7(0:2) \).
new answer

13. D. J. Kleitman has shown that \( \lim_{n \to \infty} 2^{-n} \log f(n) \leq \lim_{n \to \infty} 2^{-n} \log \Pi_{\text{odd} n \leq n} \).

[To appear.]

line -5

COUNT \( \rightarrow \) COUNT

and also page 544, answer to exercise 24

replace lines 85-87 of the MI X program by

\begin{verbatim}
ST 6 X, 1 (QLINK) QLINK[i1] \rightarrow k
\end{verbatim}

Then renumber lines RR-118 to 86-116.

Finally delete "Note: When the... as the loop." on p. 544.

lines 11-12 change to (with same indentation):

\textbf{T10.} If \( P \neq A \), set \( \text{QLINK[SUC}(P)\text{]} \rightarrow k \), \( P \rightarrow \text{NEXT}(P) \), and repeat this step.

exercise 16

line 2 : \( 29 \Sigma \rightarrow 27 \Sigma \) (twice)
line 8: \( 6 \rightarrow 4 \)

line -4 insert new sentence (no new paragraph)

[See exercise 5.2.3-29 for a faster algorithm.]

exercise 1 line 4

\begin{verbatim}
AVAIL \( \rightarrow \) Y \( \rightarrow \) INFO(P):AVAIL
\end{verbatim}

line 2

\begin{verbatim}
COL(P) \( \rightarrow \) COL(P0)
\end{verbatim}
change answer 18 (saving space for new answer 21):

the first part up to "after the final" can be shortened as follows.

18. The three pivot steps, in respective columns 3, 1, 2, yield respectively
   \((1,1), (1,1), (1,1)\).

(use the same matrices as before but squeeze onto one line)

exercise 20

A(1,1) \rightarrow A[1,1]

new answer

21. For example, \(M \rightarrow \max(1, J), \text{LOC}(A[1, J]) = \text{LOC}(A[1, 1]) + M(M-1) + I - J.\)

(Such formulas have been proposed independently by many people. A. L. Rosenberg and H. R. Strong have suggested the following \(k\)-dimensional generalization:
\[\text{LOC}(A[1, \ldots, 1]) = L_k,\] where \(L_k = \text{LOC}(A[1, \ldots, 1]) + 1 - 1, L_r = L_{r-1} + (M_r - 1) + (M_r - 1)\) for \(2 \leq r \leq k)\).

exercise 15

remove blots in first and second lines

exercise 12 line 2

A[m]. \rightarrow A[m],

new answer

13.(Solution by S. Araijo.) Let steps \(T_1\) through \(T_4\) be unchanged, except that a new variable \(Q\) is initialized to \(A\) in step \(T_1; Q\) will point to the last node visited, if any. Step \(T_5\) becomes two steps: \(T_5\). [Right branch done?] If \(\text{RLINK}(P) = A\) or \(\text{RLINK}(P) = Q, \)
   go on to \(T_6;\) otherwise set \(A \leftarrow P, P + \text{RLINK}(P)\) and return to \(T_2. T_6. [\text{Visit } P.] \) Visit "NODE(P), set Q \leftarrow P, and return to \(T_4. A similar proof applies.

line 15

\text{LOC}(T). \rightarrow \text{LOUT}.)
exercise 1 line 1

consist \(\rightarrow\) consists

exercise 12 line 2

INFO(P2)-1 \(\rightarrow\) TREE(INFO(P2)-1)

exercise 18 line 5

preorder \(\rightarrow\) postorder

exercise 7

the diagrams for Case 1 have two arrowheads in the wrong direction...the arrows should lead away from \(\alpha\) and towards \(\beta\) both Before and After

line -8

332 \(\rightarrow\) 322

exercise 12 line 5

\(a(i) \leftarrow e(i,j) \land b(i) \leftarrow j\)

\(a(j) \leftarrow e(i,j) \land b(j) \leftarrow i\)

exercise 16

line 2: the existence of \(\rightarrow\) tracing out
lines 4, 5: we have an oriented subtree \(\rightarrow\) the stated digraph is an oriented tree
line 5: configuration \(\rightarrow\) digraph
line 6: subtree \(\rightarrow\) tree

last line

exercise 24 line 2

\[ G' \sim G \]

last line of exercise 23, add:

[For \( m = 2 \) this result is due to G. Faye Sainte-Marie, *L'Intermédiaire des Mathématiciens* 1 (1894), 107-110.]

exercise 3 line 3

upper \( \sim \) right

exercise 10

height \( \sim \) weight (three times)

second-last line before exercise 6

this line isn't right-justified, add space after the semicolon

bottom line

exhausted. \( \sim \) exhausted. [See Guy L. Steele Jr., *CACM* 18 (1975), 495-508, and P. Wadler, *CACM* 19 (1976), to appear, for further information.]

[Note that there's no comma between Steele and Jr. in his name.]

lines 19-21 replace by


line 4

miniscule \( \sim \) minuscule
line before exercise 34


line -7

det (A) \rightarrow \text{det}(A)

in several places

change \cdots\text{to} \cdots \text{in the definitions of upper } k, \text{lower } k, n \text{ factorial, and Stirling numbers of both kinds}

bottom line

gives section references 1.2.5 in right-hand column

definition of Beta function

B \rightarrow B

line -20 (the entry for 1 degree of arc)

1154 \rightarrow 1155

insert new paragraph after line 7:

See the answer to exercise 1.3.3-23 for the 40-digit value of another fundamental constant.

last line

9 \rightarrow 9.
| 1.6178 | Araujo, Saulo, 560. | 161 |
| 1.6188 | Bendix G20, 120. | 162 |
| 1.6198 | Bragge, Henry, 26. | 163 |
| 1.6254 | Bolzano entry | 164 |
|         | delete "theorem," |  |
| 1.6198 | Carlyle, Thomas, xvi. | 165 |
| 1.6198 | Christie Mallowan, Dame Agatha Mary Clarissa (Miller), xix. | 166 |
| 1.6198 | Chu Shih-Chih, 52, 58. | 167 |
| 1.6198 | Clark, Douglas Wells, 594. | 168 |
| 1.6154 | Chebyshev's inequality entry | 169 |
|         | add p. 102 |  |
Dawson, Reed, 578.

Doyle, Sir Arthur Conan, 463.

Ewen, Shimon, 239.

Flye Sainte-Marie, Camille, 580.

delete Fisher, David Allen

Hamlet, Prince of Denmark, 228.

entry for Good, Irving John .

add p. 578

line -8

Exercise exercise

Kleitman, Daniel J., 541.
Knopp entry
add p.494

Krogdahl entry
fix broken type

line 1
20 ~ 20.

Linskií, V. S., 470.

Path length, 399-405.

Pfaff, Johann Friedrich, 485.

Phileo S2000, 120.

Poirot, Hercule, xix.

RCA 601, 120.
1.631N
Rosenberg, Arnold Leonard, 556.

1.631W Robson entry
add p. 594

1.631L
Shakespeare, William, 228, 465.

1.631L
delete Shih-chieh, Chu entry

1.631R
Steele Jr., Guy Lewis (=Quux), 594.

1.632L
Strong, Havcy Raymond, Jr., 556.

1.632R
Tarjan, Robert Endre, 239.

1.633R
Wadlar, Philip Lee, 594.

1.633R last line
delete "theorem," (saves one line)
1.654L
Wegbreit, Eliot Ben, 603.

1.654L
Wise, David Stephen, 434, 595.

1.654R
Zave, Derek Alan, 90, 603.

1.656 (namely the endpapers of the book)
delete “Table 1”
also make the changes specified for page 136

3.V line 4 of the Preface
system ^ systems

3.VII line 4
forcing himself ^ being encouraged

3.VIII line 10
answer ^ answers

3.XII
- raise this illustration about 3/8 inch
making the quotation format more consistent

line 5: The Prince ~ The Prince
line 10: MASON (The Case . . . 1951) MASON, in The Case of the Angry Mourner (1951)

new exercises

21. [M25] (G. Knott.) Show that the permutation \( a_1 \ldots a_n \) is obtainable with a stack, in the sense of exercise 2.2.1-5 or 2.3.1-6, if and only if \( C_j < C_{j+1} \) for \( 1 \leq j < n \) in the notation of exercise 7.

22. [M28] (C. Meyer.) When \( m \) is relatively prime to \( n \), we know that the sequence \( (m \mod n) (2m \mod n) \ldots ((n-1)m \mod n) \) is a permutation of \( \{1, 2, \ldots, n-1\} \). Show that the number of inversions of this permutation can be expressed in terms of Dedekind sums (cf. Section 3.3.3).

line -9

45885 ~ 45855

lines 5-8 after (38)

Curiously ... situation to the A n interesting one-to-one correspondence between such permutations and binary trees, more direct than the roundabout method via Algorithm 1 that we have used here, has been found by D. Rotem [Inf. Proc. Letters 4 (1975), 58-61]; similarly there is a

insert new sentence after (53):

Actually the 0 terms here should have an extra 9 in the exponent, but our manipulations make it clear that this 9 would disappear if we had carried further accuracy.

exercise 28, three changes

the average is ~ the average \( l_n \) is
... sorting" for some obscure reason, ~ sorting,"
\( 2\sqrt{n}; \ldots 1.97\sqrt{n} \) ~ \( 2\sqrt{n} \). L. A. Shepp and B. F. Logan have proved that \( \lim \inf_{n \to \infty} l_n/\sqrt{n} \geq 2 \) (to appear.)
figure 9 step 03

\[ \text{COUNT}[K_j] \rightarrow \text{COUNT}[K_j] \]

addition to step B2

(If \( \text{BOUND} = 1 \), this means go directly to B4.)

line -5

the underline shouldn't be broken

comments for lines 14 and 15 of the program

\[ \text{BOUND} \rightarrow \text{BOUND} \]

line 9

(December, 1974), (1974), 287-289.)

line 8

\[ \log_2 \rightarrow \lg \]

exercise 15 line 2

subscripts and superscripts are in wrong font

line 1

items; \( \rightarrow \) items,

line 3

r15 \( \rightarrow \) r15
3.153 line -18
one \textsuperscript{\textdagger} at least one

3.165 last line of Table 2

179 \textsuperscript{\textdagger} 170

3.200 line -2
wise, oracle \textsuperscript{\textdagger} dangerous, adversary

3.200 lines -13, -12, -9, -8
pronouncements \textsuperscript{\textdagger} outcomes (four changes)

3.200 lines -7 thru -3
oracles \textsuperscript{\textdagger} adversaries
oracle \textsuperscript{\textdagger} adversary (five changes)
Constructing lower bounds, Theorem M shows that the "information theoretic" lower bound (2) can be arbitrarily far from the true lower bound; thus the technique used to prove Theorem M gives us another way to discover lower bounds. Such a proof technique is often viewed as the creation of an adversary, a pernicious being who tries to make algorithms run slowly. When a n algorithm for merging decides to compare $A_i : B_j$, the adversary determines the fate of the comparison so as to force the algorithm down the more difficult path. If we can invent a suitable adversary, as in the proof of Theorem M, we can ensure that every valid merging algorithm will have to make a rather large number of comparisons. (Some people have used the words 'oracle' or 'demon' instead of 'adversary'; but it is preferable to avoid such terms in this context, since 'oracles' have quite a different connotation in the theory of recursive functions, and 'demons' appear in still a different guise within languages for artificial intelligence.)

We shall make use of constrained adversaries, whose power is limited with regard to the outcomes of certain comparisons. A merging method which is under the influence of a constrained adversary does not know about the constraints, so it must make the necessary comparisons even though their outcomes have been predetermined. For example, in our proof of Theorem M we constrained all outcomes by condition (5), yet the merging algorithm was unable to take use of this fact in order to avoid any of the comparisons.

The constraints that we shall use in the following discussion apply to the left and right ends of the files. Left constraints are symbolized by

\[ \text{\underline{2.202}} \text{ lines 7 and 16} \]

questions \( \mapsto \) comparisons
be answered \( \mapsto \) result in

\[ \text{\underline{2.202}} \text{ lines 9, 10, 18} \]

oracle \( \mapsto \) adversary (four changes)

\[ \text{\underline{2.202}} \text{ line 12} \]

then we define \( \mapsto \) thus,
to be \( \mapsto \) is

\[ \text{\underline{2.202}} \text{ line 15} \]

our oracle \( \mapsto \) that our adversary
the oracle

oracle adversary (six changes)

oracle adversary

oracle adversary

oracle adversary

oracle adversary

The oracle

Say Decide (six changes)
"oracle", \(\sim\) "adversary" as in Section 5.3.2.

3.215 replace the eight lines preceding Table 1 by:

may be subject to further improvement. The fact that \(V_4(7) = 10\) shows that (11) is already off by 2 when \(n = 7\).

A fairly good lower bound for the selection problem has been obtained by David G. Kirkpatrick (Ph.D. thesis, U. of Toronto, 1974), who constructed an adversary which proves that

\[ V_4(n) > n + \epsilon - \sum_{j < \log_2 n} \log((n+2-j)/j) \] for \(n > 2t - 1\). \hspace{1cm} (12)

Kirkpatrick has also established the exact behavior when \(t = 3\) by showing that \(V_3(n) = n + \log((n-1)/2) + \log((n-1)/4)\) for all \(n \geq 80\) (cf. exercise 22).

3.217

line 17: A. Schönhage \(\sim\) M. Paterson, N. Pippenger, and A. Schönhage

line 18: has \(\sim\) have

line -1: (12) \(\sim\) (13)

3.218

line -7: (13) \(\sim\) (14)

line -5: \(V_i(n) \sim V_i(n)\)

3.220

line -21: a homogeneous \(\sim\) an oblivious

line -2: arid -1: a homogeneous \(\sim\) an oblivious

\textit{any homogeneous} \(\sim\) \textit{any oblivious}
a suitable oracle.] a n adversary.]

substitute for exercise 22

22. [24] (David G. Kirkpatrick.) Show that when \( 4 \cdot 2^k < n-1 < 5 \cdot 2^k \), the upper bound \((11)\) for \( V(n) \) can be reduced by 1 as follows: (i) Form four "knockout trees" of size \( 2^k \).(ii) Find the minimum of the four maxima, and discard all \( 2^k \) elements of its tree. (iii) Using the known information, build a single knockout tree of size \( n-1-2^k \). (iv) Continue as in the proof of \((11)\).

caption

A homogeneous An oblivious

line 3

1972, Chapter 15 \( 1973, 163-172 \)

upper left corner of Fig. 51

there's a dot missing on the second line of the diagram for \( n=6 \)

line 3 new sentence

A. C. Yao and F.F. Yao have proved that \( M(2,n) = C(2,n) = \frac{\sqrt{n}}{2} \) and that \( M(m,n) \geq \frac{1}{2m} \lg(m+1) \) for \( m \leq n \). [JACM, to appear].

line 12

16 is in the wrong hold-fact font

line 13

RECORD(Q) RECORD(Q)
delete "[Hint:..., 4.5.31.]", since the proof of that theorem is being changed in the second edition of vol. 2.

line 6

other P. $\sim$ other P.

line 15

to C5. $\sim$ to C5 if $m > 0$.

lines -16 and -15

$\text{SORT10} \sim \text{SORT10}$
$\text{SORT01} \sim \text{SORT01}$

bottom line

$\log_2 \sim \log$ (twice)

line -3

"Soundex" $\sim$ contemporary form of the "Soundex"

line 17: formulated $\sim$ popularized
lines 19, 20: inversely $\sim$ Reading $\sim$ approximately proportional to $1/n$. (The Psycho-
Biology of Language (Boston, Mass.: Houghton Mifflin, 1935); Human Behavior and the
Principle of Least Effort (Reading

extra annotation on line 08 of Program B

$LrA/21 \sim LrA/21$ (rX changes to o)
only all \( \wedge \) only if all

between \( \wedge \) between and outside the extreme values of the

\[ \begin{align*}
1 \leq j & \wedge 2 \leq j \\
\end{align*} \]

800 \( \wedge \) 500

memory. It \( \wedge \) memory. The difference between \( \lg \lg N \) and \( \lg N \) is not substantial unless \( N \) is quite large, and typical files aren't sufficiently random either. Interpolation

new paragraph after line 14:

Interpolation search is asymptotically superior to binary search; one step of binary search essentially replaces the amount at watch, \( n \), by \( \frac{1}{\sqrt{n}} \), while one step of interpolation search essentially replaces \( n \) by \( \sqrt{n} \) if the keys in the table are randomly distributed. Hence it can be shown that interpolation search takes about \( \lg \lg N \) steps on the average. (See exercise 22.)

\[ \begin{align*}
\text{Replace lines -5 thru -11 by:} \\
01130934 2908085320 & 491227 \\
011314315230 & 49090712 \\
0113434048 & 48494115 \\
0113484030 & 484622592525553320 \\
0114042640 & 4836 \\
\end{align*} \]

\[ \begin{align*}
\text{Bottom line} \\
\text{was \( \wedge \) seems to have been} \\
\end{align*} \]
the last part is in nearly perfect alphabetic order! 
the alphabetic order in the last part is substantially better.

Algorithm II. Algorithm T

clearly constructed n+1 different deletions; constructed n+1 different deletions, one for each j.

A fairly A n even more

line -7: time. In fact, M. Fredman has shown that O(n) units of time suffice, if the right datastructures are used [ACM Symp. Theory of Comp. 7 (1975), 240-244].
and following pages

In the second edition of vol. 3 I must revise the subsection about the Hu-Tucker algorithm to take account of the new Garcia-Wachs algorithm. Meanwhile I could have improved my treatment of Hu-Tucker by leaving the external nodes out of the priority queues (cf. (23) on p. 444, an unnecessarily cumbersome approach).

Replace lines 3-5 by:

That the resulting maximum subtree weight, \( \max(w(0,k-1),w(k,n)) \), is as small as possible. This approach can also be fairly poor, because it may choose a node with very small \( p_k \) to be the root; however, Paul J. Haycr has proved that the resulting tree will always have a weighted path length near the optimum (see exercise 36).

Exercise 30

\[ M46 \leftrightarrow M41 \]

New version of exercise 36

36. [M40] (Paul J. Bayer.) Generalizing the upper bound of Theorem G, prove that the cost of any optimum binary search tree with nonnegative weights must be at most the total weight \( S \cdot \sum_{1 \leq i \leq n} p_i + \sum_{0 \leq j \leq n} q_i \cdot \text{times} \cdot \text{II} + 2 \), where

\[ \text{II} = \sum_{1 \leq i \leq n} (p_i/S) \cdot \log(S/p_i) + \sum_{0 \leq j \leq n} (q_i/S) \cdot \log(S/q_i); \]

In fact, the top-down procedure which repeatedly chooses roots that minimize the maximum subtree weights will yield a binary search tree satisfying this bound. Show further that the cost of the optimum binary search tree is \( 2 \cdot \text{times} \cdot \text{II} - \text{lg}(2 \cdot \text{II}/e) \).

Diagrams (2)

Put extra little vertical lines above the topmost nodes (B and X, respectively), for consistency with (1).

Line 2

\( K \leftrightarrow \text{K} \)
replace lines -4 and -3 by:

indicate that the average number of comparisons needed to insert the $N$th item is approximately $1.01 \log N + 0.1$ except when $N$ is small.

bottom line of Table 1

$2.0 \lor 2.78$

Eq. (14)

$p/(1-p) \approx 1.851. \lor 1/(1-p) \approx 2.851.$

line -12

$k = 1 is p/(1-p). \lor k is 1/(1-p).$

line 1: $\log N + 0.25 \lor 1.01 \log N + 0.1$
line 2: $11.17 \log N + 4.8 \lor 11.3 \log N + 3$
line 6: $6.5 \log N + 4.1 \lor 6.6 \log N + 3$

below the third node from the left, the 1 has a bar across it, making it look like a 4 by mistake

line -9

$R(P) \lor RANK(P)$

line 16

$RANK(R). \lor RANK(R). Co to C10.$
lines 11-12 should be replaced by:

trees which arise when we allow the height difference of subtrees to be at most K. Such structures may be called HB[k] trees (meaning "height-balanced"), so that ordinary balanced trees represent the special case HB[1]. Empirical tests on HB[k] trees have been discussed by P. L. Karlton et al., *CACM* 19 (1976), 23-28.

new exercise

31 {34} (M. L. Fredman.) Invent a representation of linear lists with the property that insertion of a new item between positions m-1 and m, given m, takes $O(\log m)$ units of time.

new paragraph before the exercises

Andrew Yao has proved that the average number of nodes after random insertions without the overflow feature will be $N/(m \ln 2) + O(N/m^2)$, for large $N$ and $m$, so the storage utilization will be approximately $1/n = 69.3$ percent [Acta Informatica, to appear].

line 11

long, ☐ tong, but always a multiple of 5 characters,

line -10

tree, ☐ trie.

line -4

HOUSE ☐ HOUSE (twice)
the nodes of the tree the tree is nonempty and that its nodes

follows: follows:

exercise 4

there will be a new illustration, with positions numbered from 1 to 49 instead of 1 to 55. The respective entries will be:

--- (20) --- WAS THAT (18) OF
BE THE HIS WHICH WITH THIS ---
(4) ON I HE A OR (19)
(3) TO HAD --- (14) BUT (1)
(17) FOR BY IN FROM AND NOT
(1) HER ARE IS IT AS AT
(7) --- HAVE (3) --- YOU ---

line 2: 55 49 lines after new illustration: 20, 1, 14,..., 2 within 20, 19, 3, 14, 1, 17, 1, 7, 3, 20, 18, 4 within

line 2

that if $n \geq 2$,

exercise 39

M47 M43

line -5 add new sentence after "of M."

(A precise formula is worked out in exercise 34.)

program line 13

empty nonempty
delete lines 15-18 (m+1 not really needed after all)

line -1

antially

line 13

similar weaker

three lines after (34)

purposes. In fact, Leo Guibas and Endre Szemerédi have succeeded in proving the difficult theorem that double hashing is asymptotically equivalent to uniform probing, in the limit as $M \to \infty$. [To appear.]

just after (37), insert new sentence:

By convention we also set $f(0,0) = 1$.

new formula for (58)

$$C_N = 1 \cdot \left( \frac{b^h}{a^h h^h} \right) \left( 2 + (\alpha-1)b + (\alpha^2-\alpha^3(\alpha-1)^2)R(a,h) \right) \cdot O(1/M).$$

line -2

until Morris'... 1968, until the late 1960's,

line 1: The only ... among - The first published appearance of the word seems to have been in H. Hellerman's book *Digital Computer System Principles* (New York: McGraw-Hill, 1967), p. 152; the only previous occurrence among

line 6: 1968 → 1967
ten or less \( \leq \) at most 1cn

\[\text{Icn or lrss U al most lcn}\]

\[\text{exercise 10}\]

\[M_{48} \land M_{43}\]

\[\text{line -4}\]

\[M^{-} > M \land M^{+} > M\]

\[\text{exercise 45}\]

\[M_{48} \land M_{43} \sim\]

\[\text{exercise 66}\]

\[66. \sim 66.\]

\[\text{new exercise}\]

\[67. [M_{25}] \text{(Andrew Yao.) Prove that all fixed-permutation single-hashing schemes in the }\]
\[\text{sense of exercise 6.2 satisfy the inequality } C_{N} > \frac{1}{M} + 1/(1 - a)). \text{[Hint: Show that an}\]
\[\text{unsuccessful search takes exactly } k \text{ probes with probability } p_{k} \leq (M - N)/M.}\]

\[\text{lines -10, -8, -6}\]

\[\text{LONGITUDE } \sim \text{LONGITUDE (three places)}\]

\[\text{in the second edition I will be revising Section 6.5 again, deleting the material on post-}\]
\[\text{office trees, paying more attention to Bentley's } k-d \text{ trees, and discussing the search}\]
\[\text{procedure of Burkhard and its analysis by Dubost and Trousse (cf. Stanford CS report of}\]
\[\text{Sept. 1975)}\]
line 13, add:

[CAACM 18 (1975), 509-516.]

line 8

3 (to appear) 4 (1974), 1 - 10

the numbers in (5) should be respectively:

0.07948358; 0.00700659; 0.00067094; 0.00006786; 0.00000728; 0.00000082.

quotation

Alice's Adventures in Wonderland  Alice's Adventures in Wonderland

lines 1-3

So WC may ... (p-1)/2. In general if \( f \) is any divisor of \( p-1 \) and \( d \) any divisor of \( \gcd(f,n) \), we can similarly determine \( (n/d) \mod f \) by looking up the value of \( b^{(p-1)/f} \) in a table of length \( f/d. \) If \( p-1 \) has the prime factors \( q_1 < q_2 < \ldots < q_t \) and if \( q_1 \) is small, we can therefore compute \( \text{rapidly by finding the digits from right to left in its mixed-radix representation, for radices } q_1, \ldots, q_t. \) (This idea is due to R. L. Silver.)

exercise 6

the 's in the exponents ride too high (twice)

exercise 13

\( b_{m-1}, \quad b_m, \quad b_{m+1}, \quad b_{m-1}, \quad b_m, \quad b_{m+1}, \)

exercise 20

new answer

22. \( L_{m_j} / n_j = L_{m_i} / n_j = L_{m(j-i)} / n_j = 0 \) or 1; and it is 0 if \( m_j \mod n > m_i \mod n \). Hence the number of inversions is \( \sum_{0 < k < n} \left( L_{m_j} / n_j - L_{m_i} / n_j - L_{m(j-i)} / n_j \right) \). This can be transformed to \( \frac{1}{4}(n-1)(n-2) - \frac{1}{4}n^2(m,n,0) \). [J. für die reine und angew. Math. 198 8 (1957), 162-166.]

exercise 19

elete lines 3-7 of this answer.
line 8: The answer \( \rightarrow (This \, formula \, now \, add \, a \, new \, paragraph: \)

**Note:** A general formula for the number of ways to place the integers \( \{1,2,...,n\} \) into an array which is the "difference" of two tableaux \( (n_1, \ldots, n_m) \) \( (l_1, \ldots, l_k) \), where \( 0 \leq l_1 \leq n \) and \( n \) - \( \sum n_i - \sum l_i \) has been found by F. Feit [Proc. Amer. Math. Soc. 4 (1953), 740-744]. This number is \( n! \det (1/(n-j) - (l_j-i))! \).

line -4

4.5N^2 + 2.5N - 6. \( \rightarrow (4.5N^2 + 2.5N - 6)u. \)

addendum to exercise 15

It is interesting to note that \( C(w,z) = \frac{F(-w,z)}{F(-w,z)} \), where \( F(z,q) = \sum_{n \geq 0} z^n q^n / \prod_{1 \leq n \leq q} \Phi_n(q) \) is the generating function for partitions \( p_1 + \cdots + p_n \) into \( n \) parts, where \( p_j \geq p_{j+1} + 2 \) for \( 1 \leq j \leq n \) and \( p_n > 0 \) (cf. exercise 5.1-16).

exercise 31 line 03

INPUT-N,4 \( \rightarrow - \) INPUT-N,4

addition to answer 2

[Algorithm 5.2.3S does exactly \( \chi(\pi) \) exchanges, see exercise 5.2.3-4.]

line 12

[To appear], 1 \( \rightarrow 1 \) 1 (1975), 29-35]
As $n \to 0^+$, \[ \Gamma(1)/n \to \Gamma(1) = -\gamma, \]

line 4

If is in wrong font (see line -2 for correct $\Gamma$)

exercise 13

397-404 $\sim$ 263-269

line-s -8, -7, -6, -3

oracle $\sim$ adversary

lines 2, 17

oracle $\sim$ adversary

exercise 9

comparisons, yet the procedure is not optimal.

exercise 14

line 1: found in $\sim$ found in $U_f(n) \leq$

also add new sentence: (Kirkpatrick's adversary actually proves that (12) is a lower bound for $U_f(n+1) - 1$.)

line 2

oracle $\sim$ adversary
22. In general when \(2^t \cdot 2^k < n \cdot 2^{-1} < (2^t + 1) \cdot 2^k \) and \(t < 2^t \cdot 2^k \), this procedure starting with \( t+1 \) knockout trees of size \(2^k\) will yield \(\lceil (t-1)/2 \rceil\) fewer comparisons than (1 l), since at least this many of the comparisons used to find the minimum in (ii) can be "reused" in (iii).

exercise 36 last line

exercise 37 and 38 combine to yield a simple sorting method with \((n \log n)/k + O(n)\) comparison cycles on \(k\) processors: First sort \(k\) subfiles of size \(\lceil n/k \rceil\), then merge them in \(k\) passes using the "odd-even transposition merge" of order \(k\).(To appear.)

exercise 2 line 4

exercise 3 for section 5.5, last line

variables, without transforming the records in any way.

line -6

Strauss

exercise 7 line 3

80; see also L. Guibas, Acta Informatica 4 (1975), 293-298.]
\[3.673\]

line - 9 (displayed nodes):
\[\begin{align*}
&'1 \quad \quad \quad 0 \\
&'2 \quad \quad \quad 1 \\
&s_1 \quad \quad \quad s_0 \\
&s_2 \quad \quad \quad s_1 \\
\end{align*}\]

line - 8:
\[\begin{align*}
&'1 \quad \quad \quad 0 \\
&s_1 \quad \quad \quad s_0 \\
&k > 1 \quad \quad k > 0 \\
\end{align*}\]

lines -6 and -8: the right subtrees of \ldots and the result \ldots the result

\[3.674\text{ new answer}\]

- 30. This has been proved by Russell Wessner [to appear].

\[3.674\text{ replace answer to 36 by:}\]


\[3.676\text{ exercise 19}\]

the fourth rectangle in the left-hand figure is too short -- it should be extended so that its bottom line is at the same level as the bottom of the first and third rectangles

\[3.677\text{ answer 20, the line following the tree should become:}\]

It may be difficult to insert a new node at the extreme left of this tree.

\[3.678\text{ answer 30 line 4}\]

left subtree of that \ldots subtree rooted at that

\[3.678\text{ new answer}\]

29. Partial solution by A. Yao: With \(N \geq 6\) keys the lowest level will contain an average of \(\frac{3}{2}N+1\) one-key nodes, \(\frac{3}{2}N+1\) two-key nodes. The average total number of nodes lies between \(0.70N\) and \(0.79N\), for large \(N\). [Acta Informatica, to appear.]
3.678 new answer

31. Use a nearly balanced tree, with additional upward links for the leftmost part, plus a stack of postponed balance factor adjustments along this path. (Each insertion does a bounded number of these adjustments.)

3.680 exercise 4 line 3

IONIC TRASH
seven six
insert new sentence on last line: [This remarkable 49-place packing is due to J. Scott Fishburn, who showed that 48 places do not suffice.]

3.682 new answer to exercise 11 (extends to p. 683)

11. No: eliminating a node with only one empty subtree will "forget" one bit in the keys of the nonempty subtree. To delete a node, it should be replaced by one of its terminal descendants, e.g., by searching to the right whenever possible.

3.685 exercise 12

line 3: Algorithm 6.2.21: the algorithm suggested in the previous answer.
last line: \( \frac{3}{8} \sim \frac{1}{4} \)

3.686 exercise 34 line 1

\[ B_{k}2^{j(k-1)} \sim B_{k}/2^{j(k-1)} \]

3.686 exercise 34, new answer to part (b)

(b) In the \( 1/(e^{x}-1) \) part, it suffices to consider values of \( j \) with \( x \leq 2 \ln n \). For \( 1 \leq x \leq 2 \ln n \) we have \( \Sigma_{1<k<n/x} (1-kx/n)^{n-1} \sim \Sigma_{k>1} e^{-kx} + O(x^{2}e^{-x}/n) \). For \( x < 1 \) we have \( \Sigma_{0<k<n} B_{k}x^{k}/k! + O(x^{2}/n) \).

3.686 line 9

*\( f(n) \), \( \sim \)
*\( f(n) \cdot 2/n \), \( k<1 \sim k>1 \)

48
new answer


3.691 line 12

and \( \sim \) with \( O/O \) when \( k = N = M - 1 \), and

3.694

in the second edition I will revise several of these answers, using Mike Paterson's simplified new approach to such analyses.

3.694 exercise 39

line 6 (third line of displayed formulas): delete "\( j \geq 1 \)," (on this line only)
line 6 (fourth line of displayed formulas): \( \left( \frac{j}{2} \right) \sim \sum_{j=1}^{j} \left( \frac{j}{2} \right) \) (two places)

3.696 new answer


3.699 new answer

47. Let \( q_k = p_k p_{k+1} \cdots \); then \( C_N = \sum_{k=1}^{N} q_k \) and \( q_k \geq \max \left( 0, 1 - (k-1)(M-N)/M \right) \).

3.700 line 1

\[ \sum_{i} p_{i}q_{i} \sim \sum_{i} p_{i}p_{i} \] minus the probability that a particular record is a "true drop", namely \( \left( \frac{N-q}{q} \right) \) / \( \binom{N}{q} \), where \( N = \binom{n}{k} \).

3.702 line -20 last column

1154 \( \sim \) 1155
A few interesting constants without common names have arisen in connection with the analysis of sorting and searching algorithms; 40-digit values of these constants appear in the answers to exercises 5.2.3-27, 5.2.4-13, and 6.3-27.

\[ \det(A) \sim \det(B) \]

...  

...  

...  

...  

...  

...  

...  

Adversaries, 200-204, 209, 211-212, 220.

Aho entry  

add p. 468
3.7120
Baudet, Gerard, 640.

3.7121
Bayer, Paul Joseph, 439, 450.

3.7122
Dedekind sums, 22.

3.7123
Demons, 290.

3.7124
Feit, Walter, 592.

3.7125
Fishburn, John Scot, 680.

3.7140
Fredman entry
add pp. 439, 471

3.7141
Gracelli

3.7142
Guibas entry
add pp. 528, 672, 696
Hellerman, Herbert, 542.

Hoshi, Mamoru, 687.

*delete* the entry for "Homogeneous comparisons".

Hyafil entry

delete p. 21s.

two new entries


Knockout tournament entry

add pp. 214, 220.

Linear list representation entry

468. 471.

two new entries

Karlton, Philip Lewis, 468.
Kirkpatrick, David Gaier, 215, 220, 636.

Logan, Benjamin Franklin, Jr., 594.
Meyer, Curl, 22.

Miyakawa, Masahiro, 687.

Oblivious algorithms, 220-221.

Oracles, 200. see Adversaries.

Parallel computation entry

add p. 610

Paterson, Michael Stewart, 217.

Pippenger, Nicholas John, 217.

line -1

Rotem, Doron, 64.
Shepp, Lawrence Alan, 594.

223, 223, 405 (exercise 22),

Silver, Roland Lazarus, 576.

Simultaneous comparisons entry add p. 640

Stevenson, David, 640.

new subentry under Sorting history of, 382-388, 417-418.

Strauss Strauss

Sugito, Yoshio, 687.

Szemerédi, Endre, 528.
3.7210
Tape searching, 400-401, 405.

3.7210 line 25
Sławomir → Sławomir

3.7220
Treesort, see Tree selection sort, Heapsort.

3.7220
Two-dimensional trees, 555, 570.

3.7220 Turski entry
Władysław → Władysław

3.7220 Ullman entry
add p. 468

3.7220 new subentry under Trie search
   generalized, 565.

3.7230
Wessner, Russell, 674.

3.7230
Yao, Foong Frances, 232, 422.
Wrench entry
add p. 686

Yao, Andrew entry
add pp. 232, 422, 479, 549, 678

Yuba, Toshitsugu, 687.

Zetafunction, 612, 666.

just before 2-3 trees entry
2D trees, 555, 570.

(namely the endpapers of the book)
delete "Table 1"
also change 1 to italic 1 in box number 35

changes to MIX booklet
p30, Fig. 3: Step P3 should say "500 found?"
p34, Fig. 4: third card should say L EQU 5 0 0
p43, line 1: 6667 ~ 66667
p43, line 2: 193,334 ~ 133,334
p44, problem 16, line 2: row...diagonal ~ row and column
p44, problem 16, line 8: 10 ~ 9
and change "record" to "block" everywhere in the discussion of MIX I/O operators.
changes to the book Surreal Numbers

p99, line 2: (4) \rightsquigarrow (3)
p111, lines 4 and 5, interchange the inside of the braces:
\((x-x^2, x-x^2+x^3-x^4, \ldots)\),
\([x, x-x^2+x^3, x-x^2+x^3-x^4+x^5, \ldots]\).
p117, problem 18, lines 3 and 4 should be:
\(X_P\) has a greatest element or is null if and only if
\(X_K\) has a least element or is null.