Chaos and Fractals:
An Elementary Introduction
Errata in the First Impression

David P. Feldman

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Most of these errata are typos or punctuation mishaps that do not affect the meaning of the text. Errors that are significant enough that they might cause confusion (as opposed to mere annoyance) are indicated with a ★.

Errata from the First Impression:

- **page 15:** Exercise 1.11(c) should read "In 1985 **there** are 20 rabbits on the island."
- **page 31:** In the second paragraph, the third line should read: "... to observe or encounter **an** unstable fixed point, ..."
- ★ **page 32:** Exercise 3.10(d) should read: "What do your answers to the above two questions let you conclude about the stability of the fixed point $x = -\mathbf{4}$?"
- **page 61:** Seventh line from the bottom of the page should read "affecting the rabbits" not "effecting the rabbits."
- **page 65:** Exercise 7.6(c) should read: "What does the slope **of** this line suggest about the stability of the fixed point at $x = \frac{1}{3}$**?**"
- **page 67:** Issac Newton should be Isaac Newton. The spelling of Isaac is also wrong in the index, page 406.
- **page 77:** The first sentence should read "In Chapter 7..."
- **page 78:** The seventh line of text should read "...to a phase line**.** **H**owever, on this sort..."
- **pages 84–86:** References to $r = 4$ should be changed to $r = 4.0$.
- **page 85:** The last line on the page should read "...the rule is just the function that **is iterated**."
- **page 86:** Line six should read: "...we keep seeing new numbers. **This** was the case..."
- **page 86:** First line of the third full paragraph should read "...that the dynamical system display**s**."

- **page 86:** Sixth line of the third full paragraph should read "...in a relatively short time. **S**ensitive dependence..."
- **page 96:** In the last line of the first paragraph, "iteratations" should be "iterations".
- **page 102:** Exercise 10.2 should read "In Table 10.3 are shown the first *seven* iterates..."
- **page 107:** The last line of the second paragraph should read "...to ordered, period**ic** regions."
- ★ **page 111:** Two sentences before Eq. (11.3). The sentence should read: "The **last** number in Sharkovsky ordering is $2^0 = 1$." (Thanks to Allan Duncan for catching this.)
- ★ **page 113:** Equation (11.6) should read:

$$\delta_2 = \frac{r_3 - r_2}{r_4 - r_3} \ .$$

- ★ **page 116:** The second sentence of the last paragraph should read: "For the cubic equation, the bifurcation from period 1 to period 2 occurs at around $\mathbf{r = 5.25}$. (Thanks to Joel Gottlieb for catching this.)
- **page 129:** Second paragraph, line 6. Insert a space between "pp." and "61–66".
- **page 141:** The sentence immediately after Eq. (14.1) should read: "There **is** an infinite number of numbers..."
- **page 146:** Second paragraph, line 4 should read "there are lots **and** lots of other..."
- **page 146:** paragraph 3, line 1 should read "There **is** an infinite number of possible algorithms. There **is** also..."
- **page 147:** The first line on the page should read "...there **is** an infinite..."
- **page 151:** The sixth line from the bottom of the page should read: "the property of the pints..."
- **page 157:** The fifth line should read "the sorts **of** dynamical systems..."
- **page 164:** Fifth line from the bottom, deleted repeated instance of "other."
- **page 173:** The second line in the second paragraph should read "which was the subject of Exercise **16.4**, is generated as follows."
- ★ **page 180:** The fifth line of the second paragraph should read "...in the dark shaded triangle in the lower **right** of Fig. 17.14."
- **page 196:** The fifth line from the bottom should read "as shown in **Table 19.1**."

- **page 197:** The second sentence in the caption for Fig. 19.1 should read "...the average winning line become**s** less jumpy..."

- ★ **page 199:** In Table 192. The column titled Total Winnings should read $4, 8, 12, \mathbf{14}, \mathbf{16}, 48, 64, \ldots$.

- **page 199:** The second to last line from the bottom of the page should read "...the average winning may have been approaching 5." (I.e., delete "were".)

- **page 202:** The last sentence of side-note 2 should read: "However, it is worth **noting** that ... ." (Thanks to Julio Cesar Campos Neto for finding this error.)

- **page 212:** The first sentence of the second paragraph should read "Let us illustrate this process **using** two sentences written by..."

- ★ **page 212:** In Figure 20.8, the graph is wrong for word frequencies of 5 and 6. The line should be twice as high, indicating that there is one word that occurs 5 times and one word that occurs 6 times. As it stands, the graph indicates that there is half a word that occurs 5 times and half a word that occurs 6 times, which makes no sense.

- ★ **page 213:** Note that the histograms in Figs. 20.9 and 20.10 are normalized.

- **page 215:** The seventh line in the first paragraph of Section 20.4 should read "...power-law distribution, $p(x) = \mathbf{A}x^2$. I.e., to be consistent with Eq. (20.5), the constant in the equation should be A, not C.

- **page 215:** Note that the histogram in Fig. 20.15 is normalized.

- **page 221:** The sixth line of the first paragraph should read "This is the focus of this chapter, **which** has a somewhat different..." (The version in the text is grammatically correct, but is somewhat stilted.)

- **page 225:** There is an ambiguity in the first paragraph. I write that the unit interval consists of all numbers between 0 and 1. However, in Eq. (21.17) I write that the unit interval is $\mathcal{L} = [0, 1]$. The square brackets mean that the endpoints—i.e. 0 and 1 —are included in $\mathcal{L}$. So I should have written that the unit interval consists of all numbers that are greater than or equal to 0, but are less than or equal to 1.

- **page 224:** In the second line from the bottom of the page there is a bit too much space between the comma and the "0" in $100,000$.

- **page 229**. In the last line of the third paragraph there is too much space between "unit" and "interval."

- ★ **page 230:** The seventh line of the second paragraph should read "...start with **0.0** lie in the first third..."

- **page 231:** the seventh line from the bottom of the page should read "... ~~the~~ an infinite size, but..."

- **page 232:** The fifth line of the last paragraph on the page should read "...contains **a** general discussion..."

- **page 232:** In the ninth line of the last paragraph, delete the comma after "Barrow's".

- **page 242:** The fourth line after Eq. (23.5) should read "...but it is possible you will encounter ~~them~~ **it** elsewhere."

- **page 244:** The first line on the page should read "...and the angle, **in a counter-clockwise direction** between the **positive** horizontal axis and a line drawn from the origin to the point z. (What is in the text is not wrong, but is potentially ambiguous.)

- **page 246:** The last line of the caption for Fig. 23.5 should read "$w = \frac{1}{2}+\frac{1}{2}i$, $w^{\mathbf{2}} = -0.5$.

- ★ **page 249:** The second line above Eq. (24.1) should read "$z_0 = (r_0 = 2, \theta_0 = \mathbf{15})$."

- ★ **page 251:** Eq. (24.5) should read:

$$0.8 + 0.2i \longrightarrow -0.4 + 0.32i \longrightarrow -0.942 - 0.256i \tag{1}$$
$$-0.178 + 0.482i \longrightarrow -1.201 - 0.172i \cdots . \tag{2}$$

  The next line should read: "Although it is not immediately apparent, this orbit does eventually tend toward infinity. (The 15^{th} iterate is $-2078.3 - 5290.4i$.)"

- **page 252:** The second sentence in the caption of Fig. 24.5 should read "This is a close-up of **the** boxed region of the Julia set... ."

- **page 253:** The caption for Fig. 24.6 should read "The Julia set for the function $f(z) = z^2+0.84i$." (I.e., "+" not "−".)

- ★ **page 255:** Exercise 24.6. The values given in the exercise are correct; they do indeed correspond to the eight Julia sets shown on page 256. However, several online Julia-set programs produce images that are flipped along a vertical axis. These programs may be using the function $f(z) = z^2 - c$ (instead of $+c$), or they may simply be rendering the images wrong. The Julia set program that is part of WolframAlpha is reliable and renders images correctly. I recommend using this program. It can be found at: `http://www.wolframalpha.com/input/?i=julia+set`.

- **page 259:** Line 7 in the second paragraph should read "... it can still take ~~a~~ some time."

- **page 259:** Table 25.2. The minus signs appear as hyphens. They should be longer. Also, there is no need for the + in the entry for z_t at time 4.

- **page 261:** The third sentence of the caption for Fig. 25.5 should read "The initial condition $z_0 = 0$ was iterated for each ~~the~~ c value."

- **page 262:** Marginal note 3 should read "A good, elementary introduction to Mandelbrot set graphics is Rood (2004)."

- **pages 262–3:** The first line in the caption for all four figures on these two pages should read: "A plot of a portion **of** the Mandelbrot set."

- **page 263:** The first line should read "Having enjoyed a journey through parts of **the** Mandelbrot set."

- **page 263:** The last line of the first paragraph should read "...a listing of all the c values that have a connected Julia sets."

- ★ **page 264:** Table 25.4 should read:

Time	z_t
0	0
1	$-0.505 + 0.574i$
2	$-0.579 - 0.00574i$
3	$-0.169 + 0.581$
4	$-0.814 + 0.377i$
5	$0.014 - 0.040i$
⋮	⋮
50	$0.015 - 0.035i$
51	$-0.506 + 0.573i$
52	$-0.577 - 0.006i$
53	$-0.172 + 0.581i$
54	$-0.813 + 0.374i$
55	$0.015 - 0.035i$

- ★ **page 267:** Table 25.5. The caption should read "The orbit of $f(z) = z^2 + c$, for $c = \mathbf{-0.157 + 1.031i}$.

- **page 267:** Table 25.5 should read:

Time	z_t
0	0
1	$-0.157 + 1.031i$
2	$-1.195 + 0.707i$
3	$0.772 - 0.660i$
⋮	⋮
50	$-1.196 + 0.707i$
51	$0.772 - 0.659i$
52	$-0.157 + 1.031i$
53	$-1.196 + 0.707i$

- ★ **page 274:** Fig. 26.1. The second sentence of the caption should read "The itinerary approaches the ~~fixed point at $x = 1$~~ period-two points at $x = 0.513$ and $x = 0.799$.
- **page 275:** The last line in Table 26.2 should have a time of 3, not 2.
- ★ **page 276:** The second line above Fig. 26.4 should read "The x part of the orbit oscillates between 2.49 and ~~0.83~~ 0.083."
- **page 277:** The first sentence of the caption for Fig. 26.5 should read "... under the Hénon map with $a =$ ~~0.115~~ 0.155."
- **pages 278 and 279:** The first sentence of the captions for both Fig. 26.9 and 26.10 should read "Time series plots of the x- and y-itineraries for the initial condition $x_0 =$ ~~1~~ 0.6, $y_0 =$ ~~2~~ 0.6... ."
- **pages 282 and 283:** In both Fig. 26.17 and 26.18, the first initial condition is (−0.514651,+0.297419).
- **page 283:** The second to last sentence in the first paragraph should read "This is hard to see on the time series plots of Figs. 26.17 ~~and 26.17~~."
- **page 288:** The second to last line on the page should read "...system in which a grid of discrete variables ~~which~~ are updated... ."
- **page 289:** Paragraph three, line six should read "...down the page instead of **across**, and instead ... ."
- **page 295:** The fourth line from the top of the page should read "...it has generally **been** recognized that... ."
- **page 295:** Paragraph two, line two should read "...behavior **is** beyond the scope of... ."

- **pages 298–300:** Section 27.5. The way I explain the naming convention for CAs is correct, but non-standard. My method yields the same names as the standard method, but readers may find the standard method more straightforward. The two methods are discussed in a separate document, available at `http://chaos.coa.edu/ca_naming_conventions.pdf`.

- ★ **page 299:** Equation (27.4) should read:

$$101 \;=\; (1 \times 2^2) + (0 \times 2^1) + (\mathbf{1} \times 2^0) \;=\; 4 + 0 + 1 \;=\; 5\,. \tag{3}$$

- **page 301:** Third line above Eq. (27.14) should read "... as was the case for $\mathbf{K} = 2$, $r = 2$ CA... ."

- **page 302:** The second sentence of exercise 27.3 should read: Starting with a single black cell, iterate using rule **182** for twenty or so time-steps.

- **page 306:** In the first line after Section 28.3 heading, insert a comma after "i.e."

- **page 306:** The sixth line from the bottom of the page should read "is 40 **degrees** warmer than room temperature it will cool twice as fast ~~as~~ **than** if it is 20 degrees warmer... ."

- **page 306:** Note 2. It is **Isaac** Netwon, not Issac. ☹

- **page 307:** In Table 28.2, the cooling rate at time 4 should be -4.92, not -4.91.

- **page 308:** Paragraphs 3 and 4. Each instance of the word "second" or "seconds" should be changed to "minute" or "minutes."

- **page 309:** Eq. (28.10), the right hand side should be -6 **C**, not -6 min.

- **page 310:** Note 4. Euler's first name is Leon**h**ard, not Leonard.

- **page 310:** Note 5 should read "Compare this with Eq. (28.12), which we repeated**ly** used to approximate... ."

- **page 312:** The sentences after Eq. (28.20) should read "This can be thought of as the differential equation version **of** the logistic equation. The population in **this** instance varies continuously... ."

- ★ **page 312:** In Exercise 28.7(d). $\Delta t = 0.5$, not 0.0.

- ★ **page 312:** The right-hand sides of Eqs. (28.20) and (28.21) should have $f(t)$ and not $f(x)$. (Or the left-hand side should be $\frac{df}{dx}$.)

- **page 315:** The caption for Fig. 29.3 should read "The phase line for the differential equation of Eq. (29.**4**)."

- **page 322:** The third sentence after Eq. (30.2) should read "The negative sign in front of this term~~s~~ indicates that... ."

- **page 322:** The last sentence in the second paragraph should read "The larger b is, the more deadly ~~are~~ **is** the presence of foxes... ."
- **page 327:** The tenth line from the bottom of the page should read "...behavior of the populations ~~are~~ **is** cyclic."
- **page 327:** The ninth line from the bottom should read "The period of the cycles ~~are~~ **is** the same... ."
- **page 328:** The second sentence in the caption of Fig. 30.4 should read "The trajectories for three different initial conditions ~~is~~ **are** shown."
- **page 333:** In Exercise 30.4, both instances of "Fig. 30.4" should read "Fig. 30.13."
- **page 338:** In note two, lines three–four should read: "have a friend gently toss **an** object at you."
- **page 338:** Second line after Section 31.3. It should be $\beta = 2.667$.
- **page 341:** The first line on the page should read: "A larger view of **the** non-repeating path..."
- **page 341:** The second line should read: "Here **one** can perhaps see more clearly..."
- **page 345:** Last line in the second paragraph. The reference "(Hilborn, 2004)" goes before the period, not after.
- **page 347:** The marginal figure of the Cantor set should be numbered 31.13, not 31.15. The typesetting program numbers figures automatically, but must have gotten confused here.
- ★ **page 349:** Exercise 31.1. The third line should read: "$x \approx 4.321$, $y \approx 4.3208$, and $\mathbf{z = 7.0}$."
- **page 359:** In the last paragraph, "StweartStewart" should be "Stewart".
- ★ **page 365:** Equation (A.19) should read: $x^1 = x$.
- ★ **page 375:** Equation (A.96) should read: $B(t) = \mathbf{100}(1.05)^t$.
- **page 382:** The first line of the fourth paragraph should read "It is crucial to remember that in normalized histograms **it** is the *area* that ..."
- **page 389:** The second line in the second paragraph should read: "And ~~there~~ there is much interesting..."
- **page 390:** Paragraph three, lines nine–ten, should read: "...some aspects of Gleick's book appeared **in a** subsequent issue..."
- **page 395:** In the first sentence of the second paragraph, "paper" should be "papers."

The majority of these errors were found by Karin Negoro. I am grateful for her careful reading of the book.