CORRECTIONS TO
Introduction to Topological Manifolds
(Second Edition)
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UPDATED JUNE 4, 2021

(2/25/18) Page xii, last paragraph: Allen Hatcher’s name is misspelled. (Sorry, Allen.)
(2/14/15) Page 23, Exercise 2.6, first line: Change “collection of topologies” to “nonempty collection of topologies.”
(6/24/19) Page 26, just above Exercise 2.12: Replace the last sentence of the paragraph by “Symbolically, this is denoted by $x_i \to x$.”
(6/18/19) Page 27, paragraph before Proposition 2.19: Just before the last sentence of that paragraph, insert “(Continuity of the restriction of a function to an open subset is understood to be with respect to the topology described in Exercise 2.5.)”

(3/16) Page 27, last line: Change two occurrences of $x$ to $y$ in the displayed equation, so it reads

\[(f|_{V_x})^{-1}(U) = \{y \in V_x : f(y) \in U\} = f^{-1}(U) \cap V_x.\]

(9/26/19) Page 31, second paragraph below the section heading, second sentence: Change “two points” to “two distinct points.”

(6/24/19) Page 32, just above Exercise 2.38: Insert the following sentence: “In view of the preceding proposition, in a Hausdorff space we can write $p = \lim_{i \to \infty} p_i$ as an alternative notation for $p_i \to p$.”

(5/17/12) Page 37, three lines from the bottom: Change “Exercise 2.49” to “Example 2.49.”

(11/26/15) Page 53, part (c) of the proposition continued from the previous page: Insert another “if” after “if and only.”

(7/14/18) Page 58, second display: Replace $k$ by $k/2$ (twice) and $l$ by $l/2$ (twice). [The tangent and cotangent functions have period $\pi$, not $2\pi$.]

(9/26/19) Page 60, last paragraph: In this paragraph and in the first one on page 61, change all subscript $k$’s to $n$’s (a total of four times).

(9/26/19) Page 61, Proposition 3.31, part (c): Change $X_k$ to $X_n$.

(11/20/19) Page 66, after the second line: Add the following sentence: “We sometimes also say informally that $Y$ is a quotient space of $X$ when $Y$ is a topological space that has the quotient topology with respect to some continuous map from $X$ to $Y$.”

(3/23/12) Page 67, Example 3.52, second sentence: Change this sentence to read “Let $\sim$ be the equivalence relation on $X$ such that $a_1 \sim a_2$ for all $a_1, a_2 \in A$ and $x \sim x$ for all other $x \in X$; the partition . . . .”

(5/17/12) Page 67, Example 3.53, last line: Change $\mathbb{R}^n$ to $\mathbb{R}^{n+1}$.

(7/17/19) Page 70, Example 3.66, first paragraph, next-to-last line: Change $\theta$ to $\frac{1}{2\pi} \theta$.

(10/7/11) Page 74, line 5: Change this statement to read “As a set, $X \cup_f Y$ is the disjoint union . . . .” [The topology on $X \cup_f Y$ is not the disjoint union topology.]

(11/30/19) Page 75, proof of Theorem 3.79, second line: Change $q(\partial M \cup \partial N)$ to $q(\partial M \sqcup \partial N)$.

(6/4/21) Page 75, proof of Theorem 3.79, second paragraph: Replace that paragraph with the following:

"Suppose $s \in S$, and let $y_0 \in \partial N$ and $y_0 = h(y_0) \in \partial M$ be the two points in the fiber $q^{-1}(s)$. We can choose coordinate charts $(U, \varphi)$ for $M$ and $(V, \psi)$ for $N$ such that $x_0 \in U$ and $y_0 \in V$, and let $\tilde{V} = \varphi(U), \tilde{V} = \psi(V) \subseteq \mathbb{H}^n$ (Fig. 3.13). It is useful in this proof to identify $\mathbb{H}^n$ with $\mathbb{R}^{n-1} \times [0, \infty)$ and $\mathbb{R}^n$ with $\mathbb{R}^{n-1} \times \mathbb{R}$. By shrinking $U$ and $V$ if necessary, we may assume that $h(V \cap \partial N) = U \cap \partial M$. Then we can write the coordinate maps as $\varphi(p) = (\varphi_0(p), \varphi_1(p))$ and $\psi(p) = (\psi_0(p), \psi_1(p))$ for some continuous maps $\varphi_0: U \to \mathbb{R}^{n-1}$, $\varphi_1: U \to [0, \infty)$, $\psi_0: V \to \mathbb{R}^{n-1}$, $\psi_1: V \to [0, \infty)$. Our assumption that $x_0$ and $y_0$ are boundary points means that $\varphi_1(x_0) = \psi_1(y_0) = 0$, and there are open subsets $U_0, V_0 \subseteq \mathbb{R}^{n-1}$ such that $\varphi_0(U \cap \partial M) = U_0, \psi_0(V \cap \partial N) = V_0$. (Here we are again using the theorem on invariance of the boundary.) After replacing $U$ and $V$ by the preimages
of \( U_0 \times [0, \infty) \) and \( V_0 \times [0, \infty) \), respectively, we can also assume that \( \hat{U} \subseteq U_0 \times [0, \infty) \) and \( \hat{V} \subseteq V_0 \times [0, \infty) \)."

(6/18/19) **Page 76, display in the middle of the page:** Change \( y^n \) to \( y_n \) (twice).

(7/16/11) **Page 76, last paragraph of the proof of Theorem 3.79:** In the second line of the paragraph, change “embedding of \( N \)” to “embedding of \( M \).” In the fourth line, change “embedding of \( M \)” to “embedding of \( N \).”

(8/8/17) **Page 87, Exercise 4.3:** Insert “nonempty” before “connected.”

(8/23/11) **Page 87, Exercise 4.4:** Insert another “if” after “if and only.”

(8/23/11) **Page 88, proof of Proposition 4.9, fourth paragraph:** In the first sentence of that paragraph, change “open subsets of \( \bigcup_{\alpha \in A} B_{\alpha} \)” to “open subsets of \( X \) whose union contains \( \bigcup_{\alpha \in A} B_{\alpha} \).”

(8/23/11) **Page 97, line 10:** Change \( B_{n_{\max}}(a) \) to \( B_{n_{\max}}(x) \).

(3/9/11) **Page 98, line 3 from the bottom:** Change “this proposition” to “this lemma.”

(6/21/20) **Page 99, second paragraph:** Delete the second sentence of the paragraph. [It’s not wrong; it’s just not needed.]

(6/21/20) **Page 103, just above Exercise 4.58:** After the word “illustrates,” insert “(using the theorem on invariance of the boundary).”

(11/11/13) **Page 104, proof of Proposition 4.60:** At the end of the first paragraph, change \( B_{r(x)}(x) \subseteq \hat{U}_i \) to \( B_{2r(x)}(x) \subseteq \hat{U}_i \). [Without this change, it might not be the case that \( \mathcal{B} \) covers \( M \).]

(6/21/20) **Page 106, proof of Theorem 4.68, last paragraph:** After the first sentence of the paragraph, insert: “Begin by setting \( W_0 = X \).” Then in the third and fourth lines of the paragraph, replace “Choosing \( r_n < \min(\varepsilon_n, 1/n) \)” by “Choosing \( r_n < \min(\varepsilon_n, 1/n) \) and setting \( W_n = B_{r_n}(x_n) \).”

(8/23/11) **Page 106, line 3 from the bottom:** Change “countable union” to “countable intersection.”

(8/23/11) **Page 109, statement of Lemma 4.74:** Insert another “if” after “if and only.”

(7/19/15) **Page 110, next-to-last line:** Change \( M \) to \( X \).

(8/23/11) **Page 114, proof of Corollary 4.83:** This proof is incorrect. Replace it with the following: “Given a closed subset \( A \subseteq X \) and a neighborhood \( U \) of \( A \), Lemma 4.80 shows that there is a neighborhood \( V \) of \( A \) such that \( V \subseteq U \).” By Urysohn’s lemma, there exists a continuous function \( f: X \rightarrow [0, 1] \) such that \( f \equiv 1 \) on \( A \) and \( f \equiv 0 \) on \( X \setminus V \). This function satisfies \( \text{supp } f \subseteq V \subseteq U \), so it is the bump function we seek.”

(6/17/19) **Page 119, statement of Proposition 4.93(b):** Add the hypothesis that \( Y \) is Hausdorff.

(10/24/19) **Page 119, proof of Proposition 4.93, second paragraph:** Change the first sentence to read “To prove (b), assume \( X \) is a second countable Hausdorff space and \( Y \) is Hausdorff, and suppose . . . .” Then replace the sentence beginning “Suppose on the contrary” by the following: “Suppose on the contrary that \( (x_i) \) is a sequence in \( L \) with no convergent subsequence in \( L \). Because \( Y \) is Hausdorff, \( K \) is closed and therefore so is \( L \), which means that \( (x_i) \) has no convergent subsequence in \( X \).”

(8/23/11) **Page 121, proof of Lemma 4.94:** Replace the last two sentences of the proof with the following: “Thus \( x \) lies in the closure of \( A \cap K \) in \( K \). Because \( A \cap K \) is closed in \( K \), it follows that \( x \in A \cap K \subseteq A \).”

(8/23/11) **Page 123, Problem 4-15(d):** Change “every connected neighborhood” to “every neighborhood.”

(9/16/11) **Page 126, Problem 4-30:** Change \( \{A_\alpha\} \) to \( \{X_\alpha\}_{\alpha \in A} \).

(4/12/20) **Page 126, Problem 4-31(c):** In the last sentence, change “every element of \( \mathcal{U} \)” to “every nonempty element of \( \mathcal{U} \).”

(4/12/20) **Page 128, proof of Prop. 5.1:** Insert before the first sentence of the proof: “The proposition is true by definition when \( n = 0 \), so assume that \( n > 0 \).”

(3/20/21) **Page 133, line above Theorem 5.6:** Change “an \( n \)-dimensional subcomplex” to “a subcomplex of dimension at most \( n \).”

(1/20/11) **Page 133, proof of Proposition 5.7:** This should refer to Problem 5.8, not 5.7.

(5/17/12) **Page 136, four lines below the displayed equations:** Change “both \( X'_{n-1} \) and \( X''_{n-1} \) are open” to “both \( X'_n \) and \( X''_n \) are open.”
Page 143, proof of Proposition 5.24, last paragraph: Change “supported in the minimum” to “one-half the minimum.”

Page 141, line 3 from the bottom: Change “the finite subcomplex $E_n$” to “the finite subcomplex $M_n$.”

Page 145, second paragraph: Change $e_n$ to $e_k$ twice (once in the first line, and once in (5.1)).

Page 146, Case 1, second paragraph: Change $Y_n$ to $Y_{v_n}$ (twice).

Page 152, sentence after the proof of Prop. 5.38: Change $i = 1,\ldots,k$ to $i = 0,\ldots,k$.

Page 156, Problem 5-4: add the hypothesis that $\dim M > 1$.

Page 158, second sentence: Replace this sentence by “More generally, suppose $K$ is a finite Euclidean simplicial complex and $w$ is a point in $\mathbb{R}^n$ such that each ray starting at $w$ intersects $|K|$ in at most one point.”

Page 158, Problem 5-18(b): In the hint, change “simplex” to “cell.”

Page 165, Example 6.7: After the second sentence, add “The disks should be chosen so that their closures are disjoint.”

Page 172, first paragraph, next-to-last line: Change $P_1 \sqcup Q$ to $P_1 \sqcup Q$.

Page 176, Fig. 6.21: The label $b$ near the lower right should be $c$, and the label $w$ near the middle of the right-hand side should be $x$.

Page 180, Proposition 6.20: In the statement of the proposition, change “compact surface” to “connected compact surface.” Then in the second sentence of the proof, change both occurrences of “surface” to “connected compact surface.”

Page 181, first full paragraph: Replace the sentence starting with “However” by “However, we will prove in Chapter 10 that a compact surface cannot have both an oriented presentation and a nonoriented one.”

Page 181, Problem 6-4: Replace the first sentence by “Suppose $M$ is a compact 2-manifold that contains a subset $B \subseteq M$ that is homeomorphic to the Möbius band, and whose interior is homeomorphic to the Möbius band minus its boundary.”

Page 190, line 3 from the bottom: Change $\Phi_g(f)$ to $\Phi_g[f]$.

Page 193, proof of Proposition 7.16, second paragraph, line 2: Change “$H_1 = f$” to “$H_1 = \tilde{f}$.”

Page 201, Corollary 7.38: This corollary should be moved after the statement of Theorem 7.40.

Page 211, line 6: Delete redundant “each.”

Page 215, Problem 7-9: Change “connected” to “path-connected.”

Page 221, Theorem 8.4: Remark: This theorem is true without the assumption that $B$ is locally connected, and the proof is not really any more difficult; see, for example, the proof of Theorem 1.7 in [Hat02].

Page 222, first paragraph: Change $\{J_1, \ldots, J_k\}$ to $\{J_1, \ldots, J_m\}$.

Page 224, two lines above the subheading: Change $\delta_0(1)$ to $\delta_1(0)$. 
Page 228, displayed equations (8.4): Replace these equations by
\[ \deg \varphi = \deg (\rho \circ \varphi)_*, \]
\[ \deg \psi = \deg (\rho \circ \psi)_*. \] (8.4)

Page 230, Problem 8-5: Replace the last sentence of the hint by the following: “Prove that \( p_n \mid S^1 \) and \( p_n(z) = z^n \) are homotopic as maps from \( S^1 \) to \( \mathbb{C} \setminus \{0\} \). If \( p \) has no zeros, use degree theory to derive a contradiction.”

Page 231, Problem 8-10(c): Change “index of \( V \) around the loop \( \omega \)” to “winding number of \( V \) around the loop \( \omega \).”

Page 239, fourth line below the section heading: Change “generated by \( G \)” to “generated by \( S \).”

Page 241, middle of the page: Change the definition of group presentation as follows: “We define a group presentation to be an ordered pair, denoted by \( \langle S \mid R \rangle \), where \( S \) is an arbitrary set and \( R \) is a set of words formed from the elements of \( S \).”

Page 241, just below the last displayed equation: Replace “where \( \bar{R} \) is the normal closure of \( R \) in \( F(S) \)” by “where now we interpret \( R \) as a set of elements of the free group \( F(S) \), and \( \bar{R} \) is the normal closure of \( R \) in \( F(S) \).”

Page 244, fourth line below the section heading: Change \( n \in \mathbb{Z} \) to \( n \in \mathbb{N} \).

Page 247, Example 9.22, last line: The formula for \( G_{tor} \) should be \( G_{tor} = \{0\} \times \mathbb{Z}/k_1 \times \cdots \times \mathbb{Z}/k_m \).

Page 249, Problem 9-4(b): Change “a subset of the free group \( F(S_i) \)” to “a set of words in the elements of \( S_i \).”

Page 249, Problem 9-5: Change “subsets of the free group \( F(S) \)” to “sets of words in the elements of \( S \).”

Page 252, just above diagram (10.2): Change “the following diagram commutes” to “the right half of the following diagram commutes.”

Page 256, statement of Theorem 10.7: Change “spaces” to “path-connected spaces.”

Page 257, Example 10.8: In the first line of the example, and in the three lines immediately above it, change “proposition” to “theorem” (three times).

Page 257, last paragraph, second sentence: Change that sentence to read “If two or more edges are incident with the same two vertices, or if two or more self-loops are incident with the same vertex, they are called multiple edges.”

Page 260, proof of Theorem 10.12, second paragraph, first line: Change \( \Gamma \) to \( \pi_1 (\Gamma, v) \).

Page 261, last paragraph of the proof, fourth line from the bottom: Change two equalities to isomorphisms: \( \pi_1 (V, v) \cong F(\langle f_1 \rangle, \ldots, \langle f_n \rangle) \) and \( \pi_1 (U, v) \cong F(\langle f_{n+1} \rangle) \).

Page 263, line 2: Change \( \tilde{U} \cap \tilde{V} \) to \( q(D \setminus \{z\}) \).

Page 268, lines 2 & 3: Change “preceding corollary” to “preceding theorem.”

Page 268, statement of Corollary 10.24: Change the statement to “A compact surface cannot have both an oriented presentation and a nonoriented one.”

Page 269, line below equation (10.7): Insert missing comma after “surjective.”

Page 271, line 3: Replace the phrase “the endpoints of the paths \( a_i \) in this product are of the form \( i/n \)” by “the paths \( a_i \) in this product are defined on subintervals whose endpoints are integral multiples of 1/n.”

Page 275, Problem 10-21(c): Delete “with nonempty intersection.”

Page 278, second line below the heading: Before “disjoint union,” insert “nonempty.”

Page 279, second line: Change “Theorem 4.15” to “Proposition 4.13.”

Page 282, Theorem 11.13: Remark: This theorem, like Theorem 8.4, is true without the assumption that \( B \) is locally connected.

Page 302, Problem 11-5, first line: Change “dimension \( n \)” to “dimension \( n \geq 2 \).”

Page 303, Problem 11-9: Add the hypothesis that the spaces are nonempty.

Page 303, Problem 11-12(c): Change “\((1,0)\) or \((-1,0)\)” to “\(1\) or \(-1\)” [to be consistent with the complex notation used elsewhere for \( S^1 \)].
(5/17/12) **Page 305, Problem 11-20:** At the end of the problem, add: “For the counterexample, you may use without proof the fact that $S^2$ is not contractible. (This follows, for example, from Corollary 13.11 and Theorem 13.23.)”

(2/25/18) **Page 312, last sentence of the paragraph after Exercise 12.13:** Allen Hatcher’s name is misspelled.

(7/8/14) **Page 315, just below the displayed diagram:** Replace the last two paragraphs on page 315 and the first (partial) paragraph on page 316 with the following:

> Replace the last two paragraphs on page 315 and the first (partial) paragraph on page 316 with the following: y

(9/27/11) **Page 315, paragraph above the displayed diagram:** After “$Q$ is a normal covering map,” insert “and $\hat{H} = \text{Aut}_Q(E)$.”

(7/8/14) **Page 315, just below the displayed diagram:** Change the period after “without proof the fact that $S^2$ is not contractible.”

(7/8/14) **Page 315, paragraph above the displayed diagram:** Change the adjective “nonempty.”

(7/8/14) **Page 315, just below the displayed diagram:** Change the period after “without proof the fact that $S^2$ is not contractible.”

(9/27/11) **Page 318, statement of Proposition 12.21, second line:** Insert “on” after “acting.”

(12/9/19) **Page 320, paragraph after the proof of Prop. 12.24, first line:** Before “locally,” insert “nonempty.”

(9/23/14) **Page 321, line 4:** Change $E \times E$ to $E$.

(9/27/11) **Page 329, paragraph just below the diagram:** Change every occurrence of $\bar{p}$ to $\bar{q}$ (five times).

(9/27/11) **Page 330, just below the bulleted list:** Change $\bar{p}$ to $\bar{q}$.

(9/27/11) **Page 332, first full paragraph, second line:** Change $\bar{p}$ to $\bar{q}$.

(9/27/11) **Page 332, second full paragraph, lines 6 and 7:** Change $\bar{p}$ to $\bar{q}$ (twice).

(9/16/14) **Page 335, Problem 12-10:** Interchange the definitions of $G$ and $H$ in the sixth and seventh lines. (Otherwise, part (c) is false as stated.)

(10/12/14) **Page 337, Problem 12-19:** Replace the first sentence of the problem with the following: “Suppose we are given a continuous action of a metrizable topological group (e.g., a discrete group) $G$ on a first countable Hausdorff space $E$.”

(7/22/19) **Page 349, line 3:** Change $\Delta_p$ to $\Delta_{p+1}$.

(9/27/11) **Page 352, lines 3 and 4:** Change $c_p$ to $c_q$ (twice), and change $p$ to $q$ (twice).

(7/22/19) **Page 352, next-to-last line:** Change $c_p$ to $c_q$ (twice), and change $p$ to $q$ (once).

(12/15/17) **Page 354, paragraph above the last display:** Insert “of some reparametrization” after “extension of the circle representative.”

(3/16/21) **Page 355, commutative diagram near the bottom of the page:** Change the period after $X$ to a comma.
(7/22/19) **Page 360, proof of Lemma 13.20:** In the second line of the displayed equation, change \( F_{i,p} \) to \( F_{i,p+1} \).

(7/22/19) **Page 361, first line of text:** Change “\( \in \mathbb{R}^n \)” to “\( \subseteq \mathbb{R}^n \).”

(4/1/21) **Page 369, line above Proposition 13.33:** Delete spurious “and.”

(10/8/15) **Page 370, line 5 from the bottom:** Change “It follows . . .” to “Assuming \( X \) is path-connected, it follows . . .”

(10/8/15) **Page 371, at the end of the first (partial) paragraph:** Insert “If \( X \) is not path-connected, just apply this argument to the path component containing the image of \( \varphi \), and use Proposition 13.5.”

(9/26/17) **Page 371, statement of Theorem 13.34(e):** Change “dimension \( n \)” to “dimension \( n \geq 2 \),” and change “the zero map” to “not injective.”

(4/1/21) **Pages 371–372, proof of Theorem 13.34:** Change “Theorem 13.33” to “Proposition 3.33” (five times).

(9/26/17) **Page 372, proof of Theorem 13.34, last paragraph:** Change “if \( \varphi_* = 0 \)” to “if \( \varphi_* \) is injective.”

(9/26/17) **Page 372, Example 13.35(b), last line:** Change “the zero map” to “noninjective.”

(9/26/17) **Page 372, Example 13.35(c):** Replace the last sentence by “The image of \( \varphi_* \) is the infinite cyclic group generated by \( \gamma(a^2_1 \ldots a^2_n) \), so \( \varphi_* \) is injective and \( H_2(M) = 0 \).”

(9/26/19) **Page 399, next-to-last line:** Change \( x \in X \) to \( x \in M_1 \).

(12/26/18) **Page 401, line 4 from the bottom:** Change “subset” to “nonempty subset.”

(10/7/19) **Page 402, Exercise C.1:** Change “any subset” to “any nonempty subset.”

(6/6/18) **Page 411, near the middle of the page:** The index entry for \( \bar{R} \) should read “(normal closure of a subset).”

(2/25/18) **Page 422:** The index entry for “Hatcher, Allen” is misspelled.