Errata for the HoTT Book, first edition

March 6, 2014

For the benefit of all readers, the available PDF and printed copies of the book are being updated on a rolling basis with minor corrections and clarifications as we receive them. Every copy has a version marker that can be found on the title page and is of the form "first-edition-XX-gYYYYYYY", where XX is a natural number and YYYYYYY is the git commit hash that uniquely identifies the exact version. Higher values of XX indicate more recent copies.

Below is a list of corrections and clarifications that have been made so far (except for trivial formatting and spacing changes), along with the version marker in which they were first made. This list is current as of March 6, 2014 and version marker "first-edition-611-ga1a258c ".

While the page numbering may differ between copies with different version markers (and indeed, already differs between the letter/A4 and printed/ebook copies with the same version marker), we promise that the numbering of chapters, sections, theorems, and equations will remain constant, and no new mathematical content will be added, unless and until there is a second edition.

Location	**Fixed in**	**Change**
§1.1	182-gb29ea2f	Change notation $a \equiv_A b$ to $a \equiv b : A$, to match that used in Appendix A. (Neither are used anywhere else in the book.)
§1.1	154-g42698c2	Clarify that algorithmic decidability of judgmental equality is only meta-theoretic.
§1.1	154-gac9b226	Mention notation $a = b = c = d$ to mean "$a = b$ and $b = c$ and $c = d$, hence $a = d$", possibly including judgmental equalities.
§1.3	42-g4bc5cc2	Cumulativity means some elements do not have unique types, the index i on $\mathcal{U}_i$ is not an internal natural number, and typical ambiguity must be justified by reinserting indices.
§§1.3 and 1.4	42-ga34b313	Explain that we can't define Fin and fmax yet where we first mention them.
§1.4	165-g0ad2aba	Add swap as another example of a polymorphic function, and discuss the use of subscripts and implicit arguments to dependent functions.
Remark 1.5.1	80-g8f95fa5	In the discussion of formation rules, the dependent function type example should be $\prod_{(x:A)} B(x)$.
§1.5	51-g67e86db	Better explanation of recursion on product types, why it is justified, and how it relates to the uniqueness principle.

Location	Fixed in	Change
§1.6	2-gbe277a8	In the types of g and $\mathsf{ind}_{\sum_{(x:A)} B(x)}$, there is a $\prod_{(a:A)} \prod_{(b:B(x))}$ in which x should be a.
§1.6	27-gd0bfa0d	At two places in the definition of ac, $R(a, \mathsf{pr}_1(g(x)))$ should be $R(x, \mathsf{pr}_1(g(x)))$.
§1.6	125-g7fdadbf	When substituting $\lambda x.\, \mathsf{pr}_1(g(x))$ for f while verifying that ac is well-typed, the left side of the judgmental equality should be $\prod_{(x:A)} R(x, \mathsf{pr}_1(g(x)))$, not $\prod_{(x:A)} R(x, \mathsf{pr}_1(f(x)))$.
§1.7	30-g264d934	In two displayed equations, $f(\mathsf{inl}(b))$ should be $f(\mathsf{inr}(b))$.
Theorem 1.8.1	391-g1ce619a	This should not be called a "Theorem", since we have not yet introduced what that means. Instead it should say "We construct an element of…".
§1.8	125-g433f87e	In the definition of binary products in terms of **2**, the definitions of $\mathsf{pr}_1(p)$ and $\mathsf{pr}_2(p)$ should be switched to match the order of arguments to $\mathsf{rec}_{\mathbf{2}}$ and $\mathsf{ind}_{\mathbf{2}}$.
§1.11	111-g1e868fa	When translating English to type theory, "unnamed variables" are unnamed in English but must be named in type theory.
§1.12	154-g4ef49f7	Emphasize that path induction, like all other induction principles, defines a *specified* function.
§1.12	244-gd58529d	In proof that path induction implies based path induction, $D(x,y,p)$ should be written $\prod_{(C:\prod_{(z:A)}(x=_A z)\to\mathcal{U})} (\cdots)$ so the type of C matches the premise of based path induction.
Remark 1.12.1	563-g3286941	The facts that any $(x,y,p) : \sum_{(x,y:A)}(x = y)$ is equal to (x,x,refl_x), and that any $(y,p) : \sum_{(y:A)}(a =_A y)$ is equal to (a, refl_a), can be proven by path induction and based path induction respectively.
Exercise 1.4	78-gcce4dc0	The second defining equation of iter should have right-hand side $c_s(\mathsf{iter}(C, c_0, c_s, n))$.
Exercise 1.4	293-g4663bfe	The defining equations of the recursor derived from the iterator only hold propositionally, and require the induction principle to prove.
Exercise 1.6	229-ged891f3	This exercise requires function extensionality (§2.9).
Exercise 1.8	450-g7f38c9a	This exercise requires symmetry and transitivity of equality, Lemmas 2.1.1 and 2.1.2.
Exercise 1.10	110-gfe4641b	To match the usual Ackermann–Péter function, the second displayed equation should be $\mathsf{ack}(\mathsf{succ}(m), 0) \equiv \mathsf{ack}(m, 1)$.
Chapter 2	239-gaf3d682	In the chapter introduction, clarify that topological homotopies between paths must be endpoint-preserving.
Lemma 2.1.1	166-g37b78ef	Add remarks before and after the proof about how a theorem's statement and proof should be interpreted as exhibiting an element of some type.
Lemma 2.1.2	374-g0bc0908	In the penultimate display in the first proof, $d(x,z,q)$ should be simply d.

Location	Fixed in	Change
§2.1	435-gee0b28a	In the third paragraph after Lemma 2.1.2, $p \cdot \mathsf{refl}_x \equiv p$ should be $p \cdot \mathsf{refl}_y \equiv p$.
§2.1	165-g18642ca	Mention that the notation $a = b = c = d$, and its displayed variant, indicate concatenation of paths.
§2.1	253-gdd47c75	Lemma 2.1.4(iv) justifies writing $p \cdot q \cdot r$ and so on.
Theorem 2.1.6	253-gdd47c75	The induction defining $\alpha \cdot_{\mathsf{r}} r$ has defining equation $\alpha \cdot_{\mathsf{r}} \mathsf{refl}_b \equiv {\mathsf{ru}_p}^{-1} \cdot \alpha \cdot \mathsf{ru}_q$, with ru_p the right unit law. For $\alpha \star \beta = \alpha \cdot \beta$ to be well-typed, we assume $p \equiv q \equiv r \equiv s \equiv \mathsf{refl}_a$ and use $\mathsf{ru}_{\mathsf{refl}_a} = \mathsf{refl}_{\mathsf{refl}_a}$ and its dual. Proving $\alpha \star \beta = \alpha \star' \beta$ requires induction not only on α and β but then on the two remaining 1-paths. After the proof, remark that we trust the reader to construct such operations from now on.
Definition 2.1.8	233-gc3fb777	The three displays should be $:\equiv$'s rather than $=$'s.
§2.2	336-g8ff8a7f	In the type of ap_f towards the end of the first proof of Lemma 2.2.1, $g(x)$ should be $f(y)$.
§2.3	154-g4ef49f7	Emphasize that unlike fibrations in classical homotopy theory, type families come with a *specified* path-lifting function.
§2.3	343-g6efd724	The functions Eq. (2.3.6) and Eq. (2.3.7) are obtained by concatenating with $\mathsf{transportconst}^B_p(f(x))$ and its inverse, respectively.
Corollary 2.4.4	253-gdd47c75	Canceling $H(x)$ may be done by whiskering with $(H(x))^{-1}$.
§2.6	74-g9896e32	In the type of $\mathsf{pair}^{=}$ (just after the proof of Theorem 2.6.2), the second factor in the domain should be $\mathsf{pr}_2(x) = \mathsf{pr}_2(y)$.
Theorem 2.6.4	349-gc7fd9d8	The path is in $A(w) \times B(w)$, not $A(y) \times B(y)$.
Theorem 2.6.4	76-ga42354c	The third displayed judgmental equality in the proof should be $\mathsf{transport}^B(p, \mathsf{pr}_2 x) \equiv \mathsf{pr}_2 x$.
Theorem 2.7.2	507-g8f10eda	In the proof, the equation $f(g(\mathsf{refl}, \mathsf{refl})) = \mathsf{refl}$ should be $f(g(\mathsf{refl}_{w_1}, \mathsf{refl}_{w_2})) = (\mathsf{refl}_{w_1}, \mathsf{refl}_{w_2})$.
§2.9	269-g3880fe2	The paragraph preceding the definition of $\mathsf{transport}^{\Pi_A(B)}(p, f)$ (before Eq. (2.9.5)) misstated the (already given) type of p.
Axiom 2.10.3	408-geee0345	The text prior to the display should read "For any $A, B : \mathcal{U}$, the function (2.10.2) is an equivalence; hence we have"
Theorem 2.11.1	310-gd5fa240	The second half of the proof is more involved than the first. It follows abstractly using the 2-out-of-6 property (Exercise 4.5), or more concretely by concatenating with ${\alpha_{f(a)}}^{-1} \cdot \alpha_{f(a)}$ on each side and then repeatedly using naturality and functoriality.
§2.11	236-g32be999	The second display after the proof of Theorem 2.11.1 should be $\prod_{(x:A)}(\mathsf{happly}(p)(x) =_{f(x)=g(x)} \mathsf{happly}(q)(x))$.
Theorem 2.11.4	364-g3c47534	The right-hand side of the displayed equality should be $(\mathsf{apd}_f(p))^{-1} \cdot \mathsf{ap}_{(\mathsf{transport}^B p)}(q) \cdot \mathsf{apd}_g(p)$.
§2.12	101-g645f763	In Theorem 2.12.5 and the preceding paragraph, in the equivalence $(\mathsf{inl}(a) = x) \simeq \mathsf{code}(x)$, the variable a should be a_0.

Location	Fixed in	Change
§2.12	370-g114db82	In the two displays after the proof of Theorem 2.12.5, the terms should be $\mathsf{encode}(\mathsf{inl}(a), -)$ and $\mathsf{encode}(\mathsf{inr}(b), -)$.
§2.14.2	261-g4ccda0a	In the first displayed pair of equations, the type of p_2 should be $\mathsf{transport}^{\mathsf{SemigroupStr}}(p_1, (m, a)) = (m', a')$.
§2.14.2	402-g2297ecb	The right hand side of the last displayed equation should be $m'(e(x_1), e(x_2))$.
§2.15	305-g64685f1	In the discussion of universal properties for product types and Σ-types surrounding Eq. (2.15.9), the phrases "left-to-right" and "right-to-left" should be switched.
Chapter 2 Notes	379-ga57eab2	It should be mentioned that Hofmann and Streicher (1998) proposed an axiom similar to univalence, which is correct (and equivalent to univalence) for a universe of 1-types.
§3.5	86-g39feab1	The definition of subset containment should say $\prod_{(x:A)}(P(x) \to Q(x))$, not $\forall(x : A).\,(P(x) \Rightarrow Q(x))$, as the latter notation has not been introduced yet.
Lemma 3.11.7	95-gce0131f	In the proof, p should be r to match the preceding definition of retraction.
Lemma 4.1.1	87-g693e9b9	At the end of the proof, Lemma 3.11.8 should be cited as the reason why $\sum_{(g:A\to A)}(g = \mathsf{id}_A)$ is contractible.
Theorem 4.2.3	275-g8ea9f71	In the proof, the path concatenations in the definitions of ϵ' and τ were written in reverse order.
Lemma 4.2.12	296-ge3dc076	In the proof, $(fgx, \epsilon(fx)) =_{\mathsf{fib}_f(fx)} (x, \mathsf{refl}_{fx})$ should be $(gfx, \epsilon(fx)) =_{\mathsf{fib}_f(fx)} (x, \mathsf{refl}_{fx})$.
Corollary 4.3.3	272-gfd47093	At the end of the proof, the equivalence follows from the fact that $\mathsf{ishae}(f)$, not $\mathsf{isContr}(f)$, is a mere proposition.
Theorem 4.4.3	299-g85b729b	In the proof, $\mathsf{lcoh}_f(g, \epsilon)$ should be $\mathsf{rcoh}_f(g, \epsilon)$, and the final displayed equation should have pr_2 applied to both occurrences of $P(fx)$.
Lemma 4.7.3	265-g64000fb	The path concatenations in the definitions of φ_b and ψ_b (and subsequent equations) are reversed, and each $f(a)$ in the next two displayed equations should be $g(a)$.
Theorem 4.7.6	275-g84ab032	The first equivalence in the proof is not by (2.15.9) but by Exercise 2.10.
Theorem 4.7.6	202-g775a3f0	The last equivalence in the proof is not by (2.15.10) but by Lemmas 3.11.8 and 3.11.9 and Exercise 2.10.
Theorem 4.8.3	205-gf9fe386	In the proof, $e \cdot \mathsf{pr}_1$ should be $(\mathsf{ua}(e))_*(\mathsf{pr}_1)$. Also, explain its computation better.
§4.9	114-gaba76c8	The point of Lemma 4.9.2 is that it follows from univalence without assuming function extensionality separately.
Corollary 4.9.3	484-g2ce1249	In the statement, "precomposition" should be "post-composition".

Location	Fixed in	Change
Exercise 4.2	358-g9543064	The text should be "Show that for any $A, B : \mathcal{U}$, the following type is equivalent to $A \simeq B$. Can you extract from this a definition of a type satisfying the three desiderata of $\mathsf{isequiv}(f)$?"
§5.3	125-g433f87e	In the definition of $\mathbf{N^w}$, use $0_\mathbf{2}$ for 0 and $1_\mathbf{2}$ for succ, to match the ordering of $0_\mathbf{2}$ and $1_\mathbf{2}$ in §1.8.
§5.3	551-g82b74bf	The definitions of $\mathbf{N^w}$ and $\mathsf{List}(A)$ as W-types should be $\mathsf{W}_{(b:\mathbf{2})}\mathsf{rec}_\mathbf{2}(\mathcal{U}, \mathbf{0}, \mathbf{1}, b)$ and $\mathsf{W}_{(x:\mathbf{1}+A)}\mathsf{rec}_{\mathbf{1}+A}(\mathcal{U}, \mathbf{0}, \lambda a.\, \mathbf{1}, x)$.
§5.3	218-g42219cb	In the description of the constructor sup, its second argument is more clearly written as $f : B(a) \to \mathsf{W}_{(x:A)}B(x)$.
§5.3	525-gb1957b8	In the computation rule, the recursive call to rec is missing an argument. It should read $\mathsf{rec}_{\mathsf{W}_{(x:A)}B(x)}(E, e, \mathsf{sup}(a, f)) \equiv e(a, f, (\lambda b.\, \mathsf{rec}_{\mathsf{W}_{(x:A)}B(x)}(E, e, f(b))))$.
§5.3	570-g6ec04c3	In the verification that double computes as expected, e_t should be e_0 and e_f should be e_1.
§5.4	554-g9b2a34b	The definition of the type of W-homomorphisms (just before Theorem 5.4.7) should read $\mathsf{WHom}_{A,B}((C, s_C), (D, s_D)) :\equiv \sum_{(f:C\to D)} \prod_{(a:A)} \prod_{(h:B(a)\to C)} f(s_C(a, h)) = s_D(a, f \circ h)$.
§5.5	608-g6af101f	In the computation rule for homotopy W-types, the left-hand side should be $\mathsf{rec}_{\mathsf{W}^h_{(x:A)}B(x)}(E, e, \mathsf{sup}(a, f))$.
Theorem 5.8.2	139-gd5c5d01	In the proof of (iv)⇒(i), the type of D' should be $(\sum_{(b:A)} R(b)) \to \mathcal{U}$.
§6.2	54-gd4a47c2	Soon after Remark 6.2.1, the phrase "An element $b : P(\mathsf{base})$ in the fiber over the constructor $\mathsf{base} : \mathbb{N}$" should say $\mathsf{base} : \mathbb{S}^1$.
Lemma 6.2.8	423-gf763ae1	Theorems 2.11.3 and 2.11.5 are needed to put q in the form required by the induction principle.
Lemma 6.3.2	417-g4aa6a15	Added Exercise 6.10: the function constructed in Lemma 6.3.2 is actually an inverse to happly, so that the full function extensionality axiom follows from an interval type.
§6.4	327-g7cbe31c	In the first sentence after the proof of Lemma 6.4.6, "$P : \mathbb{S}^2 \to P$" should be "$P : \mathbb{S}^2 \to \mathcal{U}$".
§6.6	289-gdefeb8c	In the induction principle for the torus, the types of p' and q' should be $b' =^P_p b'$ and $b =^P_q b$ respectively.
§6.7	289-gdefeb8c	In the induction principle for the torus, the types of p' and q' should be $b' =^P_p b'$ and $b =^P_q b$ respectively.
§6.9	468-g5472874	The induction principle for $\|A\|$ should conclude $f(\|a\|) \equiv g(a)$, not $f(\|a\|) \equiv a$. And in the hypotheses of the induction principle for $\|A\|_0$ and in the proof of Lemma 6.9.1, $v : p =^B_{u(x,y,p,q)} q$ should instead be $v : r =^B_{u(x,y,p,q)} s$.

Location	Fixed in	Change
Lemma 6.10.8	514-g18ade45	Instead of "is the set-quotient of A by $\sim$", the statement should say "satisfies the universal property of the set-quotient of A by $\sim$, and hence is equivalent to it". In the proof, the second displayed equation should be $e'(g,s)(x,p) :\equiv g(x)$. The fourth displayed equation should be $e(e'(g,s)) \equiv e(g \circ \mathsf{pr}_1) \equiv (g \circ \mathsf{pr}_1 \circ q, \_)$, the fifth should be $g(\mathsf{pr}_1(q(x))) \equiv g(r(x)) = g(x)$, and the proof should conclude with "g respects $\sim$ by the assumption s".
Lemma 6.10.12	535-g0a9abfe	The "computation rules" satisfied by f are only propositional equalities. Also, the proof requires transport across a few unmentioned equivalences.
Corollary 6.10.13	535-g0a9abfe	The defining clauses should use := rather than :≡ (see the erratum for Lemma 6.10.12). Also, the first clause should say refl_a rather than $\mathsf{refl}_{\mathsf{base}}$.
Lemma 6.12.3	457-g411ec6d	The right-hand side of the displayed equation in the proof should be $(\mathsf{c}(g(b)), D(b)(y))$.
§6.12	519-gc99a54c	f denotes a map $B \to A$ in this section and should not be reused for functions defined by induction on $\sum_{(w:W)} P(w)$; we may use k instead. Thus f should be k in the last sentence of Lemma 6.12.4; the first sentence of its proof; the last sentence of the next paragraph; the last sentence of Lemma 6.12.5; the first, second, and last sentences of its proof; throughout the statement and proof of Lemma 6.12.7; the statement of Lemma 6.12.8; and the second sentence of its proof.
Lemma 6.12.4	537-gdf3b51d	In the display after the definition of q, the transport in the first line should be with respect to $x \mapsto Q(\widetilde{\mathsf{c}}'(g(b),x))$, and in the second line the subscript of ap should be $x \mapsto \widetilde{\mathsf{c}}'(g(b),x)$.
Lemma 6.12.7	501-ge895f81	Both occurrences of P in the statement should be Y, and both occurrences of Q in the proof should be Z.
Theorem 7.1.4	180-gb672a4d	In the last displayed equation of the proof, q should be r.
Theorem 7.1.10	101-g713f48c	The base case in the proof is just Lemma 3.11.4.
§7.3	480-gdc84050	The third paragraph is wrong: in contrast to Remark 6.7.1, it *would* actually work to define $\Vert A \Vert_n$ omitting the hub point.
Theorem 7.3.12	412-gb9582fc	In the proof, encode and decode should be switched.
Lemma 7.5.14	367-g1c8c07e	In the proof that the first composite is the identity, all occurrences of y should be $f(x)$.
Exercise 7.2	101-ga366be2	"entires" should be "entirely".
Exercise 7.8	603-ge113e08	The penultimate sentence should ask "Is $\mathsf{AC}_{n,m}$ consistent with univalence for any $m \geq 0$ and any n?".
Lemma 8.1.8	535-g0a9abfe	The proof by induction on $n : \mathbb{Z}$ is justified by Lemma 6.10.12, not Corollary 6.10.13.

Location	Fixed in	Change
Lemma 8.1.12	535-g0a9abfe	The clauses defining q_z should use $:=$ rather than $:\equiv$ (see the erratum for Lemma 6.10.12).
Theorem 8.5.1	256-g9e6fcb8	The phrase "whose fibers are $\mathbb{S}^1$" should be "whose fiber over the basepoint is $\mathbb{S}^1$". The same change should be made in Exercises 8.8 and 8.9.
Lemma 8.6.1	396-g868335b	In the proof, the function k should have type $\prod_{(a:A)} P(f(a))$. It should also be named ℓ, to avoid confusion with the integer k.
Definition 8.6.5	87-g3f977b2	In the second displayed equation in the proof, $\mathsf{merid}(x_1)$ should be $\mathsf{merid}(x_1)^{-1}$.
Lemma 8.6.2	399-g8897c94	In the last sentence of the proof, "$(n-1)$-connected" should be "$(n-1)$-truncated".
Lemma 8.6.10	88-g0c0be67	The type of m should be $a_1 = a_2$, the second display should begin with $C(a_1, \mathsf{transport}^B(m^{-1}, b))$, and the proof should say "we may assume a_2 is a_1 and m is refl_{a_1}".
§8.6	165-gd5584c6	In (8.6.11), r'' should be r', the end point of r should be $\mathsf{transport}^B(\mathsf{merid}(x_0)^{-1}, q)$, and obtaining r' requires also identifying this with $q \cdot \mathsf{merid}(x_0)^{-1}$. Similarly, in (8.6.12), the end point of r should be $\mathsf{transport}^B(\mathsf{merid}(x_1)^{-1}, q)$.
§8.6	474-g5289470	$\pi_3(\mathbb{S}^2) = \mathbb{Z}$ should be stated as Corollary 8.6.19, following from Corollary 8.5.2 and Theorem 8.6.17.
Theorem 9.9.5	313-g8ee79db	In the second proof, the third constructor of $\widehat{A}_0$ is unneeded; it follows from the fourth constructor and path induction. In the fifth constructor, $j(g) \cdot j(f)$ should be $j(f) \cdot j(g)$, and similarly throughout the proof. Finally, for consistency, the 1-truncation constructor should be included explicitly (this was intended to be implied by "higher inductive 1-type").
Chapter 9 Notes	379-ga57eab2	It should be mentioned that Hofmann and Streicher (1998) also considered this definition of category.
Theorem 10.3.20	140-g55de417	The second sentence of the proof should say "By well-founded induction on A, suppose $A_{/b}$ is accessible for all $b < a$".
Lemma 10.3.22	140-gd7f8960	The statement should say $X : \mathcal{U}$ rather than $X : \mathcal{U}_{\mathcal{U}}$.
Theorem 10.4.3	140-gcca0bcf	The penultimate sentence of the proof should say "if $a < b$ and $b < c$" rather than "if $a < b$ and $a < c$".
Lemma 11.2.2	165-gb002a64	The statement should say "For all $x : \mathbb{R}_\mathsf{d}$ and $q : \mathbb{Q}$, $L_x(q) \Leftrightarrow (q < x)$ and $U_x(q) \Leftrightarrow (x < q)$".
Theorem 11.2.4	165-g179b359	In the proof, the sentence beginning "From $0 < ac$ it follows" should be replaced by "From $0 < ac$ and $0 < bc$ it follows that a, b, and c are either all positive or all negative. Hence either $0 < a < x$ or $x < b < 0$, so that $x \# 0$".
Lemma 11.4.1	87-g82b27c3	(11.4.2) should be $c : \prod_{(q,r:\mathbb{Q})}(q < r) \to (q < x) + (x < r)$, and therefore the use of c in the proof should be $c(s,t)$ rather than $c(x,s,t)$.

Location	Fixed in	Change
Exercise 11.13	222-g3453cf1	This is the intermediate value theorem, not the mean value theorem.
Appendix A	165-g76db618	After the introduction of the judgment "Γ ctx" in the Preliminaries, the sentence beginning "Therefore, if $\Gamma \vdash a : A, \ldots$" should say instead "In particular, therefore, if $\Gamma \vdash a : A, \ldots$".
§A.2.1	64-g7c2312e	Clarify the distinction between typing judgments and context well-formedness judgments, and remove the ⊢ from the notation for the latter.
§A.2.5	26-gcd691e8	In Σ-COMP and the following paragraph, $y.C$ should be $z.C$, and "we bind $\ldots y$ in C" should likewise say z.
§A.2.8	338-g4e1c688	The c argument in the eliminator for **1** (in the **1**-ELIM and **1**-COMP rules) should not bind a variable of type **1**.
§A.2.10	578-ga4b94a5	The unbased eliminator for the identity type should be named $\mathsf{ind}_{=_A}$, not $\mathsf{ind}'_{=_A}$.