Lean 4 Cheatsheet

If a tactic is not recognized, write `import Mathlib.Tactic` at the top of your file.

<table>
<tr><th>Logical symbol</th><th>Appears in goal</th><th>Appears in hypothesis</th></tr>
<tr><td>∀ (for all)</td><td><code>intro x</code></td><td><code>apply h</code> or <code>specialize h x</code></td></tr>
<tr><td>→ (implies)</td><td><code>intro h</code></td><td><code>apply h</code> or <code>specialize h1 h2</code></td></tr>
<tr><td>¬ (not)</td><td><code>intro h</code></td><td><code>apply h</code> or <code>contradiction</code></td></tr>
<tr><td>↔ (if and only if)</td><td><code>constructor</code></td><td><code>rw [h]</code> or <code>rw [← h]</code> or <code>apply h.1</code> or <code>apply h.2</code></td></tr>
<tr><td>∧ (and)</td><td><code>constructor</code></td><td><code>obtain ⟨h1, h2⟩ := h</code></td></tr>
<tr><td>∃ (there exists)</td><td><code>use x</code></td><td><code>obtain ⟨x, hx⟩ := h</code></td></tr>
<tr><td>∨ (or)</td><td><code>left</code> or <code>right</code></td><td><code>obtain h1|h2 := h</code></td></tr>
<tr><td>$a = b$ (equality)</td><td><code>rfl</code> or <code>ext</code></td><td><code>rw [h]</code> or <code>rw [← h]</code></td></tr>
<tr><td><code>True</code></td><td><code>trivial</code></td><td>—</td></tr>
<tr><td><code>False</code></td><td>—</td><td><code>contradiction</code></td></tr>
</table>

Tactic	Effect
	Applying Lemmas
`exact` *expr*	prove the current goal exactly by *expr*.
`apply` *expr*	prove the current goal by applying *expr* to some arguments.
`refine` *expr*	like `exact`, but *expr* can contain `?_` that will be turned into a new goal.
`convert` *expr*	prove the goal by showing that it is equal to the type of *expr*.
	Context manipulation
`have h :` *proposition* `:=` *expr*	add a new hypothesis `h` of type *proposition*. ⚠ **Do not use for data!**
`have h :` *proposition* `:= by`	add hypothesis `h` after proving it using tactics. ⚠ **Do not use for data!**
`set x :` *type* `:=` *expr*	add an abbreviation `x` with value *expr*.
`clear h`	remove hypothesis `h` from the context.
`rename_i x h`	rename the last inaccessible names with the given names.
`show` *expr*	Replaces the goal by *expr*, if they are equal by definition.
	Rewriting and simplifying
`rw [`*expr*`]`	in the goal, replace (all occurrences of) the left-hand side of *expr* by its right-hand side. *expr* must be an equality, iff statement or definition.
`rw [←`*expr*`]`	... rewrites using *expr* from right-to-left.
`rw [`*expr*`] at h`	... rewrite in hypothesis `h`.
`nth_rw` *n* `[`*expr*`]`	rewrite only the n-th occurrence of the rewrite rule *expr*.
`simp`	simplify the goal using all lemmas tagged `@[simp]` and basic reductions.
`simp at h`	... simplify in hypothesis `h`.
`simp [*,` *expr*`]`	... also simplify with all hypotheses and *expr*.
`simp only [`*expr*`]`	... only simplify with *expr* and basic reductions (not with simp-lemmas).
`simp?`	... let Lean speed up `simp` by specifying which lemmas were used.
`simp_rw [`*expr1*`, ...]`	like `rw`, but uses `simp only` at each step.
`simp_all`	repeatedly simplify the goal and all hypothesis using all hypotheses.
`norm_num`	simplify numerical expressions by calculating.
`norm_cast`	simplify the expression by moving casts (↑) outwards.
`push_cast`	push casts inwards.
`conv =>` *conv-tac*	apply rewrite rules to only part of the goal. Use `congr`, `skip`, `ext`, `lhs`, `rhs`, ... to navigate to the desired subexpression. See TPIL.
`split_ifs`	case split on every occurrence of `if` *h* `then` *expr* `else` *expr* in the goal.

Reasoning with equalities, inequalities, and other relations

`calc` $a = b$ `:= by` *tac*
  `_` $\le c$ `:= by` *tac*
  `_` $< d$ `:= by` *tac*
	perform a calculation
	💡 after writing "`calc _`" Lean can generate a basic calc-block for you.
	💡 after a `by` shift-click on a subterm in the goal to create a new step.

`rfl`	prove the current goal by reflexivity.
`symm`	swap a symmetric relation.
`trans` *expr*	split a transitive relation into two parts with *expr* in the middle.
`subst h`	if `h` equates a variable with a value, substitute the value for the variable.
`ext`	prove an equality in a specified type (e.g. functions).
`apply_fun` *expr* `at h`	apply *expr* to both sides of the (in)equality `h`.
`linear_combination`	prove an equality by specifying it as a linear combination of hypotheses.
`congr`	prove an equality using congruence rules.
`gcongr`	prove an inequality using congruence rules.
`positivity`	prove goals of the form $0 < x$, $0 \le x$ and $x \ne 0$.
`bound`	prove inequalities based on the expression structure.
`omega`	solve linear arithmetic problems over $\mathbb{N}$ or $\mathbb{Z}$.
`linarith`	prove linear (in)equalities from the hypotheses.
`nlinarith`	stronger variant of `linarith` that can solve some nonlinear inequalities.

Reasoning techniques

`exfalso`	replace the current goal by `False`.
`by_contra h`	proof by contradiction; adds the negation of the goal as hypothesis `h`.
`push_neg` or `push_neg at h`	push negations into quantifiers and connectives in the goal (or in `h`).
`by_cases h :` *proposition*	case-split on *proposition*.
`choose f h using` *expr*	extract a function from a forall-exists statement *expr*.
`lift n to` *type* `using h`	lifts a variable to *type* (e.g. $\mathbb{N}$) using side-condition `h`.
`zify` / `qify` / `rify`	shift an (in)equality to $\mathbb{Z}$ / $\mathbb{Q}$ / $\mathbb{R}$.
`induction n with` `| zero =>` *tac* `| succ n ih =>` *tac*	prove a goal by induction on `n`. 💡 after writing "`induction n`" Lean can generate the cases for you.

Searching

`exact?`	search for a single lemma that closes the goal using the current hypotheses.
`apply?`	gives a list of lemmas that can apply to the current goal.
`rw?`	gives a list of lemmas that can be used to rewrite the current goal.
`have? using h1, h2`	try to find facts that can be concluded by using both `h1` and `h2`.
`hint`	run a few common tactics on the goal, reporting which one succeeded.

General automation

`ring` / `noncomm_ring` / `module` `field_simp` / `abel` / `group`	prove the goal by using the axioms of a commutative ring / ring / module / field / abelian group / group.
`aesop`	simplify the goal, and use various techniques to prove the goal.
`tauto`	prove logical tautologies.
`decide`	run a decision procedure.
`fun_prop`	prove that a function satisfies a property (continuity, measurability, ...).

Misc

`swap`	swap the first two goals.
`pick_goal` *n*	move goal *n* to the front.
`all_goals` *tac*	apply *tac* to all goals.
`try` *tac*	apply *tac* only if it succeeds.
`sorry`	admit the current goal.

	Domain-specific tactics
`fin_cases h`	split a hypothesis `h` into finitely many cases.
`interval_cases n`	if split the goal into cases for each of the possible values for `n`.
`compute_degree`	prove (in)equalities about the degree of a polynomial
`monicity`	prove that a polynomial is monic
`measurability`	prove that a set or function is measurable.
`filter_upwards [h1, h2]`	Show that an `Eventually` goal follows from the given hypotheses.

Legend

💡 describes a code action for this tactic.
🌍 requires internet access.

Usage note

This is a quick overview of the most common tactics in Lean with only a short description. To learn more about a tactic or learn its precise syntax or variants, consult its docstring. You can use `#help tactic` *tac* to find the full syntax, variants and more information about *tac*. Use `#help tactic` to list all imported tactics.

Some useful commands

Some commands also work as tactics!

`#loogle` *query*	🌍 use Loogle! to find declarations.
`#leansearch "`*query*`."`	🌍 use LeanSearch to find declarations.
`#exit`	don't compile code after this command.
`#lint`	run linters to find common mistakes in the code *above* this command.
`#where`	print current opened namespaces, universes, variables and options.
`#help tactic` *tac*	find information about *tac*.
`#help` *category*	list all tactics/commands/attributes/options/notations.