RUBY

Intermediate / Advanced

Exception Handling · Metaprogramming Basics
Object Equality & Comparable · Iterators & Enumerable
File I/O & Serialization · Testing with RSpec
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Ruby Intermediate/Advanced — 8 Chapters

🚨 Exception Handling

Ruby Fundamentals covered the language's building blocks — now Course 2 turns to writing more robust, production-shaped code. First up: what happens when something goes wrong. Ruby's `begin/rescue/ensure` will feel structurally familiar from PHP's `try/catch/finally` or Python's `try/except/finally`, with a couple of Ruby-specific twists worth slowing down for.

🛟 begin / rescue / end

```
begin
10 / 0
rescue ZeroDivisionError => e
  puts "Can't divide by zero: #{e.message}"
end
```

`begin`...`end` wraps the risky code, and `rescue SpecificError => e` catches a matching exception, binding it to the local variable `e`. Multiple `rescue` clauses are allowed, checked top to bottom, exactly like PHP or Python's multiple `catch`/`except` blocks:

```
begin
risky_operation
rescue ZeroDivisionError => e
  puts "Math problem: #{e.message}"
rescue ArgumentError => e
  puts "Bad argument: #{e.message}"
rescue => e   # bare rescue -- catches StandardError and its subclasses, see below
puts "Something else went wrong: #{e.message}"
end
```

🔒 ensure — Always Runs

```
begin
puts "Trying..."
raise "Something broke"
rescue => e
  puts "Rescued: #{e.message}"
ensure
puts "Cleaning up, no matter what happened" # always runs
end
```

`ensure` runs whether an exception was raised or not, and even if the `rescue` block itself re-raises — the direct equivalent of PHP and Python's `finally`, just with a different keyword. Common use: closing a file handle or a database connection regardless of what happened above it.

⚠️ raise — Throwing Your Own Exceptions

```
raise "Something went wrong" # raises a plain RuntimeError with this message
raise ArgumentError, "Age can't be negative" # raises a specific exception class
```

A bare `raise "message"` is a convenient shorthand — Ruby wraps it in a `RuntimeError` automatically. For anything beyond a quick script, prefer the two-argument form (or a custom class, below) so callers can `rescue` a specific, meaningful error type instead of every possible `RuntimeError` in the codebase.

🔁 retry — Ruby-Specific, No Direct PHP/Python Equivalent

```ruby
attempts = 0
begin
  attempts += 1
puts "Attempt #{attempts}"
raise "Simulated failure" if attempts < 3
puts "Succeeded!"
rescue => e
  retry if attempts < 3 # jumps back to the start of begin, NOT to rescue
puts "Giving up: #{e.message}"
end
```

⚠ retry can loop forever if you don't cap it

`retry` jumps straight back to the top of the `begin` block, running everything inside it again — including the line that raised the exception in the first place. Without a counter (like `attempts` above) or some other cutoff condition, a persistently-failing operation combined with an unconditional `retry` will loop indefinitely. Neither PHP nor Python has a keyword for this pattern; you'd write a manual loop with your own retry-counting logic instead.

🪜 Custom Exception Classes

```
class InsufficientFundsError < StandardError
def initialize(msg = "Not enough funds for this transaction")
  super
end
end
def withdraw(balance, amount)
 raise InsufficientFundsError if amount > balance
 balance - amount
end
begin
 withdraw(50, 100)
rescue InsufficientFundsError => e
 puts e.message   # => Not enough funds for this transaction
end
```

Custom exceptions inherit from `StandardError` (not the bare `Exception` class — see the tip box below), pass a default message to `super`, and can then be `rescue`d specifically by name — exactly like extending PHP's `Exception` class or Python's `Exception` subclassing.

♉ The Modifier rescue

Echoing Chapter 3's modifier `if`/`unless`, there's a compact inline form for simple cases:

```
value = Integer("not a number") rescue 0
puts value   # => 0  -- falls back instead of crashing
```

Useful for a one-line fallback, but avoid it for anything where you'd actually want to know *which* exception occurred — the modifier form rescues everything indiscriminately, with no way to distinguish error types.

📜 Error Handling, Side by Side

PHP vs Python vs Ruby

Concept	PHP	Python	Ruby
Try block	try { }	try:	begin
Catch a specific error	catch (TypeException $e)	except TypeError as e:	rescue TypeError => e
Always runs	finally { }	finally:	ensure
Throw your own	throw new Exception("msg")	raise ValueError("msg")	raise ArgumentError, "msg"
Retry the block itself	No keyword — manual loop	No keyword — manual loop	retry

💻 Coding Challenges

Challenge 1: begin/rescue/ensure

Write a method `safe_divide(a, b)` that divides `a` by `b` inside a `begin`/`rescue` block, rescuing `ZeroDivisionError` specifically and returning `nil` in that case. Add an `ensure` clause that prints `"Division attempted"` every time, regardless of outcome.

Goal: Get the basic begin/rescue/ensure shape under your fingers with a concrete, testable example.

→ Solution

Challenge 2: A Custom Exception

Define a custom exception class `InvalidAgeError < StandardError` with a default message. Write a method `set_age(age)` that raises it when `age` is negative or over 130. Call it inside a `begin`/`rescue` that catches `InvalidAgeError` specifically and prints its message.

Goal: Practice defining and raising your own meaningful exception type instead of a generic one.

→ Solution

Challenge 3: retry With a Cap

Simulate a flaky network call: a method that raises an exception the first two times it's called and succeeds on the third. Use `begin`/`rescue`/`retry` to automatically retry up to 3 times, printing which attempt is running each time, and giving up gracefully if it never succeeds.

Goal: Practice `retry` safely, with a hard cap that prevents an infinite loop.

→ Solution

💎 Rescue StandardError, Not Exception

A bare `rescue` (with no class named) actually rescues `StandardError` and its subclasses — *not* every possible exception. This is deliberate: Ruby's `Exception` hierarchy also includes things like `SystemExit` and `NoMemoryError`, which you almost never want to silently swallow. Always inherit custom exceptions from `StandardError` (as this chapter's examples do), and be very deliberate any time you're tempted to write `rescue Exception` instead of a plain `rescue` — it's a common source of bugs where a program keeps limping along after it really should have been allowed to crash.

🎯 What's Next

Next chapter: **Metaprogramming Basics** — `method_missing`, `define_method`, `send`, and `respond_to?`, the tools behind Ruby's reputation for letting code write code.

🪄 Metaprogramming Basics

This chapter is where Ruby's reputation for "code that writes code" actually comes from. Four tools — `send`, `respond_to?`, `define_method`, and `method_missing` — let a program call methods by name at runtime, generate methods dynamically, and even respond to method calls that were never explicitly defined at all.

📞 send — Calling a Method by Name

```ruby
name = "ruby"

name.send(:upcase)          # => "RUBY"  -- same as name.upcase
name.send("upcase")         # => "RUBY"  -- a string works too
method_name = :reverse
name.send(method_name)      # => "ybur"  -- the whole point: the method name is a variable
```

`send` calls a method whose name is only known at runtime — as a symbol or a string, computed however you like. This is directly comparable to PHP's variable method call syntax `$obj->{$methodName}()` or Python's `getattr(obj, name)()`.

⚠ send can call private methods too

Unlike a normal method call, `send` bypasses Ruby's method visibility rules entirely — it can invoke `private` methods from outside the class, which a regular `obj.method` call cannot do. This is occasionally genuinely useful (testing, introspection), but it's also an easy way to accidentally break encapsulation. Ruby does provide `public_send`, which respects visibility and raises `NoMethodError` on a private method exactly like a normal call would — reach for that by default unless you specifically need to reach into private territory.

❓ respond_to? — Checking Before You Call

```ruby
name = "ruby"
if name.respond_to?(:upcase)
  puts name.upcase
end
5.respond_to?(:upcase)   # => false  -- Integer has no upcase method
```

`respond_to?` checks whether an object has a given method — the equivalent of PHP's `method_exists()` or Python's `hasattr()`. It's especially useful paired with `send`, when you're calling a dynamically-chosen method name and want to confirm it's actually valid first.

🏭 define_method — Generating Methods at Runtime

```
class Product
 [:name, :price, :sku].each do |attribute|
   define_method(attribute) do
@data[attribute]
   end
end
def initialize(data)
   @data = data
 end
end
p = Product.new(name: "Widget", price: 9.99, sku: "W-001")
p.name   # => "Widget"
p.price  # => 9.99
```

`define_method` generates a real, ordinary instance method — indistinguishable afterward from one written with `def` — but from inside a loop, driven by data instead of hand-typed one at a time. This is, in effect, a more flexible version of Chapter 6's `attr_accessor`: `attr_accessor` is really just a convenience method that calls something conceptually similar to `define_method` internally.

👻 method_missing — Handling Calls to Undefined Methods

Every method call Ruby can't find triggers a special hook method called `method_missing` before raising `NoMethodError`. Override it, and you can intercept and handle calls to methods that were never explicitly defined at all:

```
class GhostResponder
def method_missing(method_name, *args)
  if method_name.to_s.start_with?("ask_")
    "You asked about: #{method_name.to_s.sub('ask_', '')}"
else
super # important -- let genuinely unhandled calls raise normally
end
end
def respond_to_missing?(method_name, include_private = false)
  method_name.to_s.start_with?("ask_") || super
end
end
ghost = GhostResponder.new
ghost.ask_weather   # => "You asked about: weather"  -- ask_weather was never defined!
ghost.respond_to?(:ask_anything)  # => true
```

⚠ Always pair method_missing with respond_to_missing?

Overriding `method_missing` alone makes an object *answer* to dynamic method calls, but `respond_to?` won't know about them unless you also override `respond_to_missing?` to match the same logic. Skipping this pairing is a very common bug: code that calls `obj.respond_to?(:ask_weather)` to check first will get `false` even though `obj.ask_weather` actually works — a real, confusing inconsistency that's easy to introduce and easy to overlook in review.

PHP's closest equivalent is the `__call`/`__callStatic` magic methods; Python's is `__getattr__`. Ruby's `method_missing` plays the same conceptual role in each language's metaprogramming toolkit.

🌎 Where This Actually Gets Used

This isn't just a party trick. Rails' ActiveRecord famously used `method_missing`-based "dynamic finders" (`find_by_name`, `find_by_email` — one method handling infinitely many possible attribute names) for years before switching to `define_method`-based generation for better performance and clearer error messages. Ruby's standard library `OpenStruct` class — an object you can assign arbitrary attributes to on the fly — is built on exactly this mechanism.

📜 Metaprogramming Hooks, Side by Side

PHP vs Python vs Ruby

Concept	PHP	Python	Ruby
Call method by name	$obj->{$name}()	getattr(obj, name)()	obj.send(name)
Check method exists	method_exists()	hasattr()	respond_to?
Handle undefined method calls	__call() / __callStatic()	__getattr__()	method_missing
Generate methods dynamically	No direct equivalent (eval-based workarounds)	setattr(cls, name, function)	define_method

💻 Coding Challenges

Challenge 1: Dynamic Dispatch With send

Given a `Calculator` class with methods `add(a, b)`, `subtract(a, b)`, and `multiply(a, b)`, write a method `calculate(operation, a, b)` that uses `send` to call the correct method based on the `operation` symbol passed in. Use `respond_to?` to return `nil` gracefully for an unknown operation instead of raising.

Goal: Combine `send` and `respond_to?` the way they're commonly used together in practice.

→ Solution

Challenge 2: define_method in a Loop

Write a class `Coordinate` that uses `define_method` inside a loop over `[:x, :y, :z]` to generate three getter methods, backed by a single `@values` hash set in `initialize`. Confirm all three generated methods work on an instance.

Goal: Generate a family of near-identical methods from data instead of writing each one by hand.

→ Solution

Challenge 3: A Minimal OpenStruct

Write a class `DynamicRecord` whose `initialize` accepts a hash and stores it in `@attributes`. Override `method_missing` so any method call matching a key in `@attributes` returns that value, and override `respond_to_missing?` to match. Confirm both a dynamic call and `respond_to?` agree with each other.

Goal: Build a small version of what Ruby's real `OpenStruct` does, pairing `method_missing` with `respond_to_missing?` correctly.

→ Solution

💎 Just Because You Can Doesn't Mean You Should

Every technique in this chapter trades some amount of static clarity for dynamic flexibility. A method generated by `define_method` in a loop is genuinely harder to "find" with a simple text search than one written with `def`, and an object relying heavily on `method_missing` can be nearly impossible to understand from reading the class alone. Reach for these tools when the alternative is real, repetitive boilerplate (as in this chapter's examples) — not by default, and not because it looks clever.

🎯 What's Next

Next chapter: **Object Equality & Comparable** — `==`, `eql?`, `hash`, the spaceship operator `<=>`, and mixing in the `Comparable` module to get `<`, `>`, and `between?` for free.

⚖️ Object Equality & Comparable

Ruby splits "are these two things equal?" into more distinct questions than PHP or Python ask — and splits "which one comes first?" into a single method that, paired with a module you already know from Course 1, gives you an object's entire comparison operator set for free.

〓 == — Overridable Value Equality

```ruby
class Money
attr_reader :cents
def initialize(cents)
  @cents = cents
 end
def ==(other)
  other.is_a?(Money) && cents == other.cents
 end
end
Money.new(500) == Money.new(500)   # => true  -- same value, different objects
```

By default, `==` on a custom class checks object identity — two `Money.new(500)` instances would be considered different without an override, since they're separate objects in memory. Overriding `==` yourself (as shown above) is exactly like overriding `__eq__` in Python, or the loose comparison behavior PHP's `==` already applies automatically to objects with matching properties.

🆔 equal? — True Identity, Never Overridable

```
a = Money.new(500)
b = Money.new(500)

a == b       # => true   -- uses our overridden == (value equality)
a.equal?(b)  # => false  -- different objects in memory, always
a.equal?(a)  # => true   -- same object
```

`equal?` always checks true identity — the same object in memory — and, unlike `==`, it cannot be meaningfully overridden. This is the direct equivalent of Python's `is` operator, or PHP's `===` when comparing two object variables.

🔑 eql? — Stricter, Type-Sensitive Equality for Hash Keys

```
1 == 1.0 # => true   -- == treats them as equal
1.eql?(1.0)  # => false  -- eql? is stricter: different types, not equal
1.eql?(1)    # => true
```

⚠ Hash and Set use eql? + hash, not ==

When Ruby looks up a key in a `Hash` or checks membership in a `Set`, it uses `eql?` combined with `hash` — not `==`. This is why `{ 1 => "int" }[1.0]` returns `nil` even though `1 == 1.0` is true: `1` and `1.0` are `eql?`-different, so they hash to different Hash buckets. Neither PHP nor Python has a directly equivalent second equality method — Python's dicts get similarly close behavior from requiring `__eq__` and `__hash__` to agree with each other, which is the same underlying idea Ruby's `eql?`/`hash` pairing enforces explicitly.

hash — Required Alongside eql?

```
class Money
attr_reader :cents
def initialize(cents)
  @cents = cents
 end
def ==(other)
  other.is_a?(Money) && cents == other.cents
 end
alias eql? ==

 def hash
  cents.hash   # delegate to the underlying value's own hash
end
end
totals = { Money.new(500) => "Order A" }
totals[Money.new(500)]   # => "Order A"  -- works correctly, because eql? + hash both agree
```

Any time a custom class overrides `eql?` (directly, or — as shown here — by aliasing it to a custom `==`), it must also override `hash` so that two `eql?`-equal objects always produce the same `hash` value. Skip this, and using instances of the class as Hash keys or Set members produces confusing, inconsistent lookup behavior — a subtle bug that's easy to introduce and hard to spot.

🚀 <=> — The Spaceship Operator

```
3 <=> 5 # => -1  -- 3 is less than 5
5 <=> 5 # => 0   -- equal
5 <=> 3 # => 1   -- 5 is greater than 3
5 <=> "x" # => nil -- not comparable at all
```

The spaceship operator does a single three-way comparison: `-1`, `0`, `1`, or `nil` if the two values can't be meaningfully compared. PHP 7 actually adopted the exact same `<=>` symbol and semantics, directly inspired by Perl and Ruby — a rare case of syntax converging across languages. Python has no single spaceship operator; it implements `__lt__`, `__gt__`, `__eq__`, etc. separately, or uses `functools.total_ordering` to derive the rest from just one or two of them.

📐 The Comparable Module — This Chapter's Payoff

Course 1 Chapter 7 introduced modules as a way to share behavior across unrelated classes. `Comparable` is one of Ruby's own built-in modules, and it's the biggest payoff yet: define `<=>` once, `include Comparable`, and get `<`, `>`, `<=`, `>=`, `==`, `between?`, and `clamp` **all for free**:

```
class Version
include Comparable
attr_reader :major, :minor
def initialize(major, minor)
  @major = major
  @minor = minor
 end
def <=>(other)
  [major, minor] <=> [other.major, other.minor]   # Array <=> compares element by element
end
end
v1 = Version.new(2, 5)
v2 = Version.new(3, 0)

v1 < v2                 # => true   -- generated by Comparable, from our <=>
v1.between?(Version.new(1,0), v2)   # => true   -- also generated, for free

[v2, v1].sort           # => [v1, v2]  -- Array#sort uses <=> automatically
```

This is the exact same mixin mechanism `Enumerable` used in Course 1 Chapter 5 and 7 — one module method (`<=>` here, a block for `Enumerable`) unlocks an entire family of related behavior, without writing `<`, `>`, and every other comparison operator by hand.

📜 Equality Concepts, Side by Side

PHP vs Python vs Ruby

Concept	PHP	Python	Ruby
Value equality (overridable)	== (auto for objects)	__eq__	==
Identity (never overridable)	===	is	equal?
Hash/dict key equality	Same as == (no separate method)	__eq__ + __hash__ together	eql? + hash together
Three-way comparison	<=> (PHP 7+, same symbol)	No single operator — __lt__/__gt__/etc.	<=>
Get all comparisons from one method	No direct equivalent	@total_ordering decorator	include Comparable

💻 Coding Challenges

Challenge 1: Correct Hash Keys

Write a `Point` class with `x` and `y` attributes. Override `==` for value equality, alias `eql?` to it, and override `hash` to delegate to `[x, y].hash`. Prove it works by using two separately-constructed but equal `Point` instances as Hash keys and confirming a lookup with a third equal instance succeeds.

Goal: Practice the full eql?/hash pairing this chapter's warning box calls out as easy to get wrong.

→ Solution

Challenge 2: Comparable in Practice

Write a `Temperature` class storing degrees in Celsius, implement `<=>` based on that value, and `include Comparable`. Demonstrate `<`, `>`, and `between?` all working correctly despite never being written explicitly.

Goal: Feel the payoff of defining one method and getting an entire comparison API for free.

→ Solution

Challenge 3: Sorting Custom Objects

Reusing the `Temperature` class from Challenge 2, build an array of five `Temperature` instances in random order and call `.sort` on the array with no block or extra arguments. Print the sorted result to confirm `Array#sort` picked up your `<=>` automatically.

Goal: See `<=>` and `Comparable` integrate transparently with built-in Enumerable methods, not just your own code.

→ Solution

💎 The Rule to Remember

If a custom class ever needs to work correctly as a Hash key, in a Set, or with `Array#uniq`, the rule is simple and non-negotiable: **override `eql?` and `hash` together, or not at all**. Overriding just one of the two is worse than overriding neither — it produces an object that looks like it supports equality-based lookup but silently doesn't, which is a much harder bug to catch than an object that obviously uses default identity comparison.

🎯 What's Next

Next chapter: **Iterators & Enumerable Deep Dive** — building your own class that includes `Enumerable` by implementing a single `each` method, and lazy evaluation for working with sequences too large to load into memory all at once.

🔁 Iterators & Enumerable Deep Dive

Chapter 3 showed that defining a single `<=>` method and including `Comparable` unlocks an entire family of comparison operators for free. `Enumerable` — used constantly since Course 1 Chapter 5 without being built yourself — works on exactly the same principle. This chapter shows the mechanism, then goes further: what happens when a collection is too large, or too infinite, to process eagerly all at once.

🧬 Building Your Own Enumerable Class

Everything `Enumerable` provides — `map`, `select`, `reduce`, `count`, `sort_by`, dozens more — is built on top of a single method you supply: `each`.

```
class Inventory
include Enumerable # same mixin mechanism from Course 1, Chapter 7
def initialize
@items = []
 end
def add(item)
   @items << item
   self
end
def each
@items.each { |item| yield item }   # the ONE method Enumerable actually needs
end
end
stock = Inventory.new
stock.add("Widget").add("Gadget").add("Gizmo")

stock.map(&:upcase)                 # => ["WIDGET", "GADGET", "GIZMO"]
stock.select { |i| i.start_with?("G") }   # => ["Gadget", "Gizmo"]
stock.count                         # => 3
```

`map`, `select`, and `count` were never written anywhere in `Inventory` — every one of them comes from `Enumerable`, driven entirely by the `each` method that actually iterates over `@items`. This is the exact detail Course 1 Chapter 5 promised would eventually be explained.

Making a Class Iterable: PHP vs Python vs Ruby

	PHP	Python	Ruby
What you implement	Iterator interface: current(), key(), next(), rewind(), valid()	__iter__ and __next__ (or a generator with yield)	A single each method
Bonus methods you get for free	None — foreach only	None automatically — itertools helps separately	map, select, reduce, sort_by, count, and dozens more

PHP's `Iterator` interface needs five methods implemented by hand for basic `foreach` support alone, with no equivalent of `map`/`select` arriving automatically. Python's generator functions (using `yield`, similar in spirit to Ruby's) make basic iteration comparably concise — but Python still doesn't hand you a large family of transformation methods the way including `Enumerable` does.

➡️ Enumerator — Calling each Without a Block

```
enum = [10, 20, 30].each   # no block given -- returns an Enumerator object instead of iterating

enum.next   # => 10  -- pulls one value at a time, manually
enum.next   # => 20
enum.peek   # => 30  -- look ahead without advancing
enum.next   # => 30
```

Call any Enumerable method with no block, and Ruby hands back an **Enumerator** — an external, steppable iterator object rather than immediately running through every element. This is the foundation lazy evaluation is built on, next.

Lazy Evaluation

By default, Ruby's Enumerable methods are **eager**: each step in a chain builds a complete new array before the next step even starts. Add `.lazy`, and the entire chain instead processes one element at a time, only as far as actually needed:

```ruby
# DON'T do this -- (1..Float::INFINITY) is an infinite range, this hangs forever:
# (1..Float::INFINITY).select(&:even?).first(5)
# DO this instead -- .lazy processes one element at a time:
(1..Float::INFINITY).lazy
  .select(&:even?)
  .first(5)   # => [2, 4, 6, 8, 10]  -- stops as soon as it has 5, never scans "the rest" of infinity
```

⚠ Ruby defaults to eager — Python's generators default to lazy

This is a genuine philosophical difference worth internalizing rather than a small syntax quirk. In Python, a generator (or `range()` in Python 3) is lazy *by default* — you'd have to deliberately materialize it into a list to make it eager. In Ruby, plain Enumerable chains are eager by default, and laziness is something you explicitly opt into with `.lazy`. Forgetting `.lazy` on an infinite or very large range — as the commented-out line above shows — doesn't raise an error; it just hangs, attempting to build an infinitely large intermediate array.

💻 Coding Challenges

Challenge 1: A Custom Enumerable Class

Write a class `Playlist` that includes `Enumerable`, stores songs in an internal array, has an `add(song)` method, and implements `each` by yielding every song. Add five songs, then call `.select` to find songs containing a particular word and `.count` to get the total — neither method should be written directly on `Playlist`.

Goal: Implement the single `each` method and prove the rest of Enumerable follows automatically.

→ Solution

Challenge 2: Manual Stepping With an Enumerator

Given the array `["a", "b", "c", "d"]`, call `.each` with no block to get an Enumerator, then call `.next` three times, printing each result, and finally `.peek` once to preview the fourth element without consuming it.

Goal: Get comfortable with an Enumerator as a pausable, external iterator rather than an all-at-once loop.

→ Solution

Challenge 3: Lazy Evaluation on an Infinite Range

Using `(1..Float::INFINITY).lazy`, find the first 5 numbers that are both divisible by 3 *and* greater than 100, chaining `.select` calls before `.first(5)`. Add a comment explaining what would happen if `.lazy` were removed.

Goal: Use lazy evaluation to safely work with an infinite sequence.

→ Solution

💎 each Is the Only Method Enumerable Truly Needs

It's worth remembering how small the actual contract is: `Enumerable` asks for exactly one method, `each`, and derives everything else — `map`, `select`, `sort_by`, `min`, `max`, `group_by`, dozens more — purely from calling that one method repeatedly. It's one of the clearest examples in the whole language of a small, well-designed contract producing a disproportionately large amount of free functionality.

🎯 What's Next

Next chapter: **File I/O & Serialization** — reading and writing files with `File`/`IO`, and converting Ruby objects to and from JSON, YAML, and Marshal.

💾 File I/O & Serialization

Everything so far has lived and died inside a single running program. This chapter covers getting data in and out — reading and writing plain files, and converting Ruby objects into formats that survive being saved to disk or sent across a network, then reconstructed later.

Reading Files

```
# Read the whole file into one string
content = File.read("notes.txt")

# Read line by line, memory-efficient for large files
File.foreach("notes.txt") do |line|
  puts line.chomp   # .chomp strips the trailing newline
end
# Read into an array of lines
lines = File.readlines("notes.txt")
```

`File.read` loads an entire file into memory as one string — fine for small files, wasteful for huge ones. `File.foreach` streams line by line instead, similar in spirit to Python's `for line in open(path)` or PHP's `fgets` loop, without holding the whole file in memory at once.

✍️ Writing Files

```ruby
# Overwrites the file completely
File.write("output.txt", "Hello, file!")

# The block form auto-closes the file when done -- the idiomatic choice
File.open("output.txt", "w") do |file|
  file.puts "Line one"
  file.puts "Line two"
end # file is automatically closed here, even if an exception was raised inside
```

⚠ Always prefer the block form of File.open

`File.open("output.txt", "w")` without a block returns a file handle you have to remember to `.close` yourself — forget it, and the file may not be properly flushed to disk, especially if an exception interrupts your code before reaching the `close` call. The block form guarantees the file closes automatically once the block finishes, *even if an exception is raised inside it* — conceptually similar to Python's `with open(...) as f:` context manager, and safer than PHP's manual `fopen`/`fclose` pairing.

File modes work the same way across all three languages: `"r"` read (default), `"w"` write (truncates existing content), `"a"` append.

📦 JSON — the Universal Format

```
require "json"
data = { name: "Philip", age: 33, skills: ["Ruby", "PHP"] }

json_string = data.to_json
puts json_string   # => {"name":"Philip","age":33,"skills":["Ruby","PHP"]}
parsed = JSON.parse(json_string)
parsed["name"]   # => "Philip"  -- note: string keys, not symbols, after parsing!
parsed_symbols = JSON.parse(json_string, symbolize_names: true)
parsed_symbols[:name]   # => "Philip"  -- now symbol keys
```

JSON is the natural choice for interoperating with literally anything else — an API, a JavaScript frontend, another language entirely. Ruby's `require "json"` plus `.to_json`/`JSON.parse` is directly comparable to PHP's `json_encode`/`json_decode` or Python's `json.dumps`/`json.loads`.

⚠ JSON round-trips through strings, not symbols

Recall Chapter 2 of Course 1: symbols and strings are genuinely different objects. `JSON.parse` defaults to string keys, since symbols aren't a real concept in JSON — pass `symbolize_names: true` explicitly if you want symbol keys back out, and remember any symbol values used going *in* also come back out as strings.

📜 YAML — Human-Readable Configuration

```
require "yaml"
data = { name: "Philip", age: 33 }

puts data.to_yaml
# ---
# :name: Philip
# :age: 33
loaded = YAML.load(data.to_yaml)
loaded[:name]  # => "Philip"  -- YAML preserves symbol keys, unlike JSON
```

YAML is Ruby's own configuration-file format of choice — Rails' `database.yml` and Ruby's own `Gemfile.lock`-adjacent tooling lean on it heavily. Unlike JSON, YAML actually preserves Ruby-specific types like symbols across a round trip, at the cost of being Ruby-specific rather than a universal cross-language standard.

🗃️ Marshal — Ruby-Only Binary Serialization

```ruby
data = { name: "Philip", scores: [95, 88, 91] }

binary = Marshal.dump(data)     # serializes to a Ruby-specific binary format
restored = Marshal.load(binary)  # perfectly reconstructs the original object, including its exact class
```

⚠ Never Marshal.load data from an untrusted source

`Marshal` can serialize almost any Ruby object exactly, including custom class instances — a genuine convenience JSON and YAML can't match without extra work. But `Marshal.load` executes as it reconstructs objects, and loading a maliciously crafted Marshal payload from an untrusted source (a network request, user upload, etc.) is a known way to execute arbitrary code. Keep `Marshal` for trusted, internal use — caching, temporary files your own program wrote — never for data that came from outside your control.

📜 Serialization Formats, Side by Side

Choosing a Format

Format	Cross-language?	Preserves symbols/custom classes?	Safe for untrusted input?
JSON	Yes — universal	No — strings only	Yes
YAML	Mostly (other languages have YAML libraries)	Yes, within Ruby	Only with YAML.safe_load
Marshal	No — Ruby only	Yes, exactly	No — never on untrusted data

💻 Coding Challenges

Challenge 1: Write and Read a File

Use the block form of `File.open` to write three lines of your choosing to `diary.txt`. Then use `File.foreach` to read the file back and print each line prefixed with its line number (starting at 1).

Goal: Practice the safe, block-based pattern for both writing and reading a file.

→ Solution

Challenge 2: JSON Round Trip

Build a hash representing a small user profile with symbol keys (name, email, and an array of tags). Convert it to a JSON string with `.to_json`, then parse it back with `JSON.parse(json_string, symbolize_names: true)`. Confirm the parsed hash's keys are symbols again by calling `.class` on one of them.

Goal: See the string-vs-symbol round-trip issue firsthand and how `symbolize_names` fixes it.

→ Solution

Challenge 3: YAML vs JSON on the Same Data

Take the same hash from Challenge 2 and serialize it both with `.to_yaml` and `.to_json`. Print both strings side by side, then load each one back and compare whether the resulting hash's keys are symbols or strings in each case.

Goal: Directly observe the "preserves symbols" difference between the two formats from the comparison table.

→ Solution

💎 Default to JSON Unless You Have a Specific Reason Not To

When in doubt, reach for JSON: it's the safest for untrusted input, the most portable across languages and tools, and the format anything you build is most likely to eventually need to talk to. Save YAML for Ruby-specific configuration files where human readability matters, and treat `Marshal` as a specialized tool for trusted, same-process or same-machine caching — not a general-purpose serialization default.

🎯 What's Next

Next chapter: **Testing with RSpec** — `describe`/`it` blocks, expectations, and mocks/stubs, using the block-heavy syntax this course has been building toward since Course 1's final chapter.

🧪 Testing with RSpec

RSpec is the de facto standard Ruby testing framework — not part of the standard library, but close to universal in real Ruby and Rails projects (installing it is exactly what Chapter 7's gems and Bundler chapter covers next). Its entire syntax is built from the blocks, yield, and DSL-building techniques this course has covered since Course 1 Chapter 8 — a full-circle payoff worth noticing as you read through it.

📁 describe and it — the Basic Structure

```
# spec/calculator_spec.rb
describe Calculator do
it "adds two numbers correctly" do
   calc = Calculator.new
   expect(calc.add(2, 3)).to eq(5)
 end
it "subtracts two numbers correctly" do
   calc = Calculator.new
   expect(calc.subtract(10, 4)).to eq(6)
 end
end
```

Spec files live in a `spec/` directory and end in `_spec.rb` by convention. `describe` groups related examples (typically around a class or a feature); each `it` block is one individual test case with a plain-English description. Both `describe` and `it` are just methods that take a block — nothing more exotic than that, though it reads almost like a small custom language.

✅ expect().to — Expectations and Matchers

```
expect(5).to eq(5)                  # exact equality
expect(nil).to be_nil               # specific matcher for nil
expect([1,2,3]).to include(2)       # collection membership
expect("ruby").to start_with("ru")  # string matcher
expect { 1 / 0 }.to raise_error(ZeroDivisionError)  # wraps in a block -- must be lazy to catch the raise
```

The `expect(...).to matcher` phrasing is RSpec's core idiom, deliberately readable as close-to-English as Ruby syntax allows. Note the last example wraps the risky code in a block rather than evaluating it directly — `raise_error` needs to control exactly when the code runs so it can catch the exception itself.

🔄 before Hooks — Shared Setup

```
describe ShoppingCart do
  before(:each) do
@cart = ShoppingCart.new   # runs fresh before EVERY example below
end
it "starts empty" do
    expect(@cart.items).to be_empty
  end
it "adds an item" do
@cart.add("Widget")
    expect(@cart.items.count).to eq(1)
  end
end
```

`before(:each)` runs before every `it` block in its `describe`, giving each test a fresh `@cart` instead of one shared across examples (which would let one test's state leak into another). This plays the same role as PHPUnit's `setUp()` method or a pytest fixture — different mechanism, same underlying purpose.

🎭 Mocks and Stubs

Real tests often need to isolate the code under test from something slow, unreliable, or external — a network call, a database, another class entirely. RSpec's **doubles** (fake objects) and **stubs** (fake method responses) handle this:

```
describe WeatherReporter do
it "reports sunny weather" do
  fake_api = double("WeatherAPI")
  allow(fake_api).to receive(:current_conditions).and_return("sunny")  # a stub

  reporter = WeatherReporter.new(fake_api)
  expect(reporter.report).to eq("It's sunny today!")
 end
it "calls the API exactly once" do
  fake_api = double("WeatherAPI")
  expect(fake_api).to receive(:current_conditions).and_return("rainy")  # a mock -- verifies the call happens
WeatherReporter.new(fake_api).report
 end
end
```

allow().to receive() — a stub

Configures what a method returns *if* it's called, without requiring that it be called at all. Use this to control a fake dependency's behavior so the code under test has something predictable to work with.

expect().to receive() — a mock

Asserts the method *must* be called during the test, and fails the test if it never is. Use this specifically when the interaction itself — "did we actually call the API?" — is what you're testing, not just the resulting value.

PHPUnit reaches for the separate Mockery library (or its own built-in mock objects) for this; pytest uses `unittest.mock`'s `Mock`/`patch`. RSpec bakes the equivalent capability directly into the core framework rather than requiring a separate library.

📜 Testing Frameworks, Side by Side

PHPUnit vs pytest vs RSpec

Concept	PHPUnit	pytest	RSpec
Group tests	A test class extending TestCase	A file/class of test_ functions	describe block
One test case	A method starting with test	A function starting with test_	it block
Assertion style	$this->assertEquals(5, $result)	assert result == 5	expect(result).to eq(5)
Shared setup	setUp() method	@pytest.fixture	before(:each) block
Mocking	Mockery (separate library)	unittest.mock built in	double / allow / expect built in

💻 Coding Challenges

Challenge 1: Your First Spec File

Given a simple `StringFormatter` class with a method `shout(text)` that returns the text uppercased with an exclamation mark appended, write a `describe`/`it` spec with two examples: one confirming correct output for a normal string, one confirming it works on an already-uppercase string.

Goal: Write your first working RSpec examples using `expect().to eq`.

→ Solution

Challenge 2: before(:each) for Shared Setup

Write specs for a `Stack` class (with `push`, `pop`, and `empty?` methods) using `before(:each)` to create a fresh `@stack` before every example. Write at least three `it` blocks covering pushing, popping, and the empty check.

Goal: Practice avoiding shared, leaking state between test examples.

→ Solution

Challenge 3: Stubbing a Dependency

Given a class `NotificationService` that takes a `mailer` object in its constructor and calls `mailer.send_email(message)` inside a `notify(message)` method, write a spec using `double` and `allow().to receive()` to stub the mailer, then a second example using `expect().to receive()` to verify `notify` actually calls `send_email`.

Goal: Practice the difference between a stub (configuring a return value) and a mock (verifying a call happened).

→ Solution

💎 RSpec Is Blocks All the Way Down

Every piece of RSpec's syntax — `describe`, `it`, `before`, even the `expect { ... }.to raise_error` form — is an ordinary Ruby method that happens to accept a block. There's no special testing syntax baked into the language; RSpec is a library built entirely from the same block mechanics Course 1 Chapter 8 called "the single feature most responsible for Ruby's reputation as an unusually expressive language." If RSpec's DSL feels like a small custom language, that's because it genuinely is one — built entirely out of tools you already have.

🎯 What's Next

Next chapter: **Gems & Bundler** — how RSpec (and every other library used so far) actually gets installed, what a `Gemfile` does, and building a small gem of your own.

💎 Gems & Bundler

Chapter 6 used RSpec without explaining how it actually gets onto a machine or into a project. This chapter covers that: **gems**, Ruby's packaged-library format, **RubyGems**, the tool that installs them, and **Bundler**, the tool that pins exactly which versions a project depends on — then closes by building a tiny gem of your own.

📦 What Is a Gem?

A **gem** is a packaged Ruby library — code plus metadata (name, version, dependencies, author) bundled into a single distributable file — published to the central registry at **rubygems.org**. This is Ruby's direct equivalent of PHP's Composer packages (hosted on Packagist) or Python's pip packages (hosted on PyPI). RSpec, which Chapter 6 used freely, is itself just a gem like any other.

```
$ gem install rspec   # installs the latest version globally on your machine
$ gem list            # lists every gem currently installed
```

📋 Gemfile — Declaring a Project's Dependencies

Installing gems globally works for quick experiments, but real projects need every dependency and its version **declared** somewhere, so anyone (including you, six months later) can reproduce the exact same setup. That's what a `Gemfile` does:

```
# Gemfile
source "https://rubygems.org"

gem "rspec", "~> 3.12"
gem "httparty"
gem "rake"
```

`~> 3.12` is a **pessimistic version constraint** — allow any 3.12.x patch update, but never jump to 3.13. This is directly comparable to a `composer.json`'s version constraints or a Python `requirements.txt`/`pyproject.toml` entry.

🔒 Bundler and Gemfile.lock

```
$ bundle install
```

Bundler reads the `Gemfile`, resolves a complete, consistent set of exact versions for every gem *and* every gem those gems themselves depend on, installs them, and writes the precise result to `Gemfile.lock`. That lock file — comparable to Composer's `composer.lock` or Poetry's `poetry.lock` — is what guarantees everyone working on the project, and your production server, all use the exact same gem versions, not just "whatever satisfies the constraints today."

⚠ Always commit Gemfile.lock to version control

It's tempting to `.gitignore` a lock file since it's "generated," but doing so defeats the entire purpose of Bundler. Without `Gemfile.lock` committed, two different machines running `bundle install` against the same `Gemfile` could resolve to different gem versions if anything was published to RubyGems in between — the exact "works on my machine" problem lock files exist to prevent.

▶️ bundle exec

```
$ bundle exec rspec spec/
```

`bundle exec` runs a command using the *exact* gem versions locked in `Gemfile.lock`, rather than whatever version happens to be installed globally on the machine. Python's rough equivalent is activating a virtual environment before running a command; PHP typically doesn't need an analogous step, since Composer's `vendor/autoload.php` is usually required directly by the application code itself rather than needing a wrapper command.

📥 require vs require_relative

```
require "json" # a gem or standard-library file, found via Ruby's load path
require_relative "lib/helper" # a local file, relative to the CURRENT file's location
```

Use `require` for gems and standard-library code; use `require_relative` for your own project's files, since it resolves relative to wherever the requiring file actually lives rather than the current working directory a script happens to be run from.

Building Your Own Gem

```
$ bundle gem greeter   # scaffolds a new gem project
```

This generates a standard structure: a `lib/` directory for the actual code, a `greeter.gemspec` file describing the gem's metadata, plus a README, license, and test setup. The `.gemspec` is the gem's equivalent of a `composer.json` or Python `pyproject.toml`:

```
# greeter.gemspec
Gem::Specification.new do |spec|
  spec.name        = "greeter"
  spec.version     = "0.1.0"
  spec.authors     = ["Philip Osztromok"]
  spec.summary     = "A tiny gem that says hello."
  spec.files       = ["lib/greeter.rb"]
  spec.add_dependency "json", "~> 2.0"
end
# lib/greeter.rb
module Greeter
def self.say_hello(name)
    "Hello, #{name}!"
end
end

$ gem build greeter.gemspec       # produces greeter-0.1.0.gem
$ gem install ./greeter-0.1.0.gem   # installs it locally for testing
```

From there, publishing to rubygems.org with `gem push` makes it installable by `gem install greeter` from anywhere — the exact same distribution path every gem used throughout this entire course, including RSpec itself, went through.

📜 Package Management, Side by Side

Composer vs pip/Poetry vs RubyGems/Bundler

Concept	PHP (Composer)	Python (pip/Poetry)	Ruby (RubyGems/Bundler)
Central registry	Packagist	PyPI	RubyGems.org
Declare dependencies	composer.json	requirements.txt / pyproject.toml	Gemfile
Exact locked versions	composer.lock	poetry.lock (or pip freeze)	Gemfile.lock
Run with locked versions	Usually automatic via autoload	Activate a virtual environment	bundle exec

💻 Coding Challenges

Challenge 1: Write a Gemfile

Write a `Gemfile` for a small command-line project that needs `rspec` for testing (pinned with a pessimistic constraint to the 3.x line), `rake` for task running (any version), and a made-up gem `my_project_utils` pointed at a local path instead of RubyGems using `path: "../my_project_utils"`.

Goal: Get comfortable writing realistic Gemfile syntax, including version constraints and local path dependencies.

→ Solution

Challenge 2: require vs require_relative

Sketch out two small files: `lib/greeting.rb` defining a `Greeting` module with a `hello` method, and `main.rb` in the project root that needs to use it. Write the correct `require_relative` line in `main.rb`, and explain in a comment why `require` (not `require_relative`) would be the wrong choice here.

Goal: Solidify when to reach for each of the two require variants.

→ Solution

Challenge 3: Sketch a Tiny Gem

Write the `.gemspec` and the single `lib/` file for a gem called `temp_converter` that exposes one class method, `TempConverter.celsius_to_fahrenheit(c)`. Include a name, version, summary, and the `files` list in the gemspec.

Goal: Practice the minimum shape a real, publishable gem needs.

→ Solution

💎 Gemfile.lock Is the Whole Point

It's worth restating: a `Gemfile` alone only says what's *allowed* — a range of acceptable versions. `Gemfile.lock` says what's *actually installed*, down to the exact version number, for every direct and indirect dependency. Reproducibility — the guarantee that "it works on my machine" also means "it works on every machine" — comes entirely from that lock file being committed and respected, not from the Gemfile by itself.

🎯 What's Next

Next chapter — the final chapter of this course: **Ruby Idioms & Style** — Rubocop conventions, the `&.` safe navigation operator, and a last look back at common habits worth unlearning from PHP and Python.

✨ Ruby Idioms & Style

Every chapter across both Ruby courses has flagged individual idioms as they came up — this final chapter collects them into one deliberate checklist, adds a few new ones, and names the tool the Ruby community uses to enforce them automatically. The goal by the end: write Ruby that reads like Ruby, not PHP or Python with different keywords.

🚓 Rubocop — Ruby's Standard Linter

```
$ gem install rubocop   # installed as a gem, per Chapter 7
$ rubocop lib/
```

Rubocop is the de facto standard Ruby style checker and linter — the rough equivalent of PHP_CodeSniffer/PHP-CS-Fixer or Python's flake8/black/pylint. It enforces a large, configurable rule set (indentation, naming, string quoting, and a good chunk of the idioms in this chapter) via a `.rubocop.yml` config file, and many of its default rules encode community consensus about exactly the kind of "does this look like idiomatic Ruby" judgment this chapter is about.

📝 Ruby Strings Are Mutable — Unlike PHP and Python

```
name = "philip"
name << " osztromok" # mutates the SAME string object in place
puts name            # => philip osztromok
```

⚠ A genuinely important, easy-to-miss difference

PHP and Python strings are both immutable — every "modification" actually creates a new string. Ruby strings are **mutable by default**: methods like `<<`, `upcase!`, and `gsub!` (the `!` convention from Course 1 Chapter 4) change the string object in place. This has real consequences — pass a string into a method and mutate it there, and the caller's original variable changes too, since both point at the same object. It's exactly the kind of bug that doesn't exist in PHP or Python, because strings simply can't be mutated there.

```
# frozen_string_literal: true # a "magic comment" at the very top of a file
name = "philip"
name << " osztromok" # now raises FrozenError instead of silently mutating
```

The `# frozen_string_literal: true` magic comment makes every string literal in that file frozen (immutable) by default — a Rubocop-recommended, increasingly standard convention specifically because it closes off this entire category of accidental-mutation bug, bringing Ruby's default behavior closer to what PHP and Python developers already expect.

🛡️ &. — Safe Navigation

```ruby
user = nil

user.name       # raises NoMethodError -- nil doesn't respond to .name
user&.name      # => nil  -- short-circuits instead of raising
# Real payoff: chained calls where any link might be nil
user&.profile&.avatar_url   # nil the moment ANY link in the chain is nil, no crash
```

Introduced in Ruby 2.3, `&.` ("the safe navigation operator," sometimes nicknamed "the lonely operator") calls a method only if the receiver isn't `nil`, returning `nil` immediately otherwise. PHP 8 later adopted the near-identical `?->` operator — another case, like Chapter 3's spaceship operator, of a Ruby-originated idea converging into PHP's own syntax. Python has no direct native equivalent; the closest common pattern is a chain of `getattr(obj, "attr", None)` calls or explicit `is not None` checks at each step.

⚠ &. isn't a substitute for handling nil meaningfully

`&.` prevents a crash, but a chain full of `&.` can quietly swallow a `nil` that actually represents a real bug somewhere upstream — the code just keeps running with `nil` silently propagating forward. Reach for it when `nil` is a genuinely expected, valid possibility (an optional field, a not-yet-set association) — not as a reflexive way to make every warning disappear.

📋 The Idiomatic Ruby Checklist

A consolidated list of habits worth double-checking, most of them flagged individually somewhere earlier in this two-course sequence:

Prefer Enumerable over manual loops

A `result = []` followed by a `.each` loop that pushes into it is very often a `.map` or `.select` in disguise (Course 1, Chapter 5).

Use if/case as expressions

Assign the result of a conditional directly instead of declaring a variable first and mutating it inside every branch (Course 1, Chapter 3).

.each over for loops

`for` leaks its loop variable into the surrounding scope; `.each` keeps it cleanly contained (Course 1, Chapter 3).

Symbols for internal labels

Reach for a symbol (`:active`) for hash keys, statuses, and method names; reach for a string only for actual displayed or manipulated text (Course 1, Chapter 2).

attr_accessor over manual getters/setters

Default to the shortcut, narrowing to `attr_reader` only when a value genuinely shouldn't be freely rewritten (Course 1, Chapter 6).

Guard clauses over nested conditionals

`return unless valid?` at the top of a method, instead of wrapping the entire method body in one large `if` block — new to this chapter, detailed next.

🚪 Guard Clauses

```
# Not idiomatic -- deeply nested, hard to scan
def process_order(order)
 if order
  if order.paid?
   if order.items.any?
    ship(order)
   end
end
end
end
# Idiomatic -- guard clauses, flat and easy to scan top to bottom
def process_order(order)
 return unless order
 return unless order.paid?
 return unless order.items.any?

 ship(order)
end
```

PHP and Python both support early returns too, but Ruby style leans on them more heavily and more deliberately than either — each guard clause reads as a single, self-contained precondition, and the "main" logic sits unindented at the bottom instead of buried three `if` levels deep. This is Chapter 3's modifier `unless` and Chapter 6's implicit return, from Course 1, put to work together at the method-design level rather than just the single-line level.

📜 Style Tooling, Side by Side

PHP vs Python vs Ruby

Concept	PHP	Python	Ruby
Standard linter/formatter	PHP_CodeSniffer / PHP-CS-Fixer	flake8 / black / pylint	Rubocop
String mutability	Immutable	Immutable	Mutable by default; freeze/frozen_string_literal opts out
Null-safe chaining	?-> (PHP 8+, same idea as &.)	No native operator — manual getattr/None checks	&.

💻 Coding Challenges

Challenge 1: Refactor to Idiomatic Ruby

Given this "translated from another language" snippet — `evens = []; [1,2,3,4,5,6].each { |n| if n.even? then evens.push(n) end }` — rewrite it as a single idiomatic line using `.select`. Then take `status = nil; if age < 18 then status = "minor" else status = "adult" end` and rewrite it as one expression-oriented assignment.

Goal: Practice spotting and fixing the two most common "doesn't look like Ruby yet" patterns.

→ Solution

Challenge 2: Safe Navigation on a Chain

Given a `User` class that may or may not have a `profile` (which itself may or may not have an `avatar_url`), write a method `display_avatar(user)` that safely returns the avatar URL or a default fallback string, using `&.` to avoid raising when either link is `nil`. Test it with a user missing a profile entirely.

Goal: Use `&.` for its real purpose — a chain where an intermediate `nil` is genuinely expected.

→ Solution

Challenge 3: Guard Clauses

Take a method `can_checkout?(cart)` written with three levels of nested `if` (checking the cart exists, isn't empty, and every item is in stock) and refactor it into guard clauses, ending with a single unindented final line.

Goal: Practice flattening nested conditionals into a readable guard-clause sequence.

→ Solution

💎 The Question Worth Asking on Every Line

Across sixteen chapters, one question keeps coming back in a dozen different disguises: "does this look like it was written for Ruby, or does it look like PHP/Python with different keywords?" Symbols instead of strings for labels, expressions instead of temp variables, `.each`/`.map`/`.select` instead of manual loops, guard clauses instead of nesting, `attr_accessor` instead of boilerplate — none of these change what a program *does*. They change how quickly another Ruby developer can read what it does, which is exactly what "programmer happiness," Chapter 1 of Course 1's opening idea, was actually about all along.

🎯 What's Next

Course 2 (Ruby Intermediate/Advanced) is complete — 16 chapters across both Ruby courses, still framed against PHP and Python throughout. No further Ruby course is currently planned, but **Ruby on Rails** remains bucket-listed as the natural framework follow-up, building directly on everything covered here — especially blocks, modules, and the metaprogramming this course spent its middle chapters on.