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EPL

No syntax. Just logic.

ENGLISH PROGRAMMING LANGUAGE

A Programming Language for Humans & AI

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EPL
PROGRAMMING LANGUAGE

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FRONT MATTER

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FRONT MATTER

Preface

> *A message from the author — why EPL was born, what problem it solves, and what this book will teach you.*

Why I Built EPL

In 2023, I sat beside my younger cousin as she attempted her very first programming tutorial. She was twelve years old, curious, and enthusiastic. The tutorial asked her to write a Python program that checked whether a number was even or odd. Within five minutes, she had hit a `SyntaxError` on the colon she had forgotten, then an `IndentationError` from a misplaced space, and finally a `TypeError` because she had tried to print a number without converting it to a string first. She had not written a single line of logical thinking yet — she was still fighting the machinery of the language itself.

That moment stayed with me. She understood the logic perfectly — if you divide by two and the remainder is zero, then the number is even. She could explain it in plain English without hesitation. The barrier was never the *idea*; it was the translation of that idea into the rigid, symbolic syntax that languages like Python, JavaScript, and Java demand.

I started building EPL — the **English Programming Language** — that same semester. The guiding question was deceptively simple: *what if the code you wrote read exactly like the explanation you would give a friend?* What if "Create a variable called score and set it to one hundred" was literally valid EPL code? What if `If score is greater than 90 Then Say "Excellent" Otherwise Say "Keep trying" End` was a complete, runnable program?

EPL is the answer to that question. Every keyword in EPL was chosen because it is the most natural English word for the operation it represents. `Say` prints output. `Create` declares a variable. `Repeat 5 times` loops. `If ... Then ... Otherwise ... End` branches. You do not need to know what a colon means syntactically, or why braces are required, or how indentation affects execution. You just write English, and EPL runs it.

What This Book Is

This book is the complete, authoritative guide to EPL. It is written for two very different types of reader, and it serves both deliberately.

The first reader is a **complete beginner** — someone who has never written a program before. This person will find, in Parts I through IV, a thorough and patient introduction to programming concepts. The book explains not just what the syntax is, but *why* each concept exists, what problem it solves, and how to think about it correctly. No prior knowledge is assumed. If you have never used a terminal, we explain that. If you have never heard the word "variable," we define it from first principles.

The second reader is an **experienced developer** who wants to understand how a programming language actually works under the hood. This person will find, in Part II (Chapters 3–6), a detailed exposition of EPL's compiler pipeline: the Lexer, Parser, Abstract Syntax Tree, and Interpreter. These chapters explain exactly how character-by-character source code becomes running programs, using EPL's own implementation as the teaching vehicle.

By the time you finish this book, you will not only know how to write EPL programs — you will understand the fundamental theory behind how all programming languages work.

How to Use This Book

If you are a complete beginner, read this book in order from Chapter 1 through Chapter 14. Each chapter builds on the previous one. Do not skip ahead, and do not skim the explanations. The explanations are the book — the code examples exist to illustrate ideas, not to replace the act of reading and understanding.

If you have programming experience in another language, you can skim Chapters 1 and 2 to understand EPL's philosophy and setup, then dive into whichever chapters interest you. The language internals in Part II are self-contained — you can read Chapters 3–6 without reading anything else first.

If you are reading this as a reference while building something with EPL, Chapter 26 is a complete quick-reference card for every keyword, built-in function, and operator in the language.

> *"The most effective way to learn programming is not to memorize syntax — it is to understand the ideas that syntax expresses. Once the ideas are clear, the syntax becomes obvious."*
>
> — Abneesh Singh

💡 **RUN EVERY EXAMPLE**

Every code example in this book can be run immediately. Either open `docs/playground.html` in Chrome (no installation needed), or run `python epl/cli.py run yourfile.epl` from the project root. Do not just read the examples — type them, run them, and modify them. The act of breaking code and fixing it teaches you more than any explanation can.

Part I — The Language & Its World

CHAPTER 01

Introduction to EPL

> *What is EPL, where did it come from, what makes it different, and what can you build with it? This chapter gives you the full picture before you write a single line of code.*

1.1 The Problem EPL Solves

Every programming language ever created was designed by programmers, for programmers. Even languages marketed as "beginner-friendly" — Python, Ruby, Scratch — carry assumptions about what the learner already knows. They assume you understand what a function is. They assume you know why parentheses are required in certain places. They assume the mental model of a computer that only experienced developers actually have.

The result is a well-documented phenomenon: the **cognitive load barrier**. When a new programmer sits down to write their first program, they are simultaneously trying to understand:

- What the logical task is (e.g., "print a greeting")
- What the correct syntax is (`print("Hello")` vs `console.log("Hello")` vs `System.out.println("Hello")`)
- Why that syntax is the way it is
- How to use the tools — the editor, the terminal, the interpreter

This is four completely separate cognitive tasks happening at once. Research in educational psychology (Sweller, 1988) shows that the human working memory can hold approximately four discrete chunks of information simultaneously. Asking a new programmer to juggle all four of the above guarantees that some — and often all — of them will fail.

EPL attacks this problem at its root. It eliminates the syntax obstacle by making the language read as close to natural English as is computationally practical. When you write EPL, you are thinking about the logical task only. The language gets out of the way.

1.2 The Core Philosophy: English First

EPL's design is governed by a single principle: **at every decision point, choose the option that reads most naturally as English**. This principle guided every keyword choice, every structural decision, and every feature inclusion or exclusion.

Consider how other languages express a loop that runs five times:

COMPARISON

```
/* C / JavaScript / Java */
for (int i = 0; i < 5; i++) { ... }

# Python
for i in range(5): ...

// EPL
Repeat 5 times
    ...
End
```

The C-style loop requires you to know: loop initialisation syntax, comparison operators, increment operators, and block delimiters — all before you can even begin thinking about *what* to repeat. The Python version is better, but `range(5)` is still a function call that requires understanding of what "range" means and why zero-based indexing makes the loop run five times (not six). The EPL version reads as a direct English instruction: "Repeat this five times." A child can understand it without any explanation.

This is not accidental simplicity — it is deliberate, engineered accessibility. And it does not come at the cost of power. EPL supports the same features as Python: object-oriented programming, functional programming, databases, web servers, and full access to the Python ecosystem. You get English readability *and* professional capability.

1.3 EPL's Key Features at a Glance

📖 Natural Language Syntax

Keywords read as English sentences. `If score is greater than 90 Then` is valid EPL. No cryptic symbols, no mandatory punctuation.

⚡ Multi-Paradigm

Write procedural scripts, object-oriented applications, or functional pipelines — all in the same language, using whichever style fits the problem.

🌐 Multi-Target Compilation

EPL compiles to Python, JavaScript, and Kotlin. Write once, deploy anywhere — on the web, on mobile, or as a command-line tool.

🔌 Built-in Batteries

Web server, SQLite database, file I/O, and the full Python library ecosystem — all available without installing a single extra package.

1.4 EPL vs Other Languages: A Detailed Comparison

To understand what makes EPL unique, it helps to compare it side-by-side with the languages most people encounter first. The following table shows how the same concept is expressed in each language, demonstrating the syntactic complexity that EPL eliminates.

FEATURE	PYTHON	JAVASCRIPT	JAVA	EPL
Print text	`print("Hi")`	`console.log("Hi")`	`System.out.println("Hi")`	`Say "Hi"`
Declare variable	`x = 5`	`let x = 5;`	`int x = 5;`	`x = 5`

If-else	`if x>0:`
	`  print("pos")`
	`else:`
	`  print("neg")`
		`if(x>0){...}else{...}`	`if(x>0){...}else{...}`	`If x > 0 Then`
				`  Say "pos"`
				`Otherwise`
				`  Say "neg"`
				`End`

Loop 5 times	`for i in range(5):`	`for(let i=0;i<5;i++)`	`for(int i=0;i<5;i++)`	`Repeat 5 times`
Define function	`def greet(name):`	`function greet(name){`	`public static void greet(String name){`	`Define Function greet takes name`

Error handling	`try: ... except e:`	`try{...}catch(e){...}`	`try{...}catch(Exception e){...}`	`Try ... Catch e ... End`

1.5 A Tour of What You Can Build

EPL is not a toy language. It is a production-capable tool. The following are real projects built with EPL, each demonstrating a different capability domain.

Command-Line Tools and Scripts

EPL excels at writing scripts — file processors, data transformers, automation utilities. Any task you would reach for Python or Bash to accomplish, EPL can handle with cleaner, more readable code. A script to read a CSV file, filter records, and output a summary can be written in EPL in fifteen lines that any non-programmer can read and understand.

Web Applications and REST APIs

EPL includes a built-in web framework. With three keywords — `Create webapp`, `Route`, and `Start on port` — you have a running HTTP server. Add database calls, and you have a complete CRUD application. No Flask, no Express, no Spring Boot required.

Database-Backed Applications

EPL directly supports SQLite, the world's most widely deployed database engine. The functions `real_db_connect`, `real_db_execute`, and `real_db_query` provide everything you need to create tables, insert records, run queries, and process results — with no ORM, no migration system, and no configuration files.

Data Processing Pipelines

EPL's functional programming features — `map`, `filter`, `reduce`, and lambda expressions — allow you to express data transformations as clean, readable pipelines. Filter a list of students to those scoring above 80, extract their names, sort them — all in three chained lines that read almost as a sentence.

CHAPTER 1 SUMMARY

- EPL exists because traditional programming languages impose a *cognitive load barrier* on new learners — their syntax demands knowledge the learner has not yet acquired
- EPL's core principle is "English first" — every keyword was chosen for maximum readability as natural English
- Despite its simple syntax, EPL is multi-paradigm, multi-target, and production-capable
- EPL compiles to Python, JavaScript, and Kotlin, and includes a built-in web server and database
- The language does not sacrifice power for simplicity — it delivers both simultaneously

✍️ CHAPTER 1 EXERCISES

1. In your own words, explain the "cognitive load barrier" and describe one experience where you felt it (or imagine one). How would EPL reduce that barrier?
2. Write the equivalent of `Say "Hello, World!"` in three other programming languages you have encountered. Compare the amount of prior knowledge each version requires.
3. Look at the comparison table in Section 1.4. Without using EPL's syntax, write a plain English description of what an "if-else" statement does. Notice how close your English description is to EPL's actual syntax.
4. Research question: What is "cognitive load theory" in educational psychology? How does it apply to teaching programming? (Hint: search for "Sweller cognitive load programming education".)

Part I — The Language & Its World

CHAPTER 02

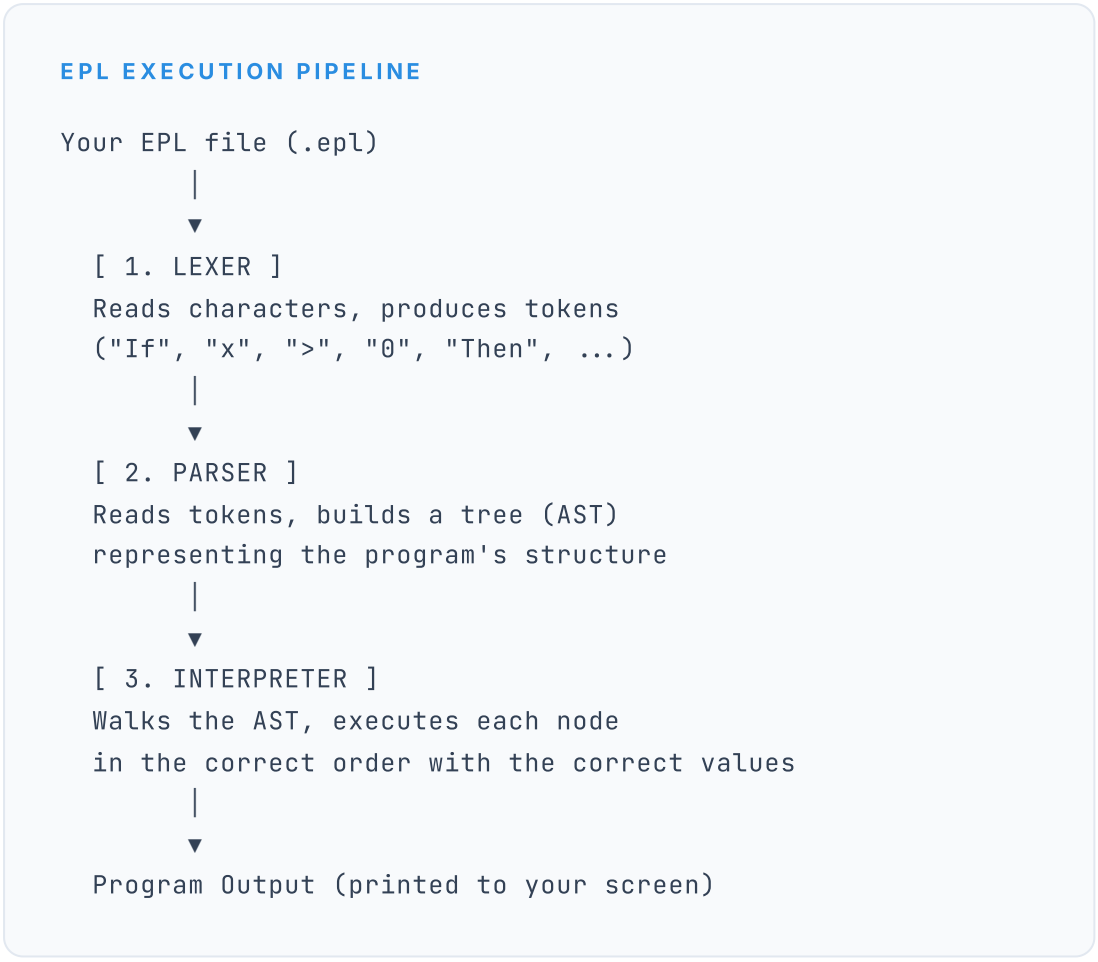
Getting Started

> *Everything you need to install EPL, run your first program, understand the tools available to you, and set up a comfortable development environment.*

2.1 How EPL Works: The 30-Second Overview

Before installing anything, let us build a mental model of what happens when you run an EPL program. Understanding this model will make everything that follows—installation, error messages, the CLI—make much more sense.

When you write EPL code in a `.epl` file and run it, the following sequence occurs behind the scenes:



This three-stage pipeline — Lexer, Parser, Interpreter — is the foundation of how nearly all interpreted programming languages work. Python uses this approach. Ruby uses it. JavaScript interpreters use it. EPL uses it too, and because EPL is open source, you can read every line of each stage in the project files. Part II of this book (Chapters 3–6) explains each stage in deep technical detail.

2.2 Installation

EPL requires Python 3.8 or newer. Python is the underlying runtime that EPL's interpreter is written in. If you do not yet have Python installed, download it from `python.org` and follow the installer instructions for your operating system.

Method 1: Install from PyPI (Recommended)

The simplest way to install EPL is via pip, Python's package manager. Open a terminal (Command Prompt on Windows, Terminal on Mac or Linux) and run:

TERMINAL

```
pip install eplang
epl --version    # Should print: EPL 1.x.x
```

Method 2: Clone from Source

If you want to explore or modify EPL's source code — which this book actively encourages — clone the repository directly:

TERMINAL

```
git clone https://github.com/abneeshsingh21/EPL
cd EPL
pip install -e .          # Editable install — changes to source take effect immediately
python epl/cli.py --version
```

2.3 Your First EPL Program

Let us write and run your first program right now. Create a file named `hello.epl` and type the following:

EPL hello.epl

```
Note: My first EPL program
Say "Hello, World!"
Say "I am learning EPL."
```

```
name = "Abneesh"Say"This language was created by: " + name
```

Now run it:

TERMINAL

```
python epl/cli.py run hello.epl
```

You should see:

OUTPUT

```
Hello, World!
I am learning EPL.
This language was created by: Abneesh
```

🔎 LINE-BY-LINE EXPLANATION

LINE 1

— `Note: My first EPL program` — This is a comment. The Lexer skips everything after `Note:` on that line. Comments are notes to human readers; EPL ignores them completely.

LINE 2

— `Say "Hello, World!"` — `Say` is EPL's print command. It evaluates whatever follows it and sends the result to your screen. The value in quotes is a string literal — a fixed piece of text.

LINE 4

— `name = "Abneesh"` — This creates a variable called `name` and stores the string "Abneesh" in it. Unlike many languages, EPL does not require you to declare the type or use a special keyword like `var` or `let` — you just assign directly.

LINE 5

— The `+` operator joins two strings together. This is called *string concatenation*. "This language was created by: " + "Abneesh" produces the combined string "This language was created by: Abneesh".

2.4 The CLI — Command Line Interface

EPL provides a rich command-line interface through `epl/cli.py`. Understanding these commands is essential to using EPL effectively.

COMMAND	WHAT IT DOES	WHEN TO USE IT

`cli.py run file.epl`	Execute the file directly	Everyday development and testing
`cli.py compile file.epl`	Compile to Python (.py)	When you want to deploy as a Python script
`cli.py compile file.epl --target js`	Compile to JavaScript	Browser or Node.js deployment
`cli.py compile file.epl --target kotlin`	Compile to Kotlin	Android or JVM deployment
`cli.py repl`	Interactive shell	Experimenting with small expressions
`cli.py check file.epl`	Syntax check only (no execution)	Before running, to catch errors early

2.5 The Browser Playground

If you prefer not to use the terminal, EPL includes a full browser-based playground at `docs/playground.html`. Open this file in Google Chrome or Microsoft Edge. You will see a code editor on the left and an output panel on the right. Type EPL code, click "Run", and see the output immediately — no installation, no terminal, no setup required.

The playground uses Pyodide — a WebAssembly port of Python — to run the EPL interpreter entirely inside your browser. This means it works offline and does not send your code to any server. Everything runs locally on your machine.

2.6 Comments — Documenting Your Code

A comment is a piece of text in your source code that EPL completely ignores during execution. Comments are written for human readers — to explain what code does, why a decision was made, or to leave notes for yourself or collaborators. Professional programmers consider well-written comments as important as the code itself.

EPL

```
Note: Single-line comment — everything after "Note:" is ignored

NoteBlock
    This is a multi-line comment block.
    Useful for longer explanations, documenting functions,
    or temporarily disabling sections of code during debugging.
End

Say "This line executes normally"   Note: Inline comment at end of a
line
```

⚠ COMMON MISTAKE: FORGETTING TO CLOSE NOTEBLOCK

Every `NoteBlock` must be closed with `End`. If you forget, EPL will treat all subsequent code as a comment and your program will appear to do nothing. If your program produces no output and you cannot figure out why, check for unclosed `NoteBlock` blocks.

CHAPTER 2 SUMMARY

- EPL programs go through three stages: Lexer → Parser → Interpreter, before producing output
- Install EPL via `pip install eplang` or by cloning the repository
- The `Say` keyword prints output; the `=` operator assigns values to variables
- The CLI provides commands for running, compiling, and checking EPL files
- The browser playground at `docs/playground.html` runs EPL without any installation
- Use `Note:` for single-line comments and `NoteBlock...End` for multi-line comments

✍️ CHAPTER 2 EXERCISES

1. Write and run an EPL program that prints your name, your age, and your current city on three separate lines.
2. Create a program with at least three variables: one storing a number, one storing text, and one storing a boolean. Print all three using `Say`.
3. Try to run an EPL file that has a deliberate error (e.g., an unclosed string: `Say "Hello`). Observe and read the error message. What information does it give you?
4. Use the `cli.py compile` command to compile a simple EPL file to Python. Open the resulting `.py` file and read its contents. Can you understand how EPL translated your code?
5. Open the playground in your browser and type `Say 2 + 2`. What does it print? Now try `Say "2" + "2"`. What is the difference, and why?

Part II — How EPL Works Internally

CHAPTER 03

The Lexer — Tokenisation in Depth

> *The Lexer is the first stage of EPL's compilation pipeline. It transforms raw source code — a plain string of characters — into a structured list of tokens that the Parser can understand. This chapter explains exactly how that transformation works.*

3.1 What is a Lexer?

Imagine you are reading a sentence in English: "The quick brown fox jumps." As your eyes move left to right, your brain is performing a remarkable operation — it is grouping sequences of characters into meaningful units called *words*. You do not process individual letters: t, h, e, (space), q, u, i, c, k. You process the grouped unit "The", then "quick", then "brown", and so on. This grouping happens automatically and unconsciously, but it is a real and necessary cognitive step before meaning can be extracted.

A **Lexer** (also called a *Tokeniser* or *Scanner*) performs exactly this operation for source code. It reads the raw character stream of your EPL program and groups characters into meaningful units called **tokens**. A token is the smallest meaningful unit in a programming language — the equivalent of a word in English.

Consider this simple EPL statement:

```
EPL
```

```
Say "Hello, World!"
```

The Lexer reads this left to right, character by character, and produces the following token list:

```
TOKEN OUTPUT

Token(type=KEYWORD,  value="Say")
Token(type=STRING,   value="Hello, World!")
```

Just two tokens. The keyword `Say` and the string literal `"Hello, World!"`. The surrounding quotation marks are consumed by the Lexer (they tell it where the string starts and ends) but they are not stored in the token value — the value is the content of the string, not the delimiters.

3.2 Token Types in EPL

EPL's Lexer recognises nine fundamental token types. Every valid EPL program is composed entirely of these nine types — if any character sequence cannot be classified into one of them, the Lexer raises a `LexError`.

TOKEN TYPE	EXAMPLES	DESCRIPTION
`KEYWORD`	`If`, `Say`, `Define`, `Function`, `For each`	Reserved words with special meaning in EPL's grammar
`IDENTIFIER`	`name`, `calculate_tax`, `student_age`	User-defined names for variables, functions, classes
`INTEGER`	`0`, `42`, `-7`, `1000`	Whole number literals

`FLOAT`	`3.14`, `0.5`, `100.0`	Decimal number literals
`STRING`	`"hello"`, `"EPL is great"`	Text enclosed in double quotes
`BOOLEAN`	`true`, `false`	Boolean literal values
`OPERATOR`	`+`, `-`, `*`, `/`, `==`, `≠`	Arithmetic and comparison operators
`PUNCTUATION`	`[`, `]`, `(`, `)`, `,`	Structural characters
`NEWLINE`	(end of line)	Statement terminator (EPL uses newlines, not semicolons)

3.3 The Maximum Munch Strategy

EPL's most distinctive lexing challenge comes from its multi-word keywords. In most programming languages, every keyword is a single word: `if`, `for`, `while`. In EPL, many keywords are composed of multiple English words: `Define Function`, `For each`, `is equal to`, `Repeat ... times`.

The Lexer uses a strategy called **maximum munch** (formally: *maximal munch*) to handle this. The rule is simple: **always consume the longest possible sequence of characters that forms a valid token**. When the Lexer sees the word "For", it does not immediately emit a token. It looks ahead — is the next significant word "each"? If yes, the entire phrase "For each" is tokenised as a single `KEYWORD` token. If the next word is something else (like "i from 2 to 10"), then "For" alone forms the keyword.

MAXIMUM MUNCH IN ACTION

```
Input: "For each student in roster"
                  |
                  ▼ Lexer sees "For"
Lookahead: next non-whitespace word is "each"
                  |
                  ▼ "For each" = known multi-word keyword
Token(KEYWORD, "For each")
Token(IDENTIFIER, "student")
Token(KEYWORD, "in")
Token(IDENTIFIER, "roster")
```

This design decision — multi-word keywords — is central to EPL's English-first philosophy. "For each student in roster" reads as a natural English phrase. The Lexer's job is to honour that phrase structure, not to artificially break it.

3.4 How the Lexer Handles String Interpolation

EPL supports an extremely useful feature called **string interpolation** : you can embed variable values directly inside strings using the `$varname` syntax. Instead of writing `"Hello, " + name + "!"`, you write `"Hello, $name!"`. The Lexer is responsible for detecting and handling this syntax at the token level.

When the Lexer encounters a string like `"Score: $score out of 100"`, it does not emit a simple `STRING` token. Instead, it recognises the `$` marker and emits an `INTERPOLATED_STRING` token that carries metadata about which substrings are literal and which are variable references. The Parser then knows to generate code that evaluates the variable and concatenates the result.

EPL

```
student = "Alice"
score   = 94
```

```
Say"Student: $student scored $score points."Note: Output: Student:
Alice scored 94 points.
```

3.5 Comment Stripping

One of the Lexer's earliest responsibilities is to identify and discard comments before any other processing occurs. When the Lexer encounters the sequence `Note:`, it reads and discards every character until the end of the current line. When it encounters `NoteBlock`, it discards everything until it finds the matching `End` keyword. This stripping happens before tokens are emitted, so comments are completely invisible to the Parser and Interpreter.

This is why comments have no performance impact on your program — they are removed at the very beginning of the pipeline, not evaluated at runtime.

3.6 Looking Inside EPL's Lexer: epl/lexer.py

EPL's Lexer is implemented in `epl/lexer.py`. The core class is `Lexer`, and its primary method is `tokenise()`, which accepts a string (your source code) and returns a list of `Token` objects. The `Token` class is a simple data container with three fields: `type`, `value`, and `line` (the source line number, used in error reporting).

The `tokenise()` method implements a *finite state machine*: a loop that maintains a "current position" in the source string and a "current state" (NORMAL, INSIDE_STRING, INSIDE_COMMENT, etc.). At each iteration, the current character determines the next state transition. This is the standard textbook approach for implementing lexers and is the same approach used in Python's own tokeniser (`tokenize` module).

CHAPTER 3 SUMMARY

- The Lexer is the first stage of EPL's pipeline — it converts raw source text into a list of typed tokens
- EPL has nine token types: KEYWORD, IDENTIFIER, INTEGER, FLOAT, STRING, BOOLEAN, OPERATOR, PUNCTUATION, NEWLINE
- The *maximum munch* strategy handles EPL's multi-word keywords like `Define Function` and `For each`
- String interpolation (the `$varname` syntax) is detected and handled by the Lexer
- Comments are stripped by the Lexer before any other processing — they have zero runtime cost
- The implementation in `epl/lexer.py` uses a finite state machine pattern

✍️ CHAPTER 3 EXERCISES

1. Open `epl/lexer.py` in your editor. Find the `tokenise()` method and read through it. Identify where multi-word keywords are handled. What data structure is used to store the keyword list?
2. Manually tokenise the following EPL line by writing out each token's type and value: `If age is greater than 18 Then Say "Adult" End`
3. What would happen if the Lexer did *not* use maximum munch, and instead tokenised each word individually? Write out what the token list would look like for `Define Function greet takes name`. Why would that be a problem for the Parser?
4. Add a print statement to `epl/lexer.py` inside the tokenise loop to print each token as it is produced. Run a simple EPL file and observe the token output. This gives you a real-time view of the Lexer's work.

Part II — How EPL Works Internally

CHAPTER 04

The Parser — Grammar, EBNF & Recursive Descent

> *The Parser takes the flat list of tokens produced by the Lexer and builds a structured tree — the Abstract Syntax Tree — that captures the hierarchical meaning of your program. This chapter explains how formal grammars work and how EPL's recursive descent Parser implements them.*

4.1 Why We Need a Parser

After the Lexer runs, we have a flat, ordered list of tokens. But a list is not enough to capture the meaning of a program. Consider this EPL expression: `2 + 3 * 4`. In a flat token list, this is just five tokens: INTEGER(2), OPERATOR(+), INTEGER(3), OPERATOR(*), INTEGER(4). But humans — and computers — know that this should be evaluated as `2 + (3 * 4) = 14`, not `(2 + 3) * 4 = 20`. The multiplication has higher *precedence* than the addition.

The token list contains no information about precedence or grouping. The **Parser** reads the token list and transforms it into a tree structure where the hierarchy of the tree encodes the correct evaluation order. In the tree, `*` is a child of `+`, which ensures multiplication is evaluated first — before the addition that depends on its result.

4.2 Formal Grammars and EBNF

Before the Parser can build a tree, it needs rules — a precise specification of what sequences of tokens are valid in EPL. These rules form the language's **grammar** . EPL's grammar is documented using a notation called **EBNF** (Extended Backus-Naur Form). EBNF is the standard way to describe programming language grammars and is used in the official specifications of Python, Java, C++, and virtually every other language.

Here is how to read EBNF notation:

EBNF SYMBOL	MEANING	EXAMPLE
`::=`	"is defined as"	`statement ::= ...`
`|`	"or" (alternative)	`A | B` means A or B
`[ ... ]`	Optional (zero or one)	`[Otherwise]`
`{ ... }`	Repetition (zero or more)	`{statement}`
`( ... )`	Grouping	`(A | B) C`
`"text"`	Literal token	`"If"`

Here is a simplified fragment of EPL's grammar in EBNF:

EPL GRAMMAR FRAGMENT (EBNF)

```
program        ::= { statement } EOF

statement      ::= say_stmt
                 | assignment
                 | if_stmt
                 | while_stmt
                 | for_stmt
                 | function_def
                 | return_stmt

say_stmt       ::= "Say" expression

assignment     ::= IDENTIFIER "=" expression

if_stmt        ::= "If" expression "Then" NEWLINE
                     { statement }
                   [ "Otherwise" NEWLINE { statement } ]
                   "End"

expression     ::= comparison { ("and" | "or") comparison }

comparison     ::= addition { ("==" | "≠" | ">" | "<" | "≥"
| "≤") addition }

addition       ::= multiplication { ("+" | "-") multiplication
}

multiplication::= primary { ("*" | "/" | "%") primary }

primary        ::= INTEGER | FLOAT | STRING | BOOLEAN
                 | IDENTIFIER
                 | "(" expression ")"
                 | function_call
```

Notice the layered structure: `expression` is built from `comparison`, which is built from `addition`, which is built from `multiplication`, which is built from `primary`. This layering is what implements operator precedence. Operators lower in the hierarchy (closer to `primary`) bind more tightly — they are evaluated first. Since

`addition` in the hierarchy, the `*` operator binds more tightly than `+`, giving us the correct mathematical precedence automatically.

4.3 Recursive Descent Parsing

EPL implements its Parser using a technique called **recursive descent**. In recursive descent parsing, each grammar rule becomes a function (a method in a class). The function for a grammar rule reads tokens from the stream and, when it encounters a sub-rule, calls the function for that sub-rule. Because grammar rules can reference other grammar rules (which is why they are called "recursive"), the functions call each other recursively — hence "recursive descent."

For example, the `parse_if_stmt()` method in EPL's Parser (`epl/parser.py`) works as follows:

PARSE_IF_STMT() IN PLAIN ENGLISH

1. Consume the `If` keyword token
2. Call `parse_expression()` to parse the condition (this may call itself recursively)
3. Consume the `Then` keyword token
4. Parse zero or more statements as the "then body" (calling `parse_statement()` repeatedly)
5. If the next token is `Otherwise If`, handle the else-if chain
6. If the next token is `Otherwise`, parse the "else body"
7. Consume the `End` keyword token
8. Return an `IfNode` AST node containing the condition, then-body, and else-body

This approach has several advantages over alternative parsing strategies (like shift-reduce parsing or parser combinators): it produces clear, readable code that directly mirrors the grammar, it generates highly informative error messages because you always know exactly which grammar rule you are inside, and it is easy to extend with new language features.

4.4 Error Reporting in the Parser

EPL's Parser is designed to produce the most helpful possible error messages. When parsing fails — because the token stream doesn't match any known grammar rule — the Parser raises a `ParseError` with three pieces of information: the line number, a description of what was expected, and a hint about how to fix the problem.

For example, if you write `If x > 0` and forget the `Then` keyword, the Parser does not just say "syntax error on line 1." It says: "ParseError on line 1: Expected 'Then' after the condition in an If statement. Did you mean: `If x > 0 Then`?" This hint-driven error system is one of EPL's most valuable features for learners, who need specific, actionable guidance rather than cryptic error codes.

CHAPTER 4 SUMMARY

- The Parser transforms the flat token list into a hierarchical tree that captures program structure and evaluation order
- Formal grammar rules written in EBNF specify exactly what sequences of tokens are valid in EPL
- Operator precedence is encoded by the layered structure of the grammar: operators that bind more tightly are lower in the rule hierarchy
- EPL uses recursive descent parsing, where each grammar rule becomes a method in the `Parser` class
- The Parser in `epl/parser.py` generates specific, hint-driven error messages with line numbers and fix suggestions

✍️ CHAPTER 4 EXERCISES

1. Draw the parse tree (by hand) for the expression `a + b * c - d`. Use the grammar fragment from Section 4.2. Which operator is at the root of the tree? Why?
2. According to the grammar, is `If x > 0 Say "positive" End` valid EPL? What is missing? Write the corrected version.
3. Open `epl/parser.py` and find the method that parses while loops. Read through it and describe what it does, in plain English, step by step.
4. Write the EBNF grammar rule for EPL's `Repeat N times ... End` loop construct. Use the notation from Section 4.2.
5. Introduce a deliberate syntax error in an EPL program (e.g., missing `End`) and run it. Read the error message. Does it tell you the exact line? Does it give a hint?

Part II — How EPL Works Internally

CHAPTER 05

The Abstract Syntax Tree

> *The Abstract Syntax Tree (AST) is the data structure the Parser builds and the Interpreter consumes. It is the bridge between syntax and execution — the program's structure represented as a tree of Python objects.*

5.1 What is an Abstract Syntax Tree?

After the Parser finishes its work, the result is an **Abstract Syntax Tree** (AST) — a tree-shaped data structure where each node represents one construct in the program. The word "abstract" means that the tree captures the *logical structure* of the program, not every syntactic detail. Tokens like parentheses, commas, and the `Then` and `End` keywords have served their purpose in helping the Parser understand the structure; they do not appear in the AST. The AST contains only the semantically meaningful elements.

Consider this EPL snippet:

```epl
x = 5 + 3
```

The AST for this single line looks like this:

```
AST FOR: X = 5 + 3

AssignNode
├── name: "x"
└── value:
    BinaryOpNode
    ├── operator: "+"
    ├── left:  NumberNode(value=5)
    └── right: NumberNode(value=3)
```

Read this tree from the bottom up to understand evaluation order. First, `NumberNode(5)` evaluates to the integer 5. Then `NumberNode(3)` evaluates to 3. Then `BinaryOpNode("+", 5, 3)` evaluates to 8. Finally, `AssignNode` takes the value 8 and stores it under the name "x" in the current scope.

5.2 EPL's Node Types

Every node in EPL's AST is an instance of a class defined in `epl/ast_nodes.py`. Each class corresponds to one language construct. There are nodes for: numbers, strings, booleans, null values, binary operations, unary operations, variable references, variable assignments, If statements, While loops, For loops, Repeat loops, function definitions, function calls, return statements, class definitions, method calls, list literals, map literals, list indexing, attribute access, and more.

NODE CLASS	REPRESENTS	KEY FIELDS
`NumberNode`	A numeric literal	`value` (int or float)
`StringNode`	A string literal	`value` (str)
`BoolNode`	true or false	`value` (bool)

`IdentifierNode`	A variable reference	`name` (str)
`AssignNode`	Variable assignment	`name`, `value`
`BinaryOpNode`	A binary expression	`op`, `left`, `right`
`IfNode`	An If statement	`condition`, `then_body`, `else_body`
`WhileNode`	A While loop	`condition`, `body`
`FuncDefNode`	A function definition	`name`, `params`, `body`
`FuncCallNode`	A function call	`name`, `args`
`ClassDefNode`	A class definition	`name`, `fields`, `methods`
`ListNode`	A list literal	`elements`

5.3 A Complete AST Example

Let us trace through a slightly more complex EPL program and see the full AST the Parser produces:

```EPL
If score ⩾ 90 then
    Say "Excellent"
Otherwise
    Say "Keep trying"
End
```

AST FOR THE IF STATEMENT ABOVE

```
IfNode
├── condition:
│   BinaryOpNode(op="⩾")
│   ├── left:  IdentifierNode(name="score")
│   └── right: NumberNode(value=90)
├── then_body: [
│   SayNode(
│     value: StringNode("Excellent")
│   )
| ]
└── else_body: [
    SayNode(
      value: StringNode("Keep trying")
    )
  ]
```

This tree completely and unambiguously represents the program structure. The Interpreter only needs to walk this tree — it does not need to re-read the source code or the token list. The AST is the canonical, authoritative representation of the program after parsing.

CHAPTER 5 SUMMARY

- The AST is a tree of Python objects where each node represents one program construct
- "Abstract" means the tree captures logical structure, not syntactic details — keywords like `Then` and `End` are not in the AST
- Tree hierarchy encodes evaluation order: children are evaluated before parents
- All EPL node classes are defined in `epl/ast_nodes.py`
- The AST is the single shared representation between the Parser (which builds it) and the Interpreter (which executes it)

Part II — How EPL Works Internally

CHAPTER 06

The Interpreter — Evaluating Code at Runtime

> *The Interpreter is the final stage of EPL's pipeline. It walks the Abstract Syntax Tree and executes each node, managing values, scopes, and control flow to produce your program's output.*

6.1 The AST Visitor Pattern

The Interpreter in `epl/interpreter.py` uses a technique called the **AST Visitor pattern**. The core idea is that the Interpreter defines a method for each type of AST node, named `exec_NodeName`. When it encounters a node in the tree, it dynamically dispatches to the corresponding method. For example:

- `NumberNode` → calls `exec_NumberNode()` → returns an integer or float value
- `AssignNode` → calls `exec_AssignNode()` → stores a value in the environment
- `IfNode` → calls `exec_IfNode()` → evaluates the condition, then executes the correct branch
- `FuncCallNode` → calls `exec_FuncCallNode()` → finds the function, creates a new scope, executes the body

The dynamic dispatch is implemented using Python's `getattr()` function, which looks up a method by name at runtime. This means adding a new AST node type to EPL requires only: (1) creating the new node class in `ast_nodes.py`, (2) adding a parsing rule in `parser.py`, and (3) adding the corresponding `exec_` method in `interpreter.py`. The rest of the system requires no changes.

6.2 The Environment and Lexical Scope

The Interpreter manages variable storage using a class called `Environment` (defined in `epl/environment.py`). An Environment is essentially a dictionary that maps variable names to their values. But EPL supports **lexical scoping** — the rule that a variable's scope is determined by where it is *written* in the source code, not by where it is called at runtime. To implement lexical scoping, each Environment maintains a reference to its *parent* Environment.

ENVIRONMENT / SCOPE CHAIN

```
Global Environment
├── score = 95
├── name  = "Alice"
└── parent: None          ← top level, no parent

Function greet's Environment (created on call)
├── greeting = "Hello"    ← local variable
└── parent: → Global      ← links to outer scope

When looking up "name" inside greet():
  1. Check greet's environment → not found
  2. Check parent (Global) → found! value = "Alice"
  3. Return "Alice"
```

When a variable is referenced inside a function, the Interpreter first looks in the function's own Environment. If not found, it follows the `parent` pointer to the enclosing scope and looks there. This continues up the chain until either the variable is found or the top-level (global) Environment is reached with no parent — at which point a `NameError` is raised.

This chain-of-environments architecture is the same fundamental mechanism used by Python, JavaScript, and all languages with lexical scoping. Understanding it deeply will help you reason about variable visibility in any language you ever work with.

6.3 How Function Calls Work

When the Interpreter encounters a `FuncCallNode`, a precise sequence of steps occurs:

1. **Lookup**: The function's name is looked up in the current Environment chain. The stored value is a `FuncDefNode` (the AST node that defined the function).
2. **Argument evaluation**: Each argument expression in the call is evaluated in the *caller's* scope, producing a list of concrete values.
3. **New environment**: A new `Environment` object is created with its parent pointing to the scope where the function was *defined* (not where it was called — this is the key to lexical scoping).
4. **Parameter binding**: Each parameter name from the function definition is bound to the corresponding argument value in the new environment.
5. **Body execution**: The function's body (a list of AST nodes) is executed statement by statement in the new environment.
6. **Return**: If a `ReturnNode` is encountered, execution stops and the return value is passed back to the caller via a special `ReturnSignal` exception (a Python exception used for control flow, not for error handling).
7. **Cleanup**: The function's environment is discarded. Its variables no longer exist.

6.4 Built-in Functions

EPL provides a set of built-in functions — `to_integer()`, `to_text()`, `type_of()`, `max()`, `min()`, and so on — that are implemented directly in Python inside `epl/builtins.py`. When the Interpreter starts, it creates the global Environment and populates it with these built-in functions. They behave exactly like user-defined functions from the caller's perspective, but their bodies are Python code rather than EPL AST nodes.

CHAPTER 6 SUMMARY

- The Interpreter uses the *AST Visitor pattern*: each node type has a corresponding `exec_` method
- Variable storage is managed by the `Environment` class — a dictionary with a parent pointer
- Lexical scoping means variable lookup walks the chain of parent Environments until the variable is found
- Function calls create a new child Environment, execute the body, then discard the environment
- Built-in functions are pre-populated into the global Environment at startup
- Understanding the Environment chain explains all scoping behaviour in EPL

✍️ CHAPTER 6 EXERCISES

1. Open `epl/interpreter.py` and find the `exec_IfNode()` method. Read through it. How does it handle the "Otherwise If" (else-if) chain?
2. The Interpreter uses a `ReturnSignal` Python exception for return values instead of a regular `return` statement. Why is this approach necessary given that exec_ methods call each other recursively?
3. Write an EPL function that references a variable defined outside it. Verify it works by running it. Then draw the Environment chain that the Interpreter creates during execution.
4. What happens if you try to access a variable inside a function that has the same name as a global variable? Write a test to find out. Does EPL use the local or global version? (This is called *variable shadowing*.)

Part III — Language Fundamentals

CHAPTER 07

Variables, Constants & Scope

> *A variable is a named container for a value. Understanding how to create, use, and reason about variables — and understanding the rules about where they are accessible — is the single most foundational skill in programming.*

7.1 What is a Variable?

Before writing a single line of EPL code, you need a clear mental model of what a variable actually is. The word "variable" comes from mathematics, where it means a symbol that can take on different values. In programming, is it much the same — but more concrete.

Think of your computer's memory as a vast grid of labelled boxes. Each box can hold one value at a time, and each box has a unique address. A **variable** gives a human-readable name to one of those boxes, so you can refer to it by name instead of by its raw memory address. When you write `age = 17` in EPL, you are saying: "Find an empty memory box, store the value 17 in it, and attach the label 'age' to it so I can find it later."

After that, whenever you write `age` anywhere in your program, EPL knows to go to that labelled box and retrieve whatever value is currently stored there. You can change the value in the box at any time — that is what makes it a *variable*: its value can vary over the program's lifetime.

7.2 Creating Variables in EPL

In EPL, you create a variable simply by assigning a value to a name using the `=` operator. There is no special keyword required — no `var`, no `let`, no `int`, no type declaration. Just write the name, an equals sign, and the value.

EPL variables.epl

```
Note: Creating variables of different types
name    = "Alice"         Note: text (string)
age     = 21              Note: whole number (integer)
gpa     = 3.85            Note: decimal number (float)
is_enrolled = true        Note: boolean (true or false)
nickname = nothing        Note: absence of a value (null)

Say "Student: " + name
Say "Age: " + to_text(age)
Say "GPA: " + to_text(gpa)
Say "Enrolled: " + to_text(is_enrolled)
```

🔎 **NAMING RULES FOR VARIABLES**

Variable names in EPL must follow these rules:

- Start with a letter or underscore: `name`, `_temp`, `value1`
- Contain only letters, digits, and underscores: `student_score`, `count2`
- **NOT** be a reserved keyword: `If`, `Say`, `End` cannot be variable names
- Are **CASE-SENSITIVE**: `Name` and `name` are two different variables

By convention, EPL programmers use *snake_case*: all lowercase words separated by underscores. Examples: `student_name`, `total_price`, `is_valid`.

7.3 Changing a Variable's Value

The whole point of a variable is that its value can change. You change it simply by assigning a new value to the same name. The old value is replaced — EPL does not keep a history of previous values.

EPL

```
score = 70
Say score              Note: prints 70

score = 85             Note: overwrites the old value
Say score              Note: prints 85

Note: EPL also has shortcut operators for common updates:
Increase score by 5    Note: score is now 90 (equivalent to score =
score + 5)
Decrease score by 10   Note: score is now 80
```

```
Multiply score by2Note: score is now 160Say score                Note:
prints 160
```

The shortcut operators `Increase by`, `Decrease by`, and `Multiply by` are EPL's English equivalents of the `+=`, `-=`, and `*=` operators found in other languages. They are purely syntactic sugar — the Interpreter converts them to the equivalent addition and assignment operations before execution.

7.4 Understanding Scope

Scope is the region of a program where a variable is accessible. This is one of the most important concepts in programming, and understanding it prevents a large class of bugs that confuse beginners and experienced developers alike.

EPL has two types of scope: **global scope** and **local scope**.

Global Scope

A variable defined at the top level of your program — not inside any function or block — exists in the *global scope*. It is accessible from anywhere in the program, including inside functions.

Local Scope

A variable defined inside a function exists in that function's *local scope*. It is created fresh every time the function is called and destroyed when the function returns. It is completely invisible outside the function. Trying to access it outside the function will cause a `NameError`.

EPL

```
greeting = "Hello"      Note: GLOBAL — accessible everywhere

Function say_hello
    message = "World"   Note: LOCAL — only exists inside this function
    Say greeting + ", " + message  Note: can read global 'greeting'
End
```

```
Say greeting          Note: Works — greeting is globalNote: Say message
← This would cause NameError: 'message' not defined
```

⚠ THE SCOPE TRAP FOR BEGINNERS

One of the most common beginner mistakes is defining a variable inside a function and then trying to use it outside. Remember: local variables exist only for the duration of the function call. Once the function returns, they are gone. If you need a value computed inside a function to be available outside it, *return* that value from the function (covered in Chapter 13).

7.5 Multiple Assignment and Swapping

EPL allows you to assign multiple variables on a single line, which is useful for readability when initialising related values together:

EPL

```
Note: Initialising multiple counters
wins = losses = draws = 0

Note: Swapping two values using a temporary variable
a = 10
b = 20
temp = a
a = b
b = temp
Say a        Note: 20
Say b        Note: 10
```

CHAPTER 7 SUMMARY

- A variable is a named memory location that stores a value — that value can change over time
- Create variables with the `=` operator: no special keyword needed in EPL
- Names must start with a letter/underscore, contain only letters/digits/underscores, and not be keywords
- `Increase by`, `Decrease by`, and `Multiply by` are English shortcut operators for common updates
- **Global scope**: defined at top-level, accessible everywhere. **Local scope**: defined inside a function, invisible outside it
- Local variables are created when a function is called and destroyed when it returns

✍️ CHAPTER 7 EXERCISES

1. Create variables to store: your full name, your birth year, your height in metres, and whether you are a student. Print each with a descriptive label.
2. Write a program that starts with `x = 100`, then uses `Increase by` and `Decrease by` to make a series of changes, printing the value after each step.
3. What happens when you try to use a variable before assigning it a value? Try it and read the error message.
4. Write a function that creates a local variable and tries to print it. Then, outside the function, try to print that same variable. What error do you get?
5. Explain in your own words: why is having local scope (variables only visible inside functions) a useful design feature rather than an annoying restriction?

Part III — Language Fundamentals

CHAPTER 08

Data Types — Numbers, Text, Booleans & Nothing

> *Every value in EPL has a type that determines what operations are valid on it, how it is stored in memory, and how it behaves in expressions. Understanding data types is essential to writing programs that work correctly.*

8.1 Why Data Types Exist

Computers store everything as binary numbers — sequences of 0s and 1s. Whether you are storing the number 42, the letter "A", or the colour red, it all ends up as binary. Data types tell the computer (and the programmer) *how to interpret* that binary data. The bit pattern `01000001` means the number 65 if interpreted as an integer, but the letter "A" if interpreted as a character.

Programming languages use type systems to protect you from interpreting data the wrong way. When you try to add a number to a text string in a strongly-typed language, it refuses — because adding those two things is almost never what you actually want. EPL is *dynamically typed*: types are checked at runtime rather than at compile time. This means EPL is flexible and fast to write, but you must be aware of types to avoid unexpected behaviour.

8.2 Integers — Whole Numbers

An **integer** is any whole number — positive, negative, or zero — with no decimal component. Integers are used for counting, indexing, and any situation where fractional values make no sense (you cannot have 2.7 students).

```epl
population  = 8000000000    Note: eight billion — no commas needed
temperature = -15           Note: negative integers are valid
inventory   = 0             Note: zero is an integer
year        = 2025

Say type_of(year)             Note: prints "integer"
Say year + 1                  Note: prints 2026
Say population / 1000000    Note: prints 8000 (integer division)
```

EPL integers have unlimited precision — they can be as large or as small as your computer's memory allows. There is no fixed maximum value (unlike C's `int` which is limited to about 2 billion). This is because EPL's integers are backed by Python's arbitrary-precision integer type.

8.3 Floats — Decimal Numbers

A **float** (short for "floating-point number") is a number with a decimal component. Floats are used for measurements, percentages, prices, scientific values, and any calculation that requires precision beyond whole numbers.

```epl
pi          = 3.14159265
price       = 19.99
tax_rate    = 0.18          Note: 18% tax rate as a decimal
temperature = -3.7

total = price * (1 + tax_rate)
```

```
Say total                    Note: 23.9882 (price + tax)Say type_of(pi)
Note: prints "float"
```

⚠ FLOATING-POINT PRECISION

Computers represent decimal numbers in binary, and most decimal fractions cannot be represented exactly in binary. This leads to tiny rounding errors. For example, `0.1 + 0.2` in EPL (as in Python and JavaScript) gives `0.30000000000000004`, not exactly `0.3`. This is not a bug in EPL — it is a fundamental property of how floating-point arithmetic works on all computers. For financial calculations requiring exact decimal arithmetic, always round results to the required number of decimal places using the `round()` function.

8.4 Strings — Text Values

A **string** is an ordered sequence of characters — letters, digits, spaces, punctuation, emoji, or any other Unicode character. Strings are used to represent any data that is inherently textual: names, messages, file paths, URLs, configuration values.

In EPL, strings are always enclosed in double quotes. They can be any length — from an empty string `""` (zero characters) to a multi-sentence paragraph.

EPL

```
empty   = ""                  Note: empty string — zero characters
letter  = "A"                 Note: single character
city    = "New Delhi"         Note: multiple words are fine
message = "She said \"hello\""  Note: escaped quotes inside string
multiline = "Line one\nLine two\nLine three"  Note: \n = newline

Say city.length             Note: 9 (number of characters)
Say city.upper()            Note: "NEW DELHI"
```

```
Say city.lower()            Note: "new delhi"Say city.contains("Delhi")
Note: true
```

Type Conversion with Strings

One of the most common operations in EPL programs is converting between strings and numbers. You cannot directly concatenate a number with a string — you must convert the number to text first using `to_text()`. Conversely, if you have a string that looks like a number (e.g., user input from the terminal), convert it to an integer or float using `to_integer()` or `to_float()`.

EPL

```
age = 21
Say "Age: " + to_text(age)    Note: correct — converts 21 to "21" first

user_input = "42"             Note: this came from a user — it's text,
not a number
actual_num = to_integer(user_input)
Say actual_num + 8          Note: 50 — now it behaves as a number
```

8.5 Booleans — True and False

A **boolean** value can only be one of two things: `true` or `false`. Booleans are the language of decisions — every `If` statement, every `While` loop condition, every comparison expression ultimately produces or consumes a boolean value.

The name "boolean" honours George Boole, a 19th-century mathematician who developed Boolean algebra — the branch of mathematics that underpins all digital logic.

EPL

```
is_raining   = true
has_umbrella = false
is_adult     = age ⩾ 18     Note: comparison produces a boolean

Say type_of(is_raining)     Note: "boolean"
```

```
Say is_adult                Note: true or false depending on ageNote:
Booleans work with logical operators
should_carry_umbrella = is_raining andnot has_umbrella
Say should_carry_umbrella   Note: true (raining AND no umbrella)
```

8.6 Nothing — The Absent Value

Sometimes a variable has *no value* — not zero, not an empty string, but genuinely no value at all. EPL represents this with the keyword `nothing`, which is equivalent to Python's `None`, JavaScript's `null`, or SQL's `NULL`.

Common uses for `nothing`: initialising a variable before you know its value, returning from a function that has no meaningful result, and representing optional fields in a data structure that may or may not be populated.

EPL

```
result = nothing            Note: no value yet

If result == nothing then
    Say "No result available yet"
End

Say type_of(result)         Note: "null"
```

8.7 The type_of() Function

At any point in your program you can ask EPL what type a value is by calling `type_of()`. This is extremely useful for debugging — when a program behaves unexpectedly, checking the type of a value often immediately reveals the problem (e.g., a number was accidentally stored as a string).

EPL

```
Say type_of(42)         Note: "integer"
Say type_of(3.14)      Note: "float"
Say type_of("hi")     Note: "string"
Say type_of(true)     Note: "boolean"
Say type_of(nothing) Note: "null"
Say type_of([1,2,3]) Note: "list"
```

CHAPTER 8 SUMMARY

- **Integer**: whole numbers, no decimal; arithmetic is exact; arbitrary precision in EPL
- **Float**: decimal numbers; beware of tiny floating-point rounding errors in comparisons
- **String**: ordered sequence of characters in double quotes; use `to_text()` to concatenate with numbers
- **Boolean**: only `true` or `false`; the output of all comparisons and conditions
- **Nothing**: the absence of a value; equivalent to Python's `None` / SQL's `NULL`
- Use `type_of()` to inspect any value's type at runtime — invaluable for debugging

✍️ CHAPTER 8 EXERCISES

1. What does EPL print for `Say 5 / 2`? Is it 2 or 2.5? Run it to find out. What type does division produce in EPL?
2. Write a program that asks the user to think of a number between 1 and 100. Store that number, then compute and display: its double, its square, its square root (hint: use `power(n, 0.5)`), and whether it is greater than 50.
3. What is the result of `type_of(to_text(42))`? Predict the answer before running it, then verify.
4. Try to concatenate a string and an integer without converting: `Say "Score: " + 95`. What error do you get? Fix it.
5. Research question: Why does `0.1 + 0.2 ≠ 0.3` evaluate to `true` in most programming languages? (Search for "floating point representation binary".) What does this imply about comparing floats for equality?

Part III — Language Fundamentals

CHAPTER 09

Operators & Expressions

> *Operators are the verbs of EPL — they act on values (operands) to produce new values. Understanding all of EPL's operators, their precedence, and how to combine them into complex expressions is essential to writing useful programs.*

9.1 What is an Expression?

An **expression** is any combination of values, variables, and operators that evaluates to a single value. The simplest expression is a literal value like `42` or `"hello"`. A slightly more complex expression is `x + 5`. A complex expression might be `(score * weight) / total_weight ⩾ pass_threshold`.

Expressions can appear anywhere a value is expected: on the right side of an assignment, as an argument to `Say`, as the condition of an `If`, as a function argument. The Interpreter always evaluates an expression to a single concrete value before using it.

9.2 Arithmetic Operators

OPERATOR	NAME	EXAMPLE	RESULT	NOTES
`+`	Addition	`10 + 3`	`13`	Also concatenates strings

`-`	Subtraction	`10 - 3`	`7`	
`*`	Multiplication	`10 * 3`	`30`	
`/`	Division	`10 / 3`	`3.333...`	Always returns float
`//`	Integer division	`10 // 3`	`3`	Discards remainder
`%`	Modulo (remainder)	`10 % 3`	`1`	Remainder after division
`**`	Exponentiation	`2 ** 8`	`256`	2 to the power of 8

The **modulo operator** (`%`) deserves special attention because beginners often overlook it. It computes the remainder after integer division. This makes it extremely useful for:

- **Checking even/odd**: `n % 2 == 0` is true if n is even
- **Cycling through values**: `counter % 7` cycles through 0, 1, 2, 3, 4, 5, 6, 0, 1, ... — useful for day-of-week calculations
- **Checking divisibility**: `n % k == 0` is true exactly when n is divisible by k

9.3 Comparison Operators

Comparison operators compare two values and always produce a boolean result (`true` or `false`). They are the foundation of all conditional logic in EPL.

EPL OPERATOR	ENGLISH ALIAS	MEANING	EXAMPLE

`==`	`is equal to`	Equal	`age == 18`
`≠`	`is not equal to`	Not equal	`name ≠ "Bob"`
`>`	`is greater than`	Greater than	`score > 90`
`<`	`is less than`	Less than	`price < 100`
`⩾`	`is greater than or equal to`	Greater or equal	`age ⩾ 18`
`⩽`	`is less than or equal to`	Less or equal	`marks ⩽ 40`

EPL supports both symbolic comparisons (`==` , `≠` , etc.) and natural English phrasing. You can write either `If age ⩾ 18 Then` or `If age is greater than or equal to 18 Then` — both are valid and produce identical code. The English forms are particularly useful in teaching contexts.

9.4 Logical Operators

Logical operators combine boolean values or expressions to produce new boolean values. They are the building blocks of compound conditions.

OPERATOR	MEANING	TRUE WHEN...	EXAMPLE
`and`	Logical AND	Both sides are true	`age ⩾ 18 and has_id == true`

`or`	Logical OR	At least one side is true	`is_member or has_coupon`
`not`	Logical NOT	The operand is false	`not is_banned`

EPL

```
age       = 20
has_ticket = true
is_vip    = false

can_enter = age ⩾ 18 and has_ticket
Say can_enter              Note: true

gets_discount = is_vip or age < 12
Say gets_discount          Note: false (neither condition is true)

must_verify = not has_ticket
Say must_verify            Note: false (they DO have a ticket)
```

9.5 Operator Precedence

When multiple operators appear in a single expression, EPL evaluates them in a fixed order called **operator precedence** . Higher-precedence operators are evaluated before lower-precedence ones — exactly as in mathematics.

PRECEDENCE	OPERATORS	ASSOCIATIVITY
Highest	`**` (exponentiation)	Right to left
	`not` (unary)	Right to left
	`* / // %`	Left to right

	`+ -`	Left to right
	`= ≠ < > ⩽ ⩾`	Left to right
	`and`	Left to right
Lowest	`or`	Left to right

When in doubt, use parentheses to make the intended order explicit. Parentheses always override precedence rules, and they also make the code much easier to read:

EPL

```
Note: Without parentheses — relies on precedence rules
result = 2 + 3 * 4     Note: 14, not 20 (multiplication first)

Note: With parentheses — explicit and clear
result = (2 + 3) * 4  Note: 20 (addition first)

Note: compound condition — parentheses make logic crystal clear
is_eligible = (age ⩾ 18 and has_id) or is_vip
```

CHAPTER 9 SUMMARY

- An expression is any combination of values, variables, and operators that evaluates to one value
- Arithmetic operators: `+`, `-`, `*`, `/`, `//`, `%`, `**` — remember that `/` always returns float
- The modulo operator (`%`) returns the remainder — essential for even/odd checks and cycling
- Comparison operators always return a boolean — both symbolic (`==`) and English forms (`is equal to`) are valid
- Logical operators (`and`, `or`, `not`) combine booleans into compound conditions
- Operator precedence determines evaluation order; use parentheses to override or clarify

✍️ CHAPTER 9 EXERCISES

1. Without running the code, predict the result of: `3 + 4 * 2 - 8 // 3`. Then verify by running it.
2. Write an expression that is true when a number n is divisible by both 3 and 5. Test it with n = 15, 9, 5, and 7.
3. A cinema gives discounts to people under 12 or over 65. Write a boolean expression that is true when a person qualifies for a discount.
4. What is the difference between `x = 5` (assignment) and `x == 5` (comparison)? Why do beginners often confuse them? When would writing `=` instead of `==` inside an `If` condition cause a bug?

Part III — Language Fundamentals

CHAPTER 10

Strings — The Art of Working with Text

> *Text processing is one of the most common tasks in programming. This chapter explores everything EPL can do with strings — from basic manipulation to searching, slicing, formatting, and validation.*

10.1 Strings as Sequences

A string in EPL is not simply a blob of text — it is an *ordered sequence of characters*, and this fact unlocks a powerful set of operations. Because a string has a specific length and each character has a specific position (called its **index**), you can do things like: extract the third character, check whether it starts with a capital letter, find all occurrences of a word, or reverse the entire string.

EPL uses **zero-based indexing** for strings. This means the first character is at index 0, the second at index 1, and so on. The last character is at index `length - 1`. While this may feel unnatural initially, it is the convention in virtually all programming languages (Python, JavaScript, Java, C++) and has important mathematical advantages.

EPL

```
word = "Programming"
Say word.length          Note: 11
Say word[0]              Note: "P" — first character (index 0)
```

```
Say word[1]              Note: "r"Say word[10]            Note: "g" —
last character (index 10)
```

10.2 String Methods Reference

EPL provides a comprehensive set of string methods. A **method** is a function that belongs to a specific type — you call it by writing the variable name, a dot, and the method name: `variable.method()`.

METHOD	RETURNS	EXAMPLE
`.upper()`	Uppercase copy	`"hello".upper()` → `"HELLO"`
`.lower()`	Lowercase copy	`"WORLD".lower()` → `"world"`
`.trim()`	Strip whitespace	`"  hi  ".trim()` → `"hi"`
`.contains(s)`	Boolean	`"apple".contains("app")` → `true`
`.starts_with(s)`	Boolean	`"hello".starts_with("he")` → `true`
`.ends_with(s)`	Boolean	`"test.epl".ends_with(".epl")` → `true`
`.replace(a, b)`	New string	`"cat".replace("c", "b")` → `"bat"`

`.split(sep)`	List	`"a,b,c".split(",")` → `["a","b","c"]`
`.slice(i, j)`	Substring	`"Hello".slice(1,3)` → `"el"`
`.index_of(s)`	Integer position	`"hello".index_of("ll")` → `2`
`.repeat(n)`	Repeated string	`"ab".repeat(3)` → `"ababab"`

10.3 String Interpolation

Concatenating strings with `+` works but becomes tedious when you have many variables to embed. EPL's **string interpolation** feature lets you embed variable values directly inside a string using the `$` prefix:

EPL

```
name   = "Alice"
score  = 94
grade  = "A"

Note: Without interpolation — verbose
Say "Student " + name + " scored " + to_text(score) + " — Grade: " +
grade

Note: With interpolation — clean and readable
Say "Student $name scored $score — Grade: $grade"

Note: Both produce: Student Alice scored 94 — Grade: A
```

10.4 Practical String Processing Example

Let us put these methods together in a real-world scenario: validating and formatting an email address entered by a user.

EPL email_validator.epl

```
email = "  Alice@Example.COM  "    Note: raw user input with spaces

Note: Step 1 — remove surrounding whitespace
email = email.trim()
Say email                          Note: "Alice@Example.COM"

Note: Step 2 — normalise to lowercase
email = email.lower()
Say email                          Note: "alice@example.com"

Note: Step 3 — basic format validation
If email.contains("@") and email.contains(".") then
    Say "Valid email: $email"
Otherwise
    Say "Invalid email format"
End

Note: Step 4 — extract the domain
at_position = email.index_of("@")
domain = email.slice(at_position + 1, email.length)
Say "Domain: $domain"             Note: "example.com"
```

CHAPTER 10 SUMMARY

- Strings are ordered sequences of characters; characters are accessed by zero-based index
- EPL provides rich string methods: `.upper()`, `.lower()`, `.trim()`, `.contains()`, `.split()`, `.slice()`, and more
- String interpolation with `$varname` is cleaner than concatenation with `+`
- Use `.trim()` and `.lower()` when processing user input to normalise case and remove whitespace
- String methods do not modify the original string — they return a new one (strings are immutable)

Part IV — Control Flow

CHAPTER 11

Conditions & Decision Making

> *Programs that do the same thing every time are not very useful. Conditions give programs the ability to make decisions — to choose different paths of execution based on the current state of data. This is where programming starts to feel like real intelligence.*

11.1 Why Conditions Are Fundamental

Every useful program makes decisions. An ATM decides whether your PIN matches before dispensing cash. A navigation app decides whether to reroute based on traffic. A game decides whether you have won based on your score. A spam filter decides whether an email belongs in your inbox.

In EPL, decisions are made with **conditional statements** — code that tests a condition (a boolean expression) and executes different blocks based on whether the condition is true or false. The most important conditional structure is the `If ... Then ... Otherwise ... End` statement.

11.2 The If Statement

The simplest form of a conditional executes a block of code only if a condition is true. If the condition is false, the block is skipped entirely.

EPL

```
temperature = 38

If temperature > 37.5 then
```

```
Say"Please rest and drink fluids."EndSay"Temperature check
complete."Note: always runs
```

🔎 **ANATOMY OF AN IF STATEMENT**

`If` — begins the conditional statement

`temperature > 37.5` — the *condition*: a boolean expression evaluated at runtime

`Then` — signals the start of the block to execute if the condition is true

(indented lines) — the *body*: one or more statements executed only if condition is true

`End` — closes the conditional block. Without this, EPL does not know where the block ends.

11.3 If–Otherwise (If–Else)

The `Otherwise` clause provides an alternative block that runs when the condition is false. Exactly one of the two blocks always executes — never both, never neither.

EPL

```
score = 72
pass_mark = 75

If score ⩾ pass_mark then
    Say "Congratulations — you passed!"
    Say "Your score: $score"
Otherwise
    Say "You did not pass this time."
    gap = pass_mark - score
    Say "You needed $gap more marks."
End
```

11.4 If–Otherwise If–Otherwise (If–Elif–Else Chains)

When you have more than two possible outcomes, you can chain multiple conditions using `Otherwise If`. EPL checks each condition in order from top to bottom, executes the first block whose condition is true, and skips all the rest. If no condition is true, the final `Otherwise` block runs.

EPL grade_calculator.epl

```
score = 83

If score ⩾ 90 then
    grade = "A"
    label = "Excellent"
Otherwise If score ⩾ 80 then
    grade = "B"
    label = "Good"
Otherwise If score ⩾ 70 then
    grade = "C"
    label = "Average"
Otherwise If score ⩾ 60 then
    grade = "D"
    label = "Below Average"
Otherwise
    grade = "F"
    label = "Fail"
End

Say "Grade: $grade — $label"
Note: Output: Grade: B — Good
```

For a score of 83, EPL tests each condition in sequence: Is 83 ≥ 90? No. Is 83 ≥ 80? Yes. The second block executes and all remaining conditions are skipped — EPL does not even bother testing them once a match is found.

11.5 Nested Conditions

You can place an `If` statement inside another `If` statement. This is called **nesting**. Use it when a second decision only makes sense after the first has been evaluated:

EPL

```
age = 20
has_id = true

If age ⩾ 18 then
    If has_id == true then
        Say "Entry granted."
    Otherwise
        Say "Age OK but ID required."
    End
Otherwise
    Say "Must be 18 or older to enter."
End
```

💡 **AVOID DEEP NESTING**

Nesting more than 2–3 levels deep makes code very hard to read. If you find yourself nesting deeply, consider: can the inner conditions be combined with `and` / `or`? Can the logic be extracted into a separate function? Flat, readable code is almost always better than deeply nested code.

CHAPTER 11 SUMMARY

- `If condition Then ... End` — executes the body only when the condition is true
- `If condition Then ... Otherwise ... End` — executes one of two paths
- `Otherwise If` — chains multiple conditions; only the first matching block runs
- EPL evaluates conditions in order from top to bottom — order matters in chains
- Nesting If statements is valid but avoid going deeper than 2–3 levels
- Always close with `End` — a missing `End` is one of the most common beginner errors

✍️ CHAPTER 11 EXERCISES

1. Write a program that takes a month number (1–12) and prints the season: 12/1/2 → Winter, 3/4/5 → Spring, 6/7/8 → Summer, 9/10/11 → Autumn.
2. A bank gives interest rates: balance < 1000 → 2%, balance < 10000 → 3.5%, balance < 100000 → 4.5%, else → 5%. Write a program that takes a balance and prints the applicable interest rate and annual interest earned.
3. Write a BMI calculator: take height (metres) and weight (kg), compute BMI = weight / (height * height), and classify: <18.5 Underweight, 18.5–24.9 Normal, 25–29.9 Overweight, ≥30 Obese.
4. Write a simple login system: define a correct username and password, then check user inputs against them. Handle four cases: both correct, wrong username only, wrong password only, both wrong.

Part IV — Control Flow

CHAPTER 12

Loops & Iteration

> *A loop is a control structure that repeats a block of code multiple times. Without loops, you would need to write the same statement hundreds of times for repetitive tasks. Loops are one of the most powerful and frequently used features in any programming language.*

12.1 Why Loops Exist

Imagine you want to print the numbers 1 through 100. Without loops, you would write 100 `Say` statements. With loops, three lines suffice. More importantly, loops let you process data structures of unknown size — you do not know in advance how many items are in a list, how many lines are in a file, or how many records are in a database. Loops handle all of these cases gracefully.

EPL provides four loop constructs, each designed for a specific use case. Choosing the right loop type produces cleaner, more readable, more maintainable code.

12.2 The Repeat Loop — Count-Based Repetition

The `Repeat N times` loop is EPL's simplest loop: it executes its body exactly N times. Use it when you know the exact number of repetitions needed and do not need a counter variable.

EPL

```
Note: Print a separator line 50 times
Repeat 50 times
    Say "-"
End
```

```
balance  = 1000
monthly_rate = 0.005Note: 0.5% per monthRepeat12timesIncrease balance
by balance * monthly_rate
EndSay"Balance after 1 year: $balance"Note: Output: Balance after 1
year: 1061.677...
```

12.3 The While Loop — Condition-Based Repetition

The `While` loop keeps repeating as long as a condition remains true. It is perfect when you do not know in advance how many repetitions will be needed — you only know when to stop.

EPL

```
Note: Collatz conjecture — count steps to reach 1
n = 27
steps = 0

While n ≠ 1
    If n % 2 == 0 then
        n = n / 2
    Otherwise
        n = n * 3 + 1
    End
    Increase steps by 1
End

Say "Reached 1 in $steps steps"
Note: Output: Reached 1 in 111 steps
```

⚠ INFINITE LOOPS

If a While loop's condition never becomes false, the loop runs forever — an *infinite loop*. Common causes: forgetting to update the variable that the condition checks, using the wrong comparison operator, or a logic error in the update step. If your program hangs and produces no output, an infinite loop is the most likely culprit. Press Ctrl+C in the terminal to stop it.

12.4 The For Loop — Range-Based Counting

The `For` loop (with a numeric range) is ideal when you need a counter variable that changes with each iteration, and you know the start and end values.

EPL

```
Note: Print multiplication table for 7
For i from 1 to 10
    product = 7 * i
    Say "7 x $i = $product"
End

Note: Sum of integers 1 through 100 (should be 5050)
total = 0
For n from 1 to 100
    Increase total by n
End
Say total    Note: 5050
```

12.5 The For-Each Loop — Iterating Collections

The `For each` loop is the most elegant loop in EPL. It iterates over every item in a collection (a list, a string, a map's keys) without you needing to manage an index. The loop variable takes on the value of each item in turn.

EPL

```
fruits = ["apple", "banana", "cherry", "date"]

For each fruit in fruits
    Say "I like $fruit"
End

Note: Calculate total price of items
prices = [29.99, 14.50, 5.00, 79.95]
total  = 0

For each price in prices
    Increase total by price
End

Say "Total: $total"    Note: 129.44
```

12.6 Loop Control: Break and Continue

`Break` immediately exits the loop entirely — no more iterations, execution continues after `End`. `Continue` skips the rest of the current iteration and jumps to the next one.

EPL

```
Note: Find the first number divisible by 7 between 1 and 100
For i from 1 to 100
    If i % 7 == 0 then
        Say "First multiple of 7: $i"
        Break          Note: exit loop immediately
    End
End
```

```
Note: Print only odd numbers using ContinueFor i from1to10If i %
2==0thenContinueNote: skip even numbersEndSay i
EndNote: Prints 1 3 5 7 9
```

CHAPTER 12 SUMMARY

- `Repeat N times` — simplest loop; use when you know the exact count and don't need a counter variable
- `While condition` — runs as long as condition is true; use when the number of repetitions is unknown
- `For i from A to B` — count-based with an accessible counter variable
- `For each item in collection` — iterate over every element; the cleanest loop for lists and strings
- `Break` exits the loop immediately; `Continue` skips the rest of the current iteration
- Always ensure While loops have a reachable exit condition to avoid infinite loops

✍️ CHAPTER 12 EXERCISES

1. Write a program that prints all prime numbers between 2 and 100. (A prime has no divisors other than 1 and itself — use a nested loop to test each candidate.)
2. Write a times table printer: for each number from 2 to 12, print its complete multiplication table (1×n through 12×n).
3. Implement a number guessing game: EPL picks a secret number (use `random_integer(1, 100)`), the user guesses in a While loop, and EPL says "higher", "lower", or "correct!" accordingly.
4. Write a program using `For each` that takes a list of student names and scores, and prints a formatted report. Identify the highest and lowest scorers.
5. Explain the difference between `Break` and `Continue`. Could every use of `Continue` be rewritten using only `If` statements? (Try it.)

Part IV — Control Flow

CHAPTER 13

Functions — Defining, Calling & Advanced Patterns

> *Functions are the single most important tool for managing complexity in programming. They allow you to name a piece of logic, reuse it from multiple places, and reason about it in isolation. This chapter covers everything about functions in EPL — from the basics to closures and higher-order functions.*

13.1 Why Functions Are Essential

Consider a program that calculates the area of circles. Without functions, every time you need the area of a circle you copy-paste the formula `3.14159 * radius * radius`. If you later discover you used the wrong value of π, you must find and fix every copy. With a function, you write the formula once and call it by name everywhere you need it. One fix — everywhere corrected.

This is called the **DRY principle** : *Don't Repeat Yourself*. Functions are the primary tool for DRY programming. Beyond avoiding repetition, functions serve two other crucial purposes: they *name* a concept (giving a meaningful label to a piece of logic makes code self-documenting) and they *hide complexity* (the caller does not need to know how a function works, only what it does).

13.2 Defining a Function

EPL

```
Function greet takes name
    message = "Hello, $name! Welcome to EPL."
    Say message
```

```
Note: Calling the function
greet("Alice")      Note: Hello, Alice! Welcome to EPL.
greet("Bob")        Note: Hello, Bob! Welcome to EPL.
greet("Charlie")    Note: Hello, Charlie! Welcome to EPL.
```

ANATOMY OF A FUNCTION DEFINITION

`Define Function` — signals to EPL that this is a function definition
`greet` — the function's name; follow the same naming rules as variables
`takes name` — declares one parameter named `name`; multiple parameters: `takes a, b, c`
indented body — the statements to execute when the function is called
`End` — closes the function definition

IMPORTANT

: Defining a function does NOT execute it. The body only runs when the function is *called*.

13.3 Parameters and Arguments

A **parameter** is the placeholder name in the function definition. An **argument** is the actual value passed when calling the function. They are different things even though people often use the terms interchangeably.

EPL

```
Note: Function with multiple parameters
Function calculate_area takes length, width
    area = length * width
    Say "Area: $area square units"
End

calculate_area(5, 3)     Note: length=5, width=3, Area: 15 square units
calculate_area(10, 7)    Note: length=10, width=7, Area: 70 square units
```

```
calculate_area(5, 3)     Note: length=5, width=3, Area: 15 square units
calculate_area(10, 7)   Note: length=10, width=7, Area: 70 square units
calculate_area(2.5, 4) Note: length=2.5, width=4, Area: 10.0 square
units
```

13.4 Return Values

Functions that only print output are limited. Far more useful are functions that *compute a value and return it* to the caller. The caller can then use that value in expressions, assign it to variables, or pass it to other functions.

EPL

```
Function circle_area takes radius
    pi = 3.14159265
    Return pi * radius * radius
End

Function circle_circumference takes radius
    pi = 3.14159265
    Return 2 * pi * radius
End

Note: Using return values in expressions
r = 7
area = circle_area(r)
circ = circle_circumference(r)

Say "Circle with radius $r:"
Say "  Area:          $area"
Say "  Circumference: $circ"
Say "  Ratio (C/A):   " + to_text(circ / area)
```

13.5 Default Parameter Values

EPL allows function parameters to have default values. When a caller does not provide an argument for a parameter that has a default, the default is used automatically. This makes functions more flexible without requiring callers to specify every detail every time.

EPL

```
Function power takes base, exponent = 2
    Return base ** exponent
End

Say power(5)         Note: 25 (5 squared — uses default exponent=2)
Say power(5, 3)      Note: 125 (5 cubed — overrides default)
Say power(2, 10)     Note: 1024 (2 to the power of 10)
```

13.6 Recursive Functions

A **recursive function** is one that calls itself. Every recursive solution has two essential parts: a *base case* (a condition where the function does NOT call itself) and a *recursive case* (where it calls itself with a simpler input). Without a base case, recursion yields an infinite loop equivalent — a stack overflow.

EPL

```
Note: Factorial — n! = n × (n-1) × (n-2) × ... × 1
Function factorial takes n
    If n == 0 or n == 1 then
        Return 1        Note: base case
    End
    Return n * factorial(n - 1)   Note: recursive case
End
```

```
Say factorial(5)    Note: 120  (5×4×3×2×1)Say factorial(10)   Note:
3628800
```

CHAPTER 13 SUMMARY

- Functions implement the DRY principle: write logic once, call it from many places
- `Define Function name takes param1, param2 ... End` — defines a function
- Parameters are placeholders; arguments are the actual values provided at call time
- `Return value` sends a result back to the caller — without `Return`, the function returns `nothing`
- Default parameter values make functions more flexible: `takes x, y = 10`
- Recursive functions call themselves; they require a base case to terminate

✍️ CHAPTER 13 EXERCISES

1. Write a function `is_prime(n)` that returns `true` if n is prime and `false` otherwise. Test it for n = 1, 2, 17, 25, 97.
2. Write a function `celsius_to_fahrenheit(c)` and another `fahrenheit_to_celsius(f)`. Verify they are inverses: `c_to_f(f_to_c(100))` should return 100.
3. Write a recursive function `fibonacci(n)` that returns the nth Fibonacci number (0, 1, 1, 2, 3, 5, 8, ...). Then rewrite it iteratively using a loop. Which is easier to understand? Which is faster?
4. Write a function `count_words(sentence)` that returns the number of words in a string. Then write `count_vowels(word)` that counts vowels. Combine them to find the average vowels per word in a sentence.

Part IV — Control Flow

CHAPTER 14

Error Handling — Writing Robust Programs

> *Errors are inevitable in real programs. Files do not exist. Users enter invalid data. Networks fail. Databases lock. Robust programs anticipate these failures and handle them gracefully — instead of crashing, they report the problem and continue working. This chapter teaches you how.*

14.1 Types of Errors in EPL

There are three fundamental categories of errors that can occur in any programming language, and EPL is no exception:

A **syntax error** occurs when the Lexer or Parser cannot understand your code because it violates EPL's grammar. These are caught immediately — before your program runs at all. They are the easiest errors to fix because EPL always tells you the exact line and what is missing or unexpected.

A **runtime error** (also called an *exception*) occurs while the program is running, when it encounters a situation it cannot handle: dividing by zero, accessing a non-existent variable, calling a method on `nothing`, or trying to open a file that does not exist. Without error handling, runtime errors crash the program immediately and display a raw error message to the user — a very poor experience.

A **logic error** is the most subtle: the program runs without crashing but produces incorrect results. Your code is syntactically valid and executes without exceptions — it is simply doing the wrong thing. Logic errors require careful reasoning, test cases, and debugging to find and fix.

14.2 Try–Catch: The Core Error Handling Pattern

EPL handles runtime errors using the `Try...Catch...End` construct. The code inside the `Try` block runs normally. If an error occurs anywhere in the `Try` block, execution immediately jumps to the `Catch` block. The variable after `Catch` captures the error message as a string.

EPL safe_divide.epl

```
Function safe_divide takes a, b
    Try
        result = a / b
        Say "$a ÷ $b = $result"
    Catch error
        Say "Cannot divide: $error"
    End
End

safe_divide(10, 2)   Note: 10 ÷ 2 = 5.0
safe_divide(10, 0)   Note: Cannot divide: division by zero
safe_divide(7, 3)    Note: 7 ÷ 3 = 2.333...
```

14.3 Raising Your Own Errors

You can intentionally signal an error using the `Raise` keyword. This is useful when a function receives arguments that violate its assumptions — rather than silently producing garbage output, it should loudly announce the problem.

EPL

```
Function square_root takes n
    If n < 0 then
        Raise "Cannot take square root of a negative number: $n"
    End
    Return n ** 0.5
End
```

```
Say square_root(25)      Note: 5.0Say square_root(-4)      Note:
triggers the RaiseCatch err
    Say"Error caught: $err"End
```

14.4 Real-World Error Handling: File Operations

File I/O is one of the most common sources of runtime errors: files may be missing, permissions may be denied, the disk may be full, or the format may be unexpected. Always wrap file operations in `Try...Catch`:

EPL

```
Try
    content = read_file("data.txt")
    Say "File read successfully"
    Say content
Catch file_error
    Say "Could not read file: $file_error"
    Say "Please check the file exists and you have permission."
End
```

> 💡 **THE GOLDEN RULE OF ERROR HANDLING**
>
> Only catch errors you can actually *handle*. A catch block that silently swallows an error — showing nothing to the user — is often worse than letting the program crash, because at least a crash is visible and debuggable. A good catch block: (1) logs what went wrong, (2) tells the user something useful, and (3) either recovers gracefully or exits cleanly.

CHAPTER 14 SUMMARY

- Three error types: syntax (caught before run), runtime (caught during run), logic (wrong output, no crash)
- `Try...Catch error...End` wraps code that might fail; the Catch block runs only if an error occurs
- `Raise "message"` intentionally triggers an error — use to enforce function preconditions
- Always wrap file, database, and network operations in Try–Catch
- A catch block should inform the user and recover gracefully — never silently swallow errors

✍️ CHAPTER 14 EXERCISES

1. Write a `safe_parse_integer(text)` function that tries to convert a string to an integer using `to_integer()`, and returns `nothing` (with a warning message) if the conversion fails.
2. Write a program that reads a list of filenames and attempts to read each one. For each file: if it succeeds, print the first 50 characters; if it fails, print the filename and the specific error.
3. What is the difference between these two approaches? When would you choose each?
   Approach A: wrap the entire program in one big Try–Catch
   Approach B: wrap each risky operation in its own Try–Catch
4. Write a function `validate_age(age_text)` that: converts the string to integer (raising an error if not a number), checks it is between 0 and 150 (raising an error if not), and returns the valid age. Test it with "25", "abc", "-5", "200".

Part V — Data Structures

CHAPTER 15

Lists — Ordered Collections

> *A list is an ordered collection of values. It is the most fundamental data structure in programming — used everywhere from storing a shopping cart to representing the pixels of an image. This chapter explains how lists work and the full set of operations EPL provides for them.*

15.1 What is a List and Why Do We Need One?

Suppose you want to store the scores of ten students. Without lists, you need ten separate variables: `score1`, `score2`, ..., `score10`. To find the maximum, you write ten comparisons. To print all scores, ten `Say` statements. Now imagine a thousand students. Ten thousand. The approach fails completely.

A **list** solves this by grouping multiple values under a single name. Instead of ten variables, you have one: `scores = [78, 92, 65, 88, 94, 71, 83, 79, 96, 87]`. A single loop processes all ten — or all ten thousand. The power of lists comes from two properties: they are *ordered* (elements stay in the order you put them) and they are *mutable* (you can add, remove, or change elements after creation).

15.2 Creating Lists

In EPL, a list literal is written with square brackets, with items separated by commas. Lists can hold any mix of types — strings, numbers, booleans, even other lists.

```epl
empty     = []                          Note: empty list — zero elements
numbers   = [1, 2, 3, 4, 5]
names     = ["Alice", "Bob", "Charlie"]
mixed     = [42, "hello", true, 3.14]   Note: mixed types are fine
nested    = [[1,2], [3,4], [5,6]]       Note: list of lists (2D grid)

Say numbers.length     Note: 5
Say names.length       Note: 3
```

15.3 Accessing Elements by Index

Every element in a list has an index — a zero-based position number. The first element is at index 0, the second at index 1, and so on. Use square bracket notation to access elements by index.

```epl
colours = ["red", "green", "blue", "yellow"]

Say colours[0]     Note: "red"   — first element
Say colours[1]     Note: "green"
Say colours[3]     Note: "yellow" — fourth element

colours[2] = "purple"    Note: replace "blue" with "purple"
Say colours              Note: ["red", "green", "purple", "yellow"]
```

15.4 List Methods — The Complete Reference

METHOD	DESCRIPTION	EXAMPLE

`.add(item)`	Append item to end	`nums.add(99)`
`.insert(i, item)`	Insert at position i	`nums.insert(0, 10)`
`.remove(item)`	Remove first occurrence	`nums.remove(5)`
`.remove_at(i)`	Remove element at index i	`nums.remove_at(2)`
`.contains(item)`	Returns boolean	`nums.contains(42)`
`.index_of(item)`	First index of item (or -1)	`nums.index_of(7)`
`.sort()`	Sort in ascending order	`nums.sort()`
`.reverse()`	Reverse order in place	`nums.reverse()`
`.slice(i, j)`	Sub-list from index i to j	`nums.slice(1, 4)`
`.join(sep)`	Concatenate as string	`words.join(", ")`
`.clear()`	Remove all elements	`nums.clear()`

15.5 Working with Lists — Practical Patterns

EPL list_patterns.epl

```
scores = [78, 92, 65, 88, 94, 71, 83]

Note: Pattern 1 — find max and min
highest = scores[0]
lowest  = scores[0]
For each s in scores
```

```
    If s > highest then
        highest = s
    EndIf s < lowest then
        lowest = s
    EndEndSay"Highest: $highest, Lowest: $lowest"Note: Pattern 2 —
compute average
total = 0For each s in scores
    Increase total by s
End
average = total / scores.length
Say"Average: $average"Note: Pattern 3 — filter to a new list
passing = []
For each s in scores
    If s ⩾75then
        passing.add(s)
    EndEndSay"Passing scores: $passing"
```

15.6 Map, Filter, Reduce — Functional List Processing

EPL supports functional-style list processing using three higher-order operations. These express transformations on lists as single readable expressions rather than verbose loops.

EPL

```
prices = [100, 250, 75, 320, 50]

Note: map — transform every element (apply 18% tax)
with_tax = map(prices, lambda p: p * 1.18)
Say with_tax     Note: [118.0, 295.0, 88.5, 377.6, 59.0]

Note: filter — keep only elements matching a condition
expensive = filter(prices, lambda p: p > 100)
Say expensive   Note: [250, 320]

Note: reduce — combine all elements into one value (sum)
total = reduce(prices, lambda acc, p: acc + p, 0)
Say total        Note: 795
```

CHAPTER 15 SUMMARY

- A list stores an ordered, mutable collection of values under a single name
- Elements are accessed by zero-based index: `list[0]` is the first element
- Key methods: `.add()`, `.remove()`, `.sort()`, `.contains()`, `.slice()`, `.join()`
- Common patterns: find max/min, compute average, filter to new list using `For each`
- Functional operations — `map()`, `filter()`, `reduce()` — are concise alternatives to loops

✍️ CHAPTER 15 EXERCISES

1. Create a list of the first 20 Fibonacci numbers using a loop. Then print only those that are even.
2. Write a function `deduplicate(lst)` that returns a new list with duplicates removed, preserving original order.
3. Write a function `flatten(nested)` that takes a list of lists and returns a single flat list: `[[1,2],[3,4],[5]]` → `[1,2,3,4,5]`.
4. Implement a basic stack (last-in-first-out) using a list: write `push(stack, item)`, `pop(stack)`, and `peek(stack)` functions.

Part V — Data Structures

CHAPTER 16

Maps — Key-Value Data Structures

> *A map (also called a dictionary, hash map, or associative array) stores data as key-value pairs. Instead of accessing values by numeric index, you access them by a meaningful key. Maps are the most versatile and widely used data structure in real-world programming.*

16.1 What is a Map?

A list is like a numbered sequence of boxes. A **map** is like a cabinet with labelled drawers. Each drawer (value) has a unique label (key). To get a value, you provide its label — not a number. This makes maps ideal for any data with a natural identifier: a student's record keyed by student ID, a word's definition keyed by the word, a country's population keyed by country name.

Maps are implemented internally using a *hash table* — a data structure that computes a numeric hash from the key and uses it to locate values in O(1) time, meaning lookup is nearly instantaneous regardless of how many entries the map contains.

16.2 Creating and Using Maps

EPL

```
student = {
    "name"  : "Alice",
    "age"   : 21,
    "gpa"   : 3.85,
    "major" : "Computer Science"
```

```
Say student["name"]     Note: "Alice"Say student["gpa"]      Note: 3.85

student["gpa"] = 3.92Note: update an existing key
student["year"] = 3Note: add a new keySay student.keys()     Note:
["name", "age", "gpa", "major", "year"]Say student.values()   Note:
["Alice", 21, 3.92, "Computer Science", 3]Say student.length     Note:
5 (number of key-value pairs)
```

16.3 Map Methods

METHOD / OPERATION	DESCRIPTION
`map[key]`	Get value for key (KeyError if missing)
`map[key] = value`	Set or update key-value pair
`map.get(key, default)`	Get value; return default if key missing
`map.has(key)`	Returns boolean — does key exist?
`map.remove(key)`	Delete a key-value pair
`map.keys()`	Returns list of all keys
`map.values()`	Returns list of all values
`map.entries()`	Returns list of [key, value] pairs
`map.length`	Number of key-value pairs

16.4 Iterating Over Maps

```epl
inventory = {"apple": 50, "banana": 30, "cherry": 120, "date": 15}

Note: Iterate over keys
For each fruit in inventory.keys()
    count = inventory[fruit]
    Say "$fruit: $count units in stock"
End

Note: Find items below reorder threshold
low_stock = []
For each item in inventory.keys()
    If inventory[item] < 25 then
        low_stock.add(item)
    End
End
Say "Reorder needed: $low_stock"
Note: Reorder needed: ["banana", "date"]
```

16.5 Maps as Records: Modelling Real Data

Maps are ideal for representing real-world entities with named attributes — the kind of structured data you would find in a database or JSON file. You can have lists of maps, and maps containing lists.

```epl
students = [
    {"name": "Alice", "score": 94, "passed": true},
    {"name": "Bob",   "score": 67, "passed": false},
    {"name": "Carol", "score": 88, "passed": true}
]

Note: Print a formatted report
Say "=== Student Report ==="
For each s in students
```

```
If s["passed"] ==falsethen
        status = "FAIL"EndSay"$s[name]  |  Score: $s[score]  |
$status"End
```

CHAPTER 16 SUMMARY

- A map stores key-value pairs; access values by key, not by numeric index
- Map literals use curly braces: `{"key": value, ...}`
- Use `map.get(key, default)` to safely access potentially missing keys
- Use `map.has(key)` before accessing keys when their existence is uncertain
- Lists of maps model database-style records — the most common pattern in real applications
- Maps use hash tables internally — lookup is O(1) regardless of map size

✍️ CHAPTER 16 EXERCISES

1. Write a word frequency counter: given a sentence, produce a map where each key is a word and each value is the number of times it appears.
2. Design a simple phone book: a map from name to phone number. Implement `add_contact`, `lookup`, `delete_contact`, and `list_all` functions.
3. Write a function `invert_map(m)` that swaps keys and values: `{"a": 1, "b": 2}` → `{1: "a", 2: "b"}`. What happens if two keys have the same value?
4. Model a simple shopping cart as a map from product name to quantity. Implement add, remove, and get_total functions (assuming you also have a price map).

Part VI — Advanced EPL

CHAPTER 17

Object-Oriented Programming — Classes & Objects

> *Object-Oriented Programming (OOP) organises code around objects — entities that bundle related data (fields) and behaviour (methods) together. It is the dominant programming paradigm in software engineering, used by Python, Java, C++, JavaScript, and EPL alike.*

17.1 The Motivation for OOP

Imagine modelling a library system. Without OOP, you have scattered maps and lists: a `book_titles` list, a `book_authors` map, a `book_available` map — all separate, all requiring careful synchronisation. With OOP, a `Book` object has a title, an author, and an available flag in one place. A `Library` object manages a collection of `Book` objects and knows how to lend and return them.

OOP has four defining principles: **Encapsulation** (bundling data and behaviour together), **Abstraction** (hiding implementation details), **Inheritance** (new classes building on existing ones), and **Polymorphism** (different objects responding to the same method call in their own way). EPL supports all four.

17.2 Defining a Class

EPL bank_account.epl

```
Class BankAccount
    field owner   = ""
    field balance = 0
```

```
Functionsetuptakes owner_name, opening_balance
        self.owner   = owner_name
        self.balance = opening_balance
    EndFunctiondeposittakes amount
        If amount ⩽0thenRaise"Deposit amount must be
positive"EndIncrease self.balance by amount
        Say"Deposited $amount. New balance:
$self.balance"EndFunctionwithdrawtakes amount
        If amount > self.balance thenRaise"Insufficient
funds"EndDecrease self.balance by amount
        Say"Withdrawn $amount. New balance:
$self.balance"EndFunctionget_balanceReturn self.balance
    EndFunctionto_stringReturn"Account[$self.owner]: ₹
$self.balance"EndEndNote: Creating objects (instances)
alice_acc = BankAccount()
alice_acc.setup("Alice", 5000)

alice_acc.deposit(2000)     Note: Deposited 2000. New balance: 7000
alice_acc.withdraw(500)     Note: Withdrawn 500. New balance: 6500Say
alice_acc.to_string()    Note: Account[Alice]: ₹6500
```

17.3 Understanding self

The keyword `self` inside a method always refers to the *current object* — the specific instance on which the method was called. It is how methods know which object's data to read and modify. When you call `alice_acc.deposit(2000)`, EPL calls the `deposit` method with `self` bound to `alice_acc`. If you also had a `bob_acc` object and called `bob_acc.deposit(500)`, `self` would be bound to `bob_acc` — the correct account would be updated each time.

17.4 Inheritance

Inheritance lets a new class (the *child* or *subclass*) automatically gain all the fields and methods of an existing class (the *parent* or *superclass*), while adding or overriding specific behaviour.

EPL

```
Note: SavingsAccount inherits from BankAccount
Class SavingsAccount extends BankAccount
    field interest_rate = 0.05

    Function apply_interest
        interest = self.balance * self.interest_rate
        Increase self.balance by interest
        Say "Interest applied: $interest"
    End
End

savings = SavingsAccount()
savings.setup("Bob", 10000)  Note: inherited from BankAccount
savings.deposit(5000)        Note: inherited from BankAccount
savings.apply_interest()      Note: new method on SavingsAccount
Say savings.to_string()      Note: Account[Bob]: ₹15750.0
```

CHAPTER 17 SUMMARY

- OOP bundles data (fields) and behaviour (methods) into *classes*; individual objects are *instances*
- `Define Class Name ... End` defines a class; `Create ClassName` creates an instance
- `self` refers to the current instance inside any method
- Use the `setup` method as EPL's constructor — called manually after `Create`
- `extends ParentClass` inherits all fields and methods from the parent
- Inheritance promotes code reuse; child classes can add new features without modifying the parent

✍️ CHAPTER 17 EXERCISES

1. Design a `Vehicle` class with fields `make`, `model`, `speed` and methods `accelerate(amount)`, `brake(amount)`, `to_string()`. Then create `Car` and `Truck` subclasses with additional fields/methods.
2. Build a `Stack` class backed by a list with `push()`, `pop()`, `peek()`, `is_empty()`, and `size()` methods.
3. Create a `Student` class with name, subject scores stored in a map, and methods `add_score(subject, score)`, `get_average()`, `get_grade()`.
4. What is the difference between a field and a local variable inside a method? Write code that demonstrates each, and explain what happens to each when the method returns.

Part VI — Advanced EPL

CHAPTER 18

Lambdas & Functional Programming

> *A lambda is an anonymous (nameless) function defined inline. Functional programming is the style of expressing computations as transformations of data rather than sequences of instructions. Together, they enable concise, expressive, and highly reusable code.*

18.1 What is a Lambda?

Named functions declared with `Define Function` are ideal when a piece of logic is used in multiple places or is complex enough to deserve a name. But sometimes you need a tiny, one-time function — for example, to tell `sort()` how to compare elements, or to define the transformation in a `map()` call. Writing a full function definition for these one-off operations is verbose. **Lambda expressions** — also called anonymous functions — solve this with a compact inline syntax.

18.2 Lambda Syntax

EPL

```
Note: A named function
Function double takes x
    Return x * 2
End

Note: The equivalent lambda
double_fn = lambda x: x * 2

Note: Both work identically
```

```
Say double(5)        Note: 10Say double_fn(5)    Note: 10Note: Multi-
parameter lambda
add = lambda a, b: a + b
Say add(3, 4)        Note: 7
```

18.3 Lambdas with Map, Filter, Sort

EPL

```
students = [
    {"name": "Alice", "score": 88},
    {"name": "Bob",   "score": 72},
    {"name": "Carol", "score": 95},
    {"name": "Dave",  "score": 61}
]

Note: map — extract just the names
names = map(students, lambda s: s["name"])
Say names          Note: ["Alice", "Bob", "Carol", "Dave"]

Note: filter — keep only passing students (score ⩾ 75)
passing = filter(students, lambda s: s["score"] ⩾ 75)
Say map(passing, lambda s: s["name"])
Note: ["Alice", "Carol"]

Note: sort by score descending
ranked = sort_by(students, lambda s: -s["score"])
For each s in ranked
    Say "$s[name]: $s[score]"
End
```

18.4 Functions as Values

In EPL (and in Python, JavaScript, and all functional languages), functions are **first-class values**: they can be assigned to variables, passed as arguments, and returned from other functions. This enables powerful patterns like function composition and strategy patterns.

EPL

```
Note: A function that takes another function as argument
Function apply_twice takes fn, value
    Return fn(fn(value))
End

Say apply_twice(lambda x: x * 2, 3)   Note: 12 (3→6→12)
Say apply_twice(lambda x: x + 10, 5) Note: 25 (5→15→25)
```

CHAPTER 18 SUMMARY

- Lambdas are anonymous functions: `Lambda params → expression`
- Use lambdas for short, one-time operations (sorting criteria, map/filter transforms)
- Functions are first-class values in EPL — assign, pass, and return them like any other value
- `map(list, fn)`, `filter(list, fn)`, `reduce(list, fn, init)` are functional alternatives to loops
- Chaining map and filter together produces clean data pipelines

Part VI — Advanced EPL

CHAPTER 19

File I/O — Reading & Writing Files

> *Most real programs need to persist data beyond a single run — saving results, reading configuration, processing CSV files, logging events. EPL provides a clean, English-readable API for all common file operations.*

19.1 How File I/O Works

When your program reads or writes a file, it interacts with the operating system's file system. The OS manages physical disk access; your program simply requests operations. This involves three steps: *opening* the file (establishing a connection), *reading or writing* data, and *closing* the file (releasing the connection). EPL's built-in functions handle all three automatically — you rarely need to think about opening and closing explicitly.

File paths can be *absolute* (the complete path from the drive root, e.g., `"C:/Users/alice/data.txt"`) or *relative* (relative to where your EPL script is running, e.g., `"data/input.txt"`). Relative paths are generally preferred because they work on any machine regardless of where the project is installed.

19.2 Reading Files

EPL file_reading.epl

```
Note: Read the entire file as one string
Try
    content = read_file("notes.txt")
    Say content
Catch e
    Say "Error reading file: $e"
```

```
EndNote: Read file as a list of linesTry
    lines = read_lines("notes.txt")
    Say"Total lines: $lines.length"For each line in lines
        Say line
    EndCatch e
    Say"Error: $e"End
```

19.3 Writing Files

EPL

```
Note: Write a string to a file (overwrites if exists)
Try
    write_file("output.txt", "Hello from EPL!\nSecond line.")
    Say "File written successfully"
Catch e
    Say "Write failed: $e"
End

Note: Append to an existing file (adds without overwriting)
append_file("log.txt", "[2025-01-01] Operation completed\n")

Note: Check if a file exists before reading
If file_exists("config.txt") then
    config = read_file("config.txt")
    Say config
Otherwise
    Say "No config file found — using defaults"
End
```

19.4 Processing CSV Data

CSV (Comma-Separated Values) is one of the most common data formats. EPL can parse CSV files into lists of maps, making it easy to process tabular data.

EPL csv_processor.epl

```
Note: Assume students.csv has header: name,score,grade
lines = read_lines("students.csv")
header = lines[0].split(",")   Note: ["name", "score", "grade"]
records = []

For i from 1 to lines.length - 1
    values = lines[i].split(",")
    row = {
        "name"  : values[0],
        "score" : to_integer(values[1]),
        "grade" : values[2]
    }
    records.add(row)
End

Note: Print all A-grade students
For each r in records
    If r["grade"] == "A" then
        Say "Top student: $r[name] ($r[score])"
    End
End
```

CHAPTER 19 SUMMARY

- `read_file(path)` returns entire file as one string; `read_lines(path)` returns a list of lines
- `write_file(path, text)` overwrites (or creates) a file; `append_file(path, text)` adds without overwriting
- `file_exists(path)` — always check existence before reading to avoid runtime errors
- Always wrap file operations in `Try...Catch` — files may be missing, locked, or unreadable
- CSV files are processed by reading lines, splitting by comma, and constructing maps from headers and values

Part VI — Advanced EPL

CHAPTER 20

Databases — SQLite Integration

> *Databases store data in a structured, queryable format that persists across program runs and scales to millions of records. EPL has built-in SQLite support — a full relational database engine requiring zero configuration or server setup.*

20.1 Why Databases, Not Files?

You have already seen how to read and write files. Why would you need a database? Files work well for simple data — a configuration file, a log, a small CSV. But they fall short when your data is complex and interconnected, when you need to search millions of records by any field in milliseconds, when multiple users might read and write simultaneously, or when you need to enforce data integrity rules (no duplicate IDs, no scores above 100).

A **relational database** solves all of these problems. Data is organised into *tables* (like spreadsheets with strict column types). Tables are connected by *relationships*. You query data using **SQL** (Structured Query Language) — a declarative language that describes *what* you want rather than *how* to get it.

EPL uses **SQLite** — a lightweight, serverless, zero-configuration SQL database engine. The entire database is stored in a single `.db` file. It is the world's most widely deployed database — used in every Android and iOS device, every Chrome browser, and countless embedded systems.

20.2 Connecting and Creating Tables

EPL school_db.epl

```
Note: Connect to database (creates file if it doesn't exist)
db = real_db_connect("school.db")

Note: Create students table
real_db_execute(db, "
    CREATE TABLE IF NOT EXISTS students (
        id      INTEGER PRIMARY KEY AUTOINCREMENT,
        name    TEXT    NOT NULL,
        age     INTEGER,
        score   REAL,
        grade   TEXT
    )
")
Say "Database ready."
```

20.3 Inserting Data (CREATE)

EPL

```
Note: Insert individual records safely using parameters (prevents SQL
injection)
real_db_execute(db, "INSERT INTO students (name, age, score, grade)
VALUES (?, ?, ?, ?)",
    ["Alice", 21, 94.5, "A"])

real_db_execute(db, "INSERT INTO students (name, age, score, grade)
VALUES (?, ?, ?, ?)",
    ["Bob", 22, 73.0, "C"])

real_db_execute(db, "INSERT INTO students (name, age, score, grade)
VALUES (?, ?, ?, ?)",
    ["Carol", 20, 88.5, "B"])
```

```
Say"3 students inserted."
```

🔒 **SQL INJECTION — ALWAYS USE PARAMETERS**

Never build SQL queries by concatenating user input into a string: `"INSERT INTO students VALUES ('" + name + "')"`. If a user enters `Alice'); DROP TABLE students; --`, your entire table is deleted. Always use parameterised queries with `?` placeholders and a separate values list. EPL's database functions support this natively.

20.4 Querying Data (READ)

EPL

```
Note: Get all students
all_students = real_db_query(db, "SELECT * FROM students ORDER BY
name")
For each s in all_students
    Say "ID:$s[id]  Name:$s[name]  Score:$s[score]  Grade:$s[grade]"
End

Note: Filter — only A and B grades
top = real_db_query(db, "SELECT name, score FROM students WHERE grade
IN ('A','B') ORDER BY score DESC")
Say "═══ Top Students ═══"
For each s in top
    Say "$s[name]: $s[score]"
End

Note: Aggregate — average score
avg_result = real_db_query(db, "SELECT AVG(score) as avg_score FROM
students")
Say "Class average: $avg_result[0][avg_score]"
```

20.5 Updating and Deleting Records

EPL

```
Note: UPDATE — change Bob's score
real_db_execute(db, "UPDATE students SET score = ?, grade = ? WHERE
name = ?",
    [81.5, "B", "Bob"])
Say "Bob's record updated."

Note: DELETE — remove failing students
real_db_execute(db, "DELETE FROM students WHERE grade = 'F'")
Say "Failing students removed."

Note: Always close the connection when done
real_db_close(db)
Say "Connection closed."
```

CHAPTER 20 SUMMARY

- SQLite is a serverless, zero-configuration relational database — the entire DB is one file
- `real_db_connect(path)` opens/creates a DB; `real_db_close(db)` closes it
- `real_db_execute(db, sql, params)` for INSERT/UPDATE/DELETE; `real_db_query(db, sql)` for SELECT
- Always use `?` parameter placeholders — never concatenate user input into SQL strings
- SQL operations: `CREATE TABLE`, `INSERT INTO`, `SELECT ... WHERE ... ORDER BY`, `UPDATE ... SET`, `DELETE FROM`
- Results from `real_db_query()` are a list of maps — iterate with `For each`

✍️ CHAPTER 20 EXERCISES

1. Create a `library.db` database with a `books` table (id, title, author, year, available). Insert 5 books, then write queries to: list all available books, find books by a specific author, and update availability when a book is borrowed.
2. Build a simple task manager: a `tasks` table with fields id, title, priority (1-5), completed (boolean), created_date. Implement add, complete, delete, and list-by-priority functions.
3. What is a PRIMARY KEY and why is every table recommended to have one? What does AUTOINCREMENT do?
4. Research: What is a database index and when should you create one? Try adding an index on the `grade` column and explain what changes.

Part VII — Real-World EPL

CHAPTER 21

Web Development — HTTP Servers & APIs

> *EPL includes a built-in web server that lets you build HTTP endpoints, REST APIs, and full web applications directly from EPL code — with no external frameworks required.*

21.1 How HTTP Works

The **HyperText Transfer Protocol (HTTP)** is the foundation of all data exchange on the Web. Every time you visit a web page, your browser sends an HTTP *request* to a server; the server processes the request and sends back an HTTP *response*. A request has: a **method** (GET, POST, PUT, DELETE), a **path** (e.g. `/users/42`), optional **headers** (metadata), and an optional **body** (data payload). A response has: a **status code** (200 OK, 404 Not Found, 500 Internal Server Error), headers, and a body (HTML, JSON, plain text, etc.).

When you build an EPL web server, you define *routes* — mappings from a method + path combination to a handler function that generates the response. The EPL runtime handles the low-level TCP socket management, HTTP parsing, and response formatting for you.

21.2 Starting an EPL Web Server

EPL server.epl

```
Note: Create and configure the server
server = web_server_create()
web_server_set_port(server, 8080)
```

```
    web_response(200, "text/html", "<h1>Welcome to EPL Web!</h1>")
)

Note: Define a GET route returning JSON
web_server_route(server, "GET", "/api/status", lambda req:
    web_response(200, "application/json", "{\"status\": \"ok\",
\"version\": \"1.0\"}")
)

Note: Start listening (blocks until Ctrl+C)Say"Server running at
http://localhost:8080"
web_server_start(server)
```

21.3 Reading Request Data

Handler functions receive a `req` object containing all details about the incoming request. You can read URL parameters, query strings, request headers, and the request body.

EPL

```
Note: Route with URL path parameter: /users/42
web_server_route(server, "GET", "/users/:id", lambda req:
    web_response(200, "application/json",
        "{\"user_id\": " + to_text(req["params"]["id"]) + "}")
)

Note: POST route — read JSON body
web_server_route(server, "POST", "/api/echo", lambda req:
    web_response(200, "application/json", req["body"])
)
```

21.4 Building a Complete REST API

EPL — todo_api.epl

```
todos = []
next_id = 1

Note: GET /todos — list all todos
web_server_route(server, "GET", "/todos", lambda req:
```

```
    web_response(200, "application/json", to_json(todos))
)

Note: POST /todos — create new todo
web_server_route(server, "POST", "/todos", lambda req: (
    todo = from_json(req["body"]),
    todo["id"] = next_id,
    todos.add(todo),
    next_id = next_id + 1,
    web_response(201, "application/json", to_json(todo))
))

Note: DELETE /todos/:id — remove a todo
web_server_route(server, "DELETE", "/todos/:id", lambda req: (
    target_id = to_integer(req["params"]["id"]),
    todos = filter(todos, lambda t: t["id"] ≠ target_id),
    web_response(204, "application/json", "{}")
))
```

21.5 Serving Static Files

EPL

```
Note: Serve files from a 'public' folder
web_server_static(server, "/static", "./public")

Note: Requests to /static/style.css serve ./public/style.css
Note: Requests to /static/app.js  serve ./public/app.js
```

CHAPTER 21 SUMMARY

- HTTP is a request-response protocol; every web page and API uses it
- `web_server_create()`, `web_server_set_port()`, `web_server_start()` — create and launch a server
- `web_server_route(server, method, path, handler)` — define an endpoint; handler receives a `req` map
- URL parameters (:id) are accessible via `req["params"]["id"]`
- Use `to_json()` and `from_json()` to serialise and deserialise data for API responses
- `web_server_static(server, prefix, folder)` serves files from a directory

✍️ CHAPTER 21 EXERCISES

1. Build a note-taking REST API with endpoints: GET /notes (list all), POST /notes (create), GET /notes/:id (single note), DELETE /notes/:id (remove). Persist notes in a SQLite database.
2. Add a search endpoint: GET /notes?q=keyword that returns only notes whose content contains the keyword.
3. What HTTP status code should you return when: a requested resource is not found? When the user sends malformed JSON? When an operation succeeds but returns no body?

Part VII — Real-World EPL

CHAPTER 22

The Python Bridge — Unlimited Power

> *EPL runs on Python and provides a direct bridge to the entire Python ecosystem — 400,000+ packages on PyPI, including NumPy, pandas, requests, Pillow, scikit-learn, and more. This chapter explains how to harness Python from EPL.*

22.1 Why a Python Bridge?

EPL is designed to be learnable and readable, but no single language reinvents every wheel. Python has spent decades building one of the richest library ecosystems in the world. The **Python Bridge** lets EPL programs call any Python function, use any Python library, and pass data seamlessly between the two languages. You get EPL's clean syntax for your own logic and Python's ecosystem for everything else.

22.2 Running Python Code from EPL

EPL python_bridge.epl

```
Note: Execute a Python expression and get the result
result = python_eval("2 ** 32")
Say result        Note: 4294967296

Note: Import a Python module and call its functions
math_sqrt = python_eval("import math; math.sqrt(144)")
Say math_sqrt      Note: 12.0

Note: Use Python's datetime
today = python_eval("from datetime import date; str(date.today())")
Say "Today is: $today"
```

```
Note: Use pandas to analyse data
python_exec("import pandas as pd")
python_exec("df = pd.read_csv('data.csv')")
mean_age = python_eval("df['age'].mean()")
Say"Mean age: $mean_age"
```

22.3 Passing EPL Data to Python

You can pass EPL variables into Python code using the `python_set()` function, which creates a Python variable with the given name and value. EPL data types (strings, numbers, lists, maps) are automatically converted to their Python equivalents.

EPL

```
scores = [78, 92, 65, 88, 94]

Note: Pass EPL list to Python
python_set("epl_scores", scores)

Note: Use Python statistics on EPL data
stats = python_eval("import statistics; {'mean':
statistics.mean(epl_scores), 'stdev':
round(statistics.stdev(epl_scores), 2)}")
Say "Mean: $stats[mean]"
Say "Std Dev: $stats[stdev]"

Note: Use requests library for HTTP calls
python_exec("import requests")
python_exec("response = requests.get('https://api.github.com')")
status = python_eval("response.status_code")
Say "GitHub API status: $status"
```

22.4 Defining Python Functions for EPL Use

EPL

```
Note: Define a reusable Python helper
python_exec("
def send_email(to, subject, body):
```

```
from email.message import EmailMessage
    msg = EmailMessage()
    msg['To'] = to
    msg['Subject'] = subject
    msg.set_content(body)
    return 'Email would be sent to: ' + to
")

Note: Call the Python function from EPL
python_set("recipient", "alice@example.com")
result = python_eval("send_email(recipient, 'Hello', 'Greetings from
EPL!')")
Say result
```

CHAPTER 22 SUMMARY

- The Python Bridge connects EPL to Python's entire ecosystem of 400,000+ packages
- `python_eval(code)` evaluates a Python expression and returns the result
- `python_exec(code)` runs Python statements (no return value)
- `python_set(name, value)` passes an EPL variable into Python's namespace
- EPL ↔ Python type conversion is automatic: lists become Python lists, maps become dicts
- For machine learning use NumPy/scikit-learn; for data analysis use pandas; for HTTP use requests

✍️ CHAPTER 22 EXERCISES

1. Use the Python `random` module to generate 100 random numbers between 1 and 1000, bring them into EPL as a list, and compute mean, median, and mode using EPL loops.
2. Build an EPL program that fetches weather data from a public API (like `wttr.in`) using Python's `requests` library and displays a formatted summary.
3. Use Python's `hashlib` to create a password hasher: take a plaintext password in EPL, hash it with SHA-256 via the Python bridge, and display the hex digest.

Part VII — Real-World EPL

CHAPTER 23

Modules — Code Organisation & Reuse

> *As programs grow, keeping all code in a single file becomes unmanageable. Modules let you split your program into focused, reusable files — each responsible for one part of the system. This chapter covers creating, importing, and organising EPL modules.*

23.1 Why Modules?

A program with 10,000 lines in one file is nearly impossible to navigate. When you split code into modules — `math_utils.epl`, `string_helpers.epl`, `database.epl` — each file is focused and comprehensible in isolation. Other files can import only what they need. Two developers can work on different modules simultaneously without conflicts. You can share and reuse a module across multiple projects.

Modules also enforce **encapsulation**: only functions and variables explicitly exported from a module are available to importers. Internal implementation details stay hidden, making the module's public interface clear and stable.

23.2 Creating a Module

EPL — math_utils.epl

```
Note: A module file — nothing special, just EPL code
PI = 3.14159265358979
E  = 2.71828182845905
```

```
EndFunctionis_primetakes n
    If n <2thenReturnfalseEndFor i from2to n - 1If n % i
==0thenReturnfalseEndEndReturntrueEndFunctionfactorialtakes n
    If n ⩽1thenReturn1EndReturn n * factorial(n - 1)
End
```

23.3 Importing Modules

EPL main.epl

```
Note: Import the entire module
Import "math_utils.epl"

Say circle_area(5)      Note: 78.5398...
Say is_prime(17)        Note: true
Say factorial(6)        Note: 720
Say PI                  Note: 3.14159265358979

Note: Import with a namespace alias (recommended for large projects)
Import "math_utils.epl" as math

Say math.circle_area(5)   Note: same result but clearly namespaced
Say math.PI               Note: 3.14159...
```

🔎 **IMPORT RESOLUTION**

EPL searches for imported files in this order:

1. The directory of the current file
2. Any directories in the `EPL_PATH` environment variable
3. The EPL standard library directory

Use relative paths for project files (`"./utils/math.epl"`) and bare names for installed packages (`"math_utils.epl"`).

23.4 Real-World Module Organisation

For a larger project such as a to-do web application, a well-organised module structure makes the codebase navigable at a glance:

TEXT — Project Layout

```
todo_app/
├── main.epl              ← entry point, starts the server
├── config.epl            ← constants (port, DB path, etc.)
├── db/
│   ├── connection.epl    ← open/close the database
│   └── migrations.epl    ← CREATE TABLE statements
├── models/
│   ├── todo.epl          ← Todo class and CRUD functions
│   └── user.epl          ← User class and auth helpers
├── routes/
│   ├── todos.epl         ← GET/POST/DELETE /todos endpoints
│   └── auth.epl          ← /login, /logout, /register
└── utils/
    ├── validators.epl    ← input validation functions
    └── formatters.epl    ← response formatting helpers
```

EPL — main.epl

```
Import "config.epl"
Import "db/connection.epl" as db
Import "db/migrations.epl"
Import "routes/todos.epl"
Import "routes/auth.epl"

conn = db.connect(DB_PATH)
run_migrations(conn)

server = web_server_create()
web_server_set_port(server, SERVER_PORT)
register_todo_routes(server, conn)
register_auth_routes(server, conn)
```

```
Say"App running on port $SERVER_PORT"
web_server_start(server)
```

CHAPTER 23 SUMMARY

- Modules split code into focused, reusable files — one responsibility per file
- `Import "filename.epl"` executes the file and makes its definitions available
- `Import "file.epl" as alias` creates a namespace — use `alias.function()` to call
- Organise large projects by layer: entry point, config, models, routes, utils
- Modules enforce encapsulation: callers see only the module's public functions, not internal helpers

✍️ CHAPTER 23 EXERCISES

1. Refactor a previous exercise (e.g. the Todo API from Chapter 21) into a proper module structure with at least 4 separate files.
2. Write a `validation.epl` module with functions: `is_email(text)`, `is_positive_integer(text)`, `is_non_empty(text)`. Import and use them in a form validation program.
3. What is the problem with having two modules that both define a function called `format()`? How does namespace aliasing solve it?

Part VIII — Mastery

CHAPTER 24

Capstone Project — Building a Full Library Management System

> *This chapter brings together everything you have learned — variables, functions, OOP, lists, maps, file I/O, databases, error handling, modules, and web APIs — into one cohesive, real-world application built step-by-step.*

24.1 Project Overview

You will build a **Library Management System** with three layers: a SQLite database for persistence, an EPL class layer for the domain model, and a REST API web layer for external access. By the end, you will have a running HTTP server that manages books, members, and loan records.

The system handles: adding and searching books, registering members, checking out a book to a member (with due-date calculation), returning a book, and generating an overdue report. These are real operations used in library software worldwide.

24.2 Database Schema

EPL db/migrations.epl

```
db = real_db_connect("library.db")

real_db_execute(db, "
CREATE TABLE IF NOT EXISTS books (
    id        INTEGER PRIMARY KEY AUTOINCREMENT,
    isbn      TEXT    UNIQUE NOT NULL,
    title     TEXT    NOT NULL,
    author    TEXT    NOT NULL,
```

```
copies    INTEGER DEFAULT 1
)")

real_db_execute(db, "
CREATE TABLE IF NOT EXISTS members (
    id        INTEGER PRIMARY KEY AUTOINCREMENT,
    name      TEXT    NOT NULL,
    email     TEXT    UNIQUE NOT NULL,
    joined    TEXT    DEFAULT (date('now'))
)")

real_db_execute(db, "
CREATE TABLE IF NOT EXISTS loans (
    id          INTEGER PRIMARY KEY AUTOINCREMENT,
    book_id     INTEGER REFERENCES books(id),
    member_id   INTEGER REFERENCES members(id),
    loaned_on   TEXT    DEFAULT (date('now')),
    due_on      TEXT    NOT NULL,
    returned_on TEXT
)")

Say"Schema created."
real_db_close(db)
```

24.3 The Book Model

EPL — models/book.epl

```
Class BookRepository
    field db = nothing

    Function setup takes conn
        self.db = conn
    End

    Function add takes isbn, title, author, year, copies = 1
        Try
            real_db_execute(self.db,
                "INSERT INTO books (isbn,title,author,year,copies)
VALUES (?,?,?,?,?)",
                [isbn, title, author, year, copies])
            Say "Book added: $title"
        Catch e
            Say "Error adding book: $e"
        End
    End
```

```
Functionsearchtakes query
        pattern = "%" + query + "%"Return real_db_query(self.db,
            "SELECT * FROM books WHERE title LIKE ? OR author LIKE ?
ORDER BY title",
            [pattern, pattern])
    EndFunctionget_allReturn real_db_query(self.db, "SELECT * FROM
books ORDER BY title")
    EndFunctionis_availabletakes book_id
        active_loans = real_db_query(self.db,
            "SELECT COUNT(*) as cnt FROM loans WHERE book_id=? AND
returned_on IS NULL",
            [book_id])
        book = real_db_query(self.db,
            "SELECT copies FROM books WHERE id=?", [book_id])
        If book.length ==0thenReturnfalseEndReturn active_loans[0]
["cnt"] < book[0]["copies"]
    EndEnd
```

24.4 The Loan Service

EPL — models/loan.epl

```
Class LoanService
    field db      = nothing
    field books   = nothing
    field loan_days = 14

    Function setup takes conn, book_repo
        self.db    = conn
        self.books = book_repo
    End

    Function checkout takes book_id, member_id
        If not self.books.is_available(book_id) then
            Raise "Book $book_id is not available for loan"
        End
        due_date = python_eval("from datetime import date, timedelta;
str(date.today() + timedelta(days=14))")
        real_db_execute(self.db,
            "INSERT INTO loans (book_id, member_id, due_on) VALUES
(?,?,?)",
            [book_id, member_id, due_date])
        Say "Loan created. Due: $due_date"
    End

    Function return_book takes loan_id
```

```
        today = python_eval("from datetime import date;
str(date.today())")
        real_db_execute(self.db,
            "UPDATE loans SET returned_on=? WHERE id=? AND returned_on
IS NULL",
            [today, loan_id])
        Say"Book returned on $today"EndFunctionoverdue_report
        today = python_eval("from datetime import date;
str(date.today())")
        Return real_db_query(self.db, "
            SELECT l.id, b.title, m.name, m.email, l.due_on
            FROM loans l
            JOIN books b ON b.id = l.book_id
            JOIN members m ON m.id = l.member_id
            WHERE l.returned_on IS NULL AND l.due_on < ?
            ORDER BY l.due_on", [today])
    EndEnd
```

24.5 The API Layer

EPL main.epl

```
Import "db/migrations.epl"
Import "models/book.epl"
Import "models/loan.epl"

db       = real_db_connect("library.db")
books    = BookRepository()
books.setup(db)
loans    = LoanService()
loans.setup(db, books)
server   = web_server_create()
web_server_set_port(server, 8080)

Note: Books endpoints
web_server_route(server, "GET", "/books", lambda req:
    web_response(200, "application/json", to_json(books.get_all())))

web_server_route(server, "GET", "/books/search", lambda req:
    web_response(200, "application/json",
        to_json(books.search(req["query"]["q"]))))

Note: Overdue report
web_server_route(server, "GET", "/loans/overdue", lambda req:
    web_response(200, "application/json",
```

```
Say"Library API running on :8080"
web_server_start(server)
```

💡 **EXTENDING THE CAPSTONE**

Try extending the project: add authentication (member login required for checkout), pagination to the books list (limit/offset query parameters), email notifications for overdue items (using Python's smtplib via the bridge), and a simple HTML frontend served from `/static` that calls your API.

CHAPTER 24 SUMMARY — WHAT YOU BUILT

- A 3-tier application: SQLite (data) → EPL classes (business logic) → HTTP API (interface)
- Relational database design with foreign keys across 3 tables
- Repository pattern: `BookRepository` isolates all SQL for books
- Service layer: `LoanService` enforces business rules (availability check, due-date calculation)
- Python Bridge used for date arithmetic without reinventing the wheel
- Module system keeps code organised by responsibility: migrations, models, routes, main

Part VIII — Mastery

CHAPTER 25

Best Practices — Writing Professional EPL Code

> *Knowing the language is necessary but not sufficient for being a good programmer. This chapter distils the hard-won wisdom of software engineering into concrete, actionable practices for writing EPL code that is readable, maintainable, testable, and secure.*

25.1 Naming Conventions

Names are the primary communication channel between you and the next person who reads your code (often your future self). Choose names that are precise, unambiguous, and self-documenting:

ENTITY	CONVENTION	GOOD EXAMPLE	BAD EXAMPLE
Variables	snake_case	`student_score`	`x`, `tmp2`
Functions	snake_case verbs	`calculate_tax()`	`do_thing()`
Classes	PascalCase nouns	`BankAccount`	`myclass`

Constants	UPPER_SNAKE	`MAX_RETRY_COUNT`	`max`
Booleans	is_/has_/can_	`is_valid`	`valid`, `flag`

25.2 Function Design Principles

Every function should follow these principles: **Single Responsibility** — a function does one thing and does it well. If you cannot describe a function in one sentence without using "and", it is doing too much. **Small size** — aim for under 20 lines; if longer, extract sub-functions. **Clear contracts** — validate inputs with early returns or `Raise`, and make return types consistent (always return a value, or always return nothing — not sometimes one and sometimes the other).

EPL

```
Note: BAD — function does too many things and has unclear contract
Function process takes data
    Note: validates, transforms, saves, and emails in one function
End

Note: GOOD — each function has one clear job
Function validate_email takes email
    Return email.contains("@") and email.contains(".")
End

Function normalise_email takes email
    Return email.trim().lower()
End

Function save_user takes db, email
    real_db_execute(db, "INSERT INTO users(email) VALUES (?)", [email])
End
```

25.3 Error Handling Strategy

Follow the **Fail Fast** principle: validate inputs early, raise informative errors immediately, and never let invalid data propagate deep into your program. Categorise your error handling into three tiers: *validation errors* (user input failures — return informative messages, do not crash), *operational errors* (file/network/database failures — catch, log, notify user, continue), and *programming errors* (bugs — let them crash loudly so you find and fix them).

25.4 Security Essentials

🔒 **THE OWASP TOP 10 FOR EPL DEVELOPERS**

1. **SQL INJECTION**: Always use parameterised queries — **NEVER** concatenate user input into SQL.
2. **SENSITIVE DATA EXPOSURE**: Never store plain-text passwords. Hash with bcrypt (via Python bridge). Never log passwords or tokens.
3. **SECRETS IN SOURCE CODE**: Never hardcode API keys or credentials. Use environment variables: `python_eval("import os; os.environ.get('API_KEY', '')")`.
4. **INPUT VALIDATION**: Validate *all* user input before processing. Assume all external data is malicious until proven otherwise.
5. **ERROR MESSAGES**: Never expose internal stack traces or database schema details to end users.

25.5 Code Review Checklist

Before submitting any code for review or releasing it to production, verify:

- ☐ Every function has a single, clearly-named responsibility
- ☐ All database queries use parameterised placeholders
- ☐ All file and network operations are wrapped in Try–Catch
- ☐ No secrets, API keys, or passwords appear in the code
- ☐ User-facing error messages are informative but safe (no internals exposed)
- ☐ All input from external sources (user input, API responses, files) is validated before use
- ☐ Functions are under 20 lines; complex logic is extracted into helper functions
- ☐ Variable and function names clearly communicate their purpose
- ☐ There is no dead code (commented-out blocks, unreachable branches, unused variables)

CHAPTER 25 SUMMARY

- Naming: snake_case for variables/functions, PascalCase for classes, UPPER_SNAKE for constants
- Single Responsibility: one function, one job; extract when functions grow beyond ~20 lines
- Fail Fast: validate inputs early with informative error messages
- SQL safety: parameterised queries always; input validation everywhere; no secrets in code
- Review every piece of code against the security checklist before release

Appendix A — Quick Reference

CHAPTER 26

EPL Quick Reference

> *A complete, scannable reference to all EPL keywords, built-in functions, operators, and syntax patterns. Keep this chapter bookmarked — you will return to it often.*

A.1 Keywords & Statement Syntax

KEYWORD / PATTERN	PURPOSE	EXAMPLE
`Say expr`	Print to console	`Say "Hello, " + name`
`If cond Then ... End`	Conditional	`If x > 0 Then Say x End`
`Otherwise`	Else branch	`Otherwise Say "negative" End`
`Otherwise If cond Then`	Else-if chain	Inside If...End block
`While cond ... End`	Condition loop	`While x > 0 ... End`
`Repeat N times ... End`	Count loop	`Repeat 5 times Say "-" End`

`For i from A to B ... End`	Range loop	`For i from 1 to 10 Say i End`
`For each x in list ... End`	Iterator loop	`For each n in nums Say n End`
`Break`	Exit loop	Inside any loop
`Continue`	Skip iteration	Inside any loop
`Define Function name takes p...`	Define function	`Define Function add takes a,b`
`Return value`	Return from function	`Return x * 2`
`Try ... Catch e ... End`	Error handling	Wrap risky operations
`Raise "message"`	Throw an error	`Raise "Invalid input"`
`Define Class Name ... End`	Define class	`Define Class Dog`
`Define Method name takes...`	Class method	Inside Define Class block
`Create ClassName`	Instantiate class	`d = Create Dog`
`Import "file.epl"`	Import module	`Import "utils.epl" as u`
`Lambda params -> expr`	Anonymous function	`Lambda x -> x * 2`

A.2 Operators

CATEGORY	OPERATORS
Arithmetic	`+ - * / // % **`
Comparison	`== != < > <= >=` and English equivalents
Logical	`and or not`
Assignment	`= Increase by Decrease by Multiply by`
Membership	`in` (inside For each)

A.3 Built-in Functions — Complete List

FUNCTION	RETURNS	DESCRIPTION
`Say(x)`	—	Print value to stdout
`Ask(prompt)`	string	Read line from user input
`to_text(x)`	string	Convert any value to string
`to_integer(x)`	integer	Convert string/float to integer

`to_float(x)`	float	Convert string/integer to float
`type_of(x)`	string	Type name: "integer","string",etc.
`length(x)`	integer	Length of string, list, or map
`range(n)`	list	List [0, 1, ..., n-1]
`random_integer(a, b)`	integer	Random integer between a and b
`round(x, dp)`	float	Round to dp decimal places
`abs(x)`	number	Absolute value
`power(base, exp)`	number	Exponentiation
`min(a, b)`	number	Smaller of two values
`max(a, b)`	number	Larger of two values
`map(list, fn)`	list	Transform each element
`filter(list, fn)`	list	Keep matching elements
`reduce(list, fn, init)`	value	Fold list into single value
`sort_by(list, fn)`	list	Sort using key function

`read_file(path)`	string	Read entire file
`read_lines(path)`	list	Read file as list of lines
`write_file(path, text)`	—	Write/overwrite a file
`append_file(path, text)`	—	Append to a file
`file_exists(path)`	boolean	Does file exist?
`to_json(x)`	string	Serialise to JSON string
`from_json(s)`	map/list	Parse JSON string
`python_eval(code)`	any	Evaluate Python expression
`python_exec(code)`	—	Execute Python statements
`python_set(name, val)`	—	Set Python variable
`real_db_connect(path)`	conn	Open SQLite database
`real_db_execute(db,sql,p)`	—	Run SQL statement
`real_db_query(db,sql,p)`	list	Run SELECT, get rows as maps

`real_db_close(db)`	—	Close database connection
`web_server_create()`	server	Create HTTP server
`web_server_route(s,m,p,fn)`	—	Register route handler
`web_server_start(s)`	—	Start listening (blocks)
`web_response(code,type,body)`	response	Create HTTP response

A.4 String Methods Summary

METHOD	RETURNS	METHOD	RETURNS
`.upper()`	string	`.lower()`	string
`.trim()`	string	`.length`	integer
`.contains(s)`	boolean	`.starts_with(s)`	boolean
`.ends_with(s)`	boolean	`.replace(a,b)`	string
`.split(sep)`	list	`.slice(i,j)`	string
`.index_of(s)`	integer	`.repeat(n)`	string

A.5 Common Error Messages and Fixes

ERROR	CAUSE	FIX
`NameError: 'x' not defined`	Using a variable before assignment, or accessing a local outside its scope	Check spelling; ensure variable is assigned before use
`TypeError: cannot concatenate`	Adding a string and a number without conversion	Use `to_text()` to convert before `+`
`IndexError: list index out of range`	Accessing `list[i]` where i ≥ list.length	Check index with `If i < list.length Then`
`KeyError: 'key'`	Accessing a map key that doesn't exist	Use `map.has(key)` before access or `map.get(key, default)`
`ZeroDivisionError`	Dividing by zero	`If divisor ≠ 0 Then` before dividing
`SyntaxError`	Missing `End`, wrong block structure	Count your `If/Define/While` vs `End` — they must match

JOURNEY COMPLETE

You have reached the end of the EPL Programming Language book. You have explored every layer of EPL — from the theoretical foundations of lexing and parsing, through the practical fundamentals of variables, conditions, loops, and functions, to the advanced capabilities of OOP, databases, web servers, and the Python bridge. The concepts you have learned here are not EPL-specific: they are the universal language of software engineering, applicable in Python, JavaScript, Java, Rust, and every language you encounter in the future.

The next step is to build. Take the capstone project and extend it. Create a new project from scratch. Contribute to the EPL interpreter itself. The best way to consolidate programming knowledge is to write programs. Go write yours.

Part IV - The Future of EPL

CHAPTER 27

What's New in EPL v7.4.0

The release of EPL v7.4.0 represents a monumental leap forward for the language, evolving it from an esoteric hobby language into an industrial-grade tool. With new compilation targets, interactive AI frameworks, and universal commenting standards, v7.4.0 introduces capabilities unmatched by many mainstream languages.

This chapter dives deep into the major new features and explains how to adopt them in your production workflows.

Native iOS Transpilation & Execution

EPL v7.4.0 introduces the world-first "English-to-Native-Mobile" pipeline. You can now write standard EPL code and immediately compile it down into native Swift/Objective-C binaries capable of running directly on iOS devices.

BASH

```
epl ios hello.epl
```

When you run this command, the EPL compiler:

1. Validates your AST natively.
2. Transpiles the instructions directly into a temporary XCode project (using Swift).
3. Triggers the LLVM compiler to build a highly optimized `.app` binary payload.

This bypasses interpreted overhead entirely, offering near-C level application performance directly on your iPhone.

Universal `#` Comment Support

While `Note:` has historically been EPL's beloved way to document code organically, many developers transitioning from Python or Ruby requested a faster shortcut for inline disabling of code during debugging.

EPL v7.4.0 introduces support for the standard `#` symbol for single-line comments.

EPL

```
# This is a fast, universal comment
# x = 10 (this code is disabled)

Note: This is the traditional, organic EPL comment
Say "Hello!" # You can even add them inline!
```

The parser intercepts the `#` token directly inside the `skip_newlines` phase, meaning it carries absolutely zero runtime performance penalty in the VM.

Advanced AI Chatbot Starter Templates

Building production-scale AI applications used to require integrating Python wrappers manually. EPL v7.4.0 ships with native templating commands to instantly generate intelligent AI conversational applications using the new `epl.ai` framework.

BASH

```
epl new mybot --template chatbot
```

This single command generates a full-stack directory layout including:

- A modern Native WebApp Backend routing structure.
- Pre-configured AI Module imports (`Import "epl.ai" As ai`).
- Message history management using Native Maps.

```epl
Route "/api/chat" responds with
    messages = [Map with role = "user" and content =
request_data.get("message")]
    Send json Map with reply = ai.chat(messages)
End
```

The Package Publisher (`epl publish`)

Sharing EPL modules is now official. The new packaging system allows developers to bundle their `.epl` modules and publish them to a global registry.

```bash
epl publish
```

This recursively scans your project, statically verifies types, bundles imports, and creates a distributable package that any other user can install via `epl install` .

CHAPTER SNAPSHOT

- Use **epl ios** to compile directly to Native Swift binaries.
- Use **#** for fast, universal Pythonic comments alongside *Note:*.
- Generate full AI frameworks with **epl new mybot --template chatbot**.
- Distribute code safely with **epl publish**.

Appendices

APPENDIX B

Formal Grammar Reference (EBNF)

> *For language enthusiasts, parser developers, and compiler designers, here is the complete formal grammar of the EPL language, written in Extended Backus-Naur Form (EBNF).*

B.1 Understanding the EBNF Notation

The grammar is defined using standard EBNF notation. Terminals (exact literal strings matched by the lexer) are enclosed in double quotes. Non-terminals (grammar rules) are written in lowercase with underscores. The symbols mean:

- `=` defines a rule.
- `|` means alternation (this OR that).
- `( ... )` groups items together.
- `[ ... ]` means an optional item (zero or one occurrence).
- `{ ... }` means zero or more occurrences (repetition).

B.2 The Complete EPL Grammar

EBNF

```
Note: A program is a sequence of zero or more statements
program        = { statement } ;

Note: Statements are the top-level constructs
statement      = print_stmt
```

```
                | ask_stmt
                | var_decl_stmt
                | assign_stmt
                | if_stmt
                | while_stmt
                | repeat_stmt
                | for_loop_stmt
                | for_each_stmt
                | func_def_stmt
                | return_stmt
                | class_def_stmt
                | try_catch_stmt
                | raise_stmt
                | break_stmt
                | continue_stmt
                | expr_stmt ;

print_stmt     = "Say" expression ;
ask_stmt       = "Ask" expression ;
var_decl_stmt  = "Create" "Variable" identifier "with" "value"
expression ;
assign_stmt    = identifier "=" expression
                | identifier "Increase" "by" expression
                | identifier "Decrease" "by" expression
                | identifier "Multiply" "by" expression ;

if_stmt        = "If" expression "Then" { statement }
                  { "Otherwise" "If" expression "Then" { statement } }
                  [ "Otherwise" { statement } ]
                  "End" ;

while_stmt     = "While" expression { statement } "End" ;
repeat_stmt    = "Repeat" expression "times" { statement } "End" ;

for_loop_stmt  = "For" identifier "from" expression "to" expression {
statement } "End" ;
for_each_stmt  = "For" "each" identifier "in" expression { statement }
"End" ;

func_def_stmt  = "Define" "Function" identifier [ "takes" param_list ]
                  { statement } "End" ;
param_list     = identifier { "," identifier } ;

return_stmt    = "Return" [ expression ] ;

class_def_stmt = "Define" "Class" identifier
                  { field_decl | method_decl } "End" ;
field_decl     = "field" identifier "=" expression ;
method_decl    = "Define" "Method" identifier [ "takes" param_list ]
                  { statement } "End" ;
```

```
try_catch_stmt = "Try" { statement } "Catch" identifier { statement }
"End" ;
raise_stmt     = "Raise" expression ;

break_stmt     = "Break" ;
continue_stmt  = "Continue" ;

expr_stmt      = expression ;

Note: Expressions and operator precedence (lowest to highest)
expression     = assignment_expr ;
assignment_expr= logical_or ;
logical_or     = logical_and { "or" logical_and } ;
logical_and    = logical_not { "and" logical_not } ;
logical_not    = [ "not" ] comparison ;

comparison     = term { ( "=" | "≠" | "<" | ">" | "≤" | "≥"
                        | "is" "equal" "to"
                        | "is" "not" "equal" "to"
                        | "is" "less" "than"
                        | "is" "greater" "than"
                        | "in" ) term } ;

term           = factor { ( "+" | "-" ) factor } ;
factor         = power { ( "*" | "/" | "//" | "%" ) power } ;
power          = primary [ "**" power ] ;

Note: Primary values — the atomic building blocks
primary        = number
               | string
               | "true"
               | "false"
               | "nothing"
               | list_literal
               | map_literal
               | lambda_expr
               | "Create" identifier [ "(" [ arg_list ] ")" ]
               | identifier [ func_call | index_access | dot_access ]
               | "(" expression ")" ;

list_literal   = "[" [ expr_list ] "]" ;
map_literal    = "{" [ key_val_list ] "}" ;
key_val_list   = expression ":" expression { "," expression ":"
expression } ;
expr_list      = expression { "," expression } ;

lambda_expr    = "lambda" param_list ":" expression ;

func_call      = "(" [ expr_list ] ")" ;
index_access   = "[" expression "]" ;
```

```
dot_access     = "." identifier [ func_call ] ;

identifier     = letter { letter | digit | "_" } ;
number         = [ "-" ] digit { digit } [ "." digit { digit } ] ;
string         = '"' { any_char_except_quotes } '"' ;
```

Appendices

APPENDIX C

Building a Text Adventure Game

> *To truly test a language, there is no better exercise than writing a game. This complete listing shows how to build a stateful, interactive Zork-style text adventure using EPL's Object-Oriented tools, maps, and loops.*

C.1 Game Architecture

Our game consists of three core classes: `Room`, `Player`, and `Game`. A Room manages connectivity to other rooms and holds items. A Player tracks inventory and current location. The Game class runs the main REPL (Read-Evaluate-Print Loop) to parse user inputs.

EPL game.epl

```
Class Room
    field name = ""
    field description = ""
    field exits = {}
    field items = []

    Function setup takes name, desc
        self.name = name
        self.description = desc
    End

    Function add_exit takes direction, room_obj
        self.exits[direction] = room_obj
    End

    Function add_item takes item_name
        self.items.add(item_name)
    End

    Function remove_item takes item_name
        self.items = filter(self.items, lambda x: x ≠ item_name)
    End
```

```
FunctiondescribeSay""Say"═══ " + self.name + " ═══"Say self.description
        If self.items.length >0thenSay"You see here: " +
self.items.join(", ")
        EndSay"Exits: " + self.exits.keys().join(", ")
    EndEndClassPlayer
    field current_room = nothing
    field inventory = []

    Functionmovetakes direction
        If self.current_room.exits.has(direction) then
            self.current_room = self.current_room.exits[direction]
            self.current_room.describe()
        OtherwiseSay"You cannot go that way."EndEndFunctiontaketakes
item
        If item in self.current_room.items then
            self.inventory.add(item)
            self.current_room.remove_item(item)
            Say"You picked up the " + item + "."OtherwiseSay"There is
no " + item + " here."EndEndEndClassGame
    field player = nothing
    field is_running = trueFunctioninit_world
        cave = Room()
        cave.setup("Dark Cave", "A damp, incredibly dark cave. Water
drips from the ceiling.")
        cave.add_item("lantern")

        hall = Room()
        hall.setup("Great Hall", "A massive stone hall with faded
banners hanging from the walls.")
        hall.add_item("sword")

        cave.add_exit("north", hall)
        hall.add_exit("south", cave)

        self.player = Player()
        self.player.current_room = cave
    EndFunctionstart
        self.init_world()
        Say"Welcome to Ruins of EPL!"
        self.player.current_room.describe()

        While self.is_running
            cmd = Ask("\nWhat do you want to do? > ")
```

```
            parts = cmd.trim().lower().split(" ")
            verb = parts[0]

            If verb =="quit"then
                self.is_running = falseSay"Thanks for
playing!"OtherwiseIf verb =="go"and parts.length >1then
                self.player.move(parts[1])
            OtherwiseIf verb =="take"and parts.length >1then
                self.player.take(parts[1])
            OtherwiseIf verb =="look"then
                self.player.current_room.describe()
            OtherwiseIf verb =="inventory"thenSay"You are carrying: " +
self.player.inventory.join(", ")
            OtherwiseSay"I don't understand that command."EndEndEndEnd

game = Game()
game.start()
```

Appendices

APPENDIX D

Language Design Philosophy

> *A language is defined as much by what it omits as by what it includes. Why does EPL lack semicolons, curly braces, or type declarations? The answers trace back to EPL's core philosophy.*

D.1 Readability Above All

Code is read ten times more often than it is written. Therefore, optimizing a language for the speed of *typing* (by using cryptic symbols like `{}`, `$`, or `⇒`) is a false economy. EPL optimizes for the speed of *comprehension* by a human reader. When a non-programmer can read an EPL file and roughly guess what it does, the language has succeeded.

D.2 "No Magic" Execution

There is no variable hoisting. There are no implicit globals. Scope rules are lexical and strict. Functions must be explicitly called. By removing "magic" — the hidden rules that frameworks or runtimes invoke behind your back — debugging becomes an exercise in logic rather than an exercise in memorizing obscure edge-cases.

D.3 The "Batteries Included" Bridge

Designing a standard library is a monumental task. Rather than spending a decade rebuilding HTTP clients, machine learning wrappers, and image processors native to EPL, we made the architectural decision to build the **Python Bridge**. This allowed EPL to remain a small, pure, focused language while instantly wielding the world's largest library ecosystem. It is a philosophy of pragmatism: use the right tool for the job.