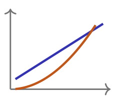
Algorithms & Programming

AP Computer Science Principles ▪ Unit 3

AP Computer Science Principles



What we will cover

`total`

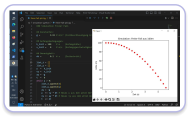
← 16

1 Variables & data

Variables, expressions & strings

Variable 变量	**Expressions**	**Strings 字符串**
a named box; **assignment** 赋值 ←	×÷ before +−: 2+3×4 = 14	ordered characters; index from 0

Data abstraction 数据抽象 groups many values under one name – a **list** 列表 – so the same code works for any amount of data.



Programs use variables, expressions, and control flow

A variable is a named store whose value can change

age

$\boxed{16}$

a variable is a named box that holds a value

A variable is a named store whose value can change

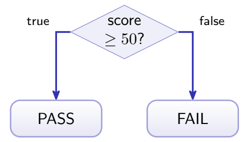
The three families of operators

arithmetic	relational	logical
`+` `-` `*` `/` `MOD` `DIV`	`=` `<>` `<` `>` `<=` `>=`	`AND` `OR` `NOT`
give a **number**	compare → **true** or **false**	join conditions → **true** or **false**

The three families of operators: arithmetic, relational, and logical

2 Logic

Boolean logic & conditionals

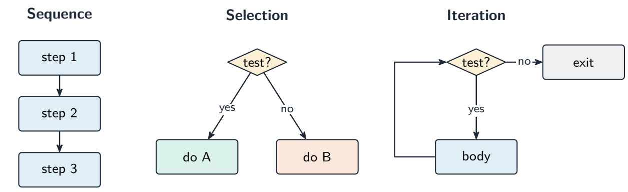


A **Boolean expression** 布尔表达式 is true or false.

- **relational** 关系运算符: $>, <, =, \neq$
- **logical** 逻辑运算符: AND, OR, NOT

A **conditional** 条件语句 runs one branch – **selection** 选择. An **else-if** 否则如果 chain picks among three or more.

Selection chooses between paths based on a condition



> Selection chooses between paths based on a condition

3 Iteration & algorithms

Iteration & the three building blocks

Iteration 迭代 repeats a block with a **loop** 循环 – beware the **infinite loop** 无限循环. Every **algorithm** 算法 is built from three structures:

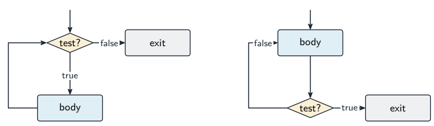
Sequencing 顺序 | **Selection** | **Iteration**

Express an algorithm as **pseudocode** 伪代码, a **flowchart** 流程图, or natural language. Different algorithms can give the **same result** 相同结果.

A pre-condition (WHILE) loop tests before the body

WHILE
(pre-condition)

REPEAT
(post-condition)



tested first ⇒ may run **zero** times

tested last ⇒ runs **at least once**

> A pre-condition (WHILE) loop tests before the body, so it may run zero times

4 Lists & searching

Lists & binary search

A **list** 列表 stores an ordered collection reached by **index** 索引 (from 0); **traverse** 遍历 it with a loop.

Binary search halves the range

Binary search 二分查找 needs a **sorted** 已排序 list: check the **middle** 中间, then keep only the half that could hold the target. Each step **halves** 减半 the range – 1000 items in ∼ 10 checks, not 1000.

Search algorithms trade work for speed

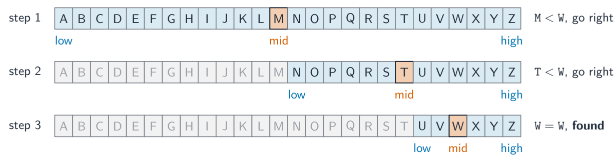
A list holds many values in one variable

index	1	2	3	4	5
scores	**90**	**75**	**60**	**88**	**50**

`scores[2]` is 75

A list holds many values in one variable, each found by its index

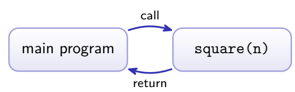
Binary Search



Binary search halves the range at each step (the list must be sorted)

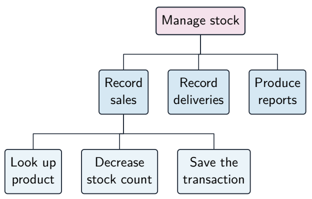
5 Procedures

Procedures & libraries



A **procedure** 过程 is reusable code you **call** 调用 by name, passing **arguments** 实参 into **parameters** 形参 and getting a **return value** 返回值. A **library** 库 bundles tested procedures – use its **API** 应用程序接口 without seeing inside. This is **procedural abstraction** 过程抽象.

Developing Procedures



> Decomposing a program into procedures and sub-procedures

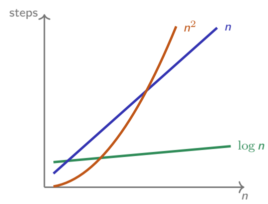
Simulations

A **simulation 模拟** is a program that models a real-world process to study it safely and cheaply.

> Simulations **simplify** reality (they leave out detail) and often use **randomness** to imitate chance events.

6 Randomness & limits

Algorithmic efficiency



Algorithmic efficiency 算法效率 counts **steps** 步骤 as n grows.

- $\log n$, n, n^2 are **reasonable** 合理
- 2^n is **unreasonable** 不合理

When exact is too slow, use a **heuristic** 启发式方法.

The vocabulary this unit is built from

operators	+, −, *, /, and `MOD` – the **remainder** 余数 of a division: `17 MOD 5` is 2
concatenation 连接	joining strings end to end
conditional 条件 (selection)	choosing a path; a **nested conditional** 嵌套条件 puts one inside another
iteration 迭代	a loop – repeating a block
a procedure 过程 (function)	a named block, reusable and testable on its own
`RANDOM(a, b)`	returns a random integer from a to b inclusive, letting a program produce unpredictable results

> **Efficiency** 效率 is how much time or memory an algorithm needs as its input grows. A reasonable-time algorithm's work grows like a polynomial of the input size.

Randomness, simulation & undecidability

Random 随机 values add **variability** 可变性; a **simulation** 模拟程序 models a real **phenomenon** 现象 cheaply, but has **limitations** 局限性.

Decidable 可判定	Undecidable 不可判定
an algorithm always answers (is n prime?)	no algorithm for every case (will it halt?)

Undecidable means **impossible**, not merely **inefficient** 低效 (slow).

Undecidable problems

undecidable 不可判定	no algorithm can solve every case of the problem with a correct yes/no answer
the point	this is a fundamental limit of computation, not a limit of today's computers
the classic case	deciding whether an arbitrary program will halt
what is still possible	an algorithm may solve *some* instances, or give an answer that is usually right
the neighbouring idea	an unreasonable-time algorithm is solvable but grows too fast to run at scale
the distinction	undecidable means no algorithm exists; unreasonable means one exists and is too slow

Undecidable and intractable are different claims. The exam offers them as distractors for each other.

Key points

Algorithms = **sequencing, selection, iteration**

Binary search halves a sorted list each step

Procedures & libraries give abstraction & reuse

Efficiency compares growth; some problems are **undecidable**

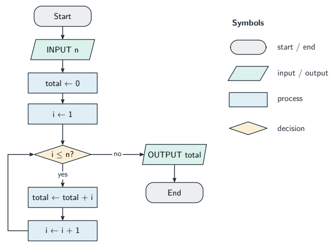
Worked example – why halving wins

Search a sorted list of 8 items

Binary search halves the range each step: $8 \to 4 \to 2 \to 1$ – at most 3 comparisons ($\log_2 8 = 3$). A linear search could take up to 8. The advantage grows explosively: $1{,}000$ items need ≈ 10 binary steps (but up to $1{,}000$ linear); $1{,}000{,}000$ items need just ≈ 20.

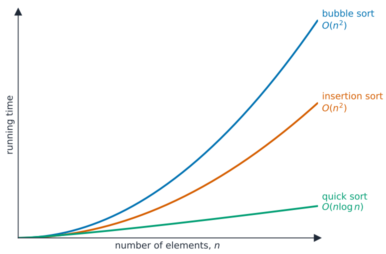
Halving is what makes it a reasonable-time algorithm – and why the list must be sorted first.

Developing Algorithms



A flowchart lays out an algorithm using the standard symbols

Check yourself, in detail



How the running time of an algorithm grows with the input size n

Exam tips

- Know a variable is a named store for a value and trace how **assignment** updates it step by step.
- Read the AP **pseudocode** carefully – `a <- expression` assigns, and lists are **1-indexed** on the exam reference sheet.
- Distinguish a variable from a **list** (a collection accessed by index) and use list operations correctly.
- Evaluate expressions with the right precedence and boolean logic (`AND`, `OR`, `NOT`).
- Pick clear, meaningful variable names – the written tasks reward readable code.

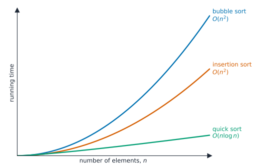
7 Recap

Unit 3 – key takeaways

1. **Variable**
   named store; trace assignment step by step
2. **Pseudocode**
   $a \leftarrow$ expression; lists are 1-indexed
3. **List**
   a collection by index – not a single variable
4. **Names**
   clear names; written tasks reward readable code

Check yourself

1. Binary search on $1{,}000$ items: about how many steps?
2. What must be true of the list before binary search works?
3. Name the three building blocks of any algorithm.
4. What makes a problem undecidable?



Answers **1.** about 10 $(\log_2 1000)$ **2.** it must be sorted **3.** sequencing, selection, iteration **4.** no algorithm can solve it for every input