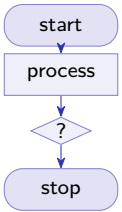
Algorithm Design

AS Computer Science ▪ Topic 9

A-Level Computer Science



What we will cover

1. Computational thinking
2. Algorithms
3. Pseudocode constructs
4. Notations & refinement
5. Logic statements
6. Recap

1 Computational thinking

Abstraction

Abstraction 抽象 keeps the essential features and drops the irrelevant detail. A metro map keeps the stations and lines, not the geography. A **class** in object-oriented programming does the same: only the attributes and methods the system needs.

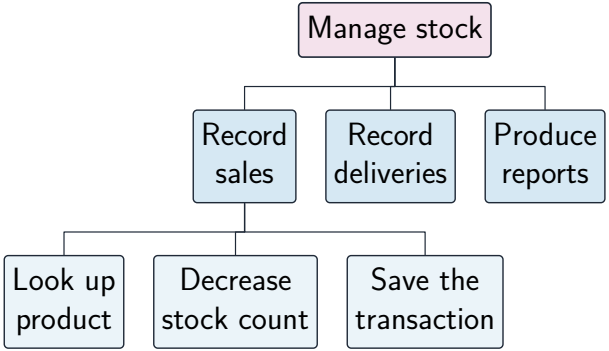
real geography

abstraction

metro map

keep stations + lines, drop the geography

Decomposition



Decomposition 分解 breaks a big problem into smaller sub-problems, each easy to solve. Find the main parts, split each into steps, keep splitting until each is easy, then solve them and combine. Each module becomes a **procedure** 过程 or function.

Algorithms and the identifier table

An **algorithm** 算法 is a sequence of steps that is unambiguous, deterministic, finite and effective. It says *what* to do – independent of the language.

Name	Type	Description
`ItemCost`	`REAL`	cost
`InStock`	`BOOLEAN`	in stock?
`SaleDate`	`DATE`	sold on

An **identifier table** 标识符表 names every variable first.

Identifier table

list every piece of data first - name, type, description

name	data type	description
`ItemCost`	`REAL`	cost of the item
`Category`	`STRING`	the product category
`SaleDate`	`DATE`	when the item was sold
`InStock`	`BOOLEAN`	TRUE if in stock

use **descriptive** names (`ItemCost`, not `x`) - the table forces you to plan the data

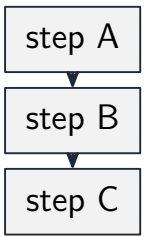
> An identifier table names every piece of data before you write code

2 Pseudocode

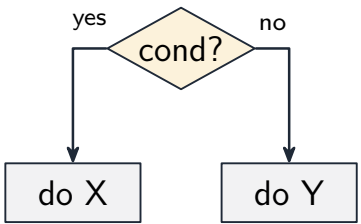
The three basic constructs

- **sequence** 顺序 – one step after another
- **selection** 选择 – `IF/ELSE`; for more options, `CASE OF … ENDCASE`
- **iteration** 迭代 – `FOR`, `WHILE`, `REPEAT`

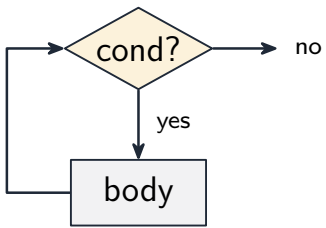
sequence



selection



iteration



Pseudocode operations

Selection

```
IF Age >= 18 THEN
OUTPUT "Adult"
ELSE
OUTPUT "Minor"
ENDIF
```

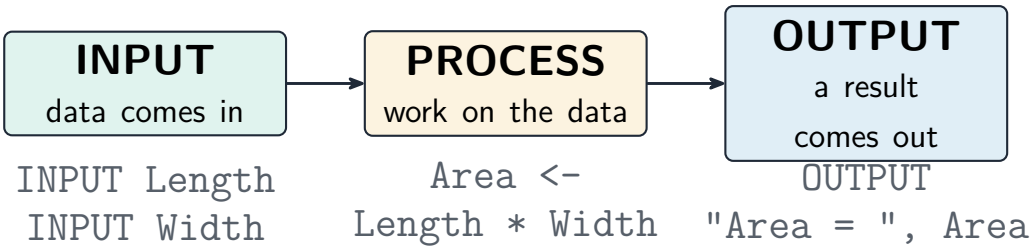
- assignment: `x` ← `5`
- arithmetic `+ - * /`, plus `DIV` (integer ÷) and `MOD` (remainder)
- `WHILE` tests before; `REPEAT` tests after
- `&` joins strings (**concatenation** 拼接)

Input → Process → Output

Every program follows this shape: `INPUT` the values, process them, then `OUTPUT` the result.

> Listing the inputs and outputs first makes the algorithm cleaner – and naming all three parts is what the mark scheme asks for.

Input → Process → Output, in detail



Every program follows the Input, Process, Output shape

Worked example: trace the algorithm

```
x ← 0
FOR i ← 1 TO 5
  IF i MOD 2 = 0 THEN
    x ← x + i
  ENDIF
NEXT i
OUTPUT x
```

What is the output?

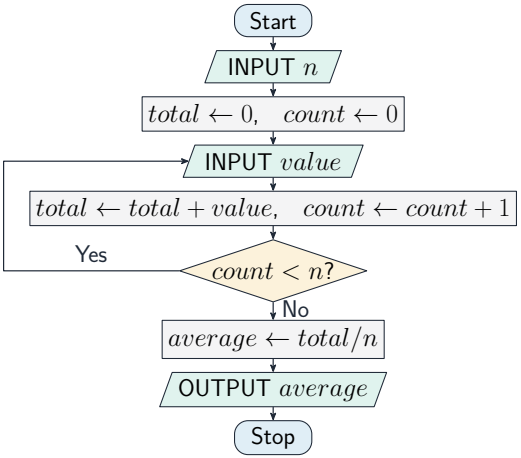
i	i MOD 2	x
–	–	0
1	1	0
2	**0**	**2**
3	1	2
4	**0**	**6**
5	1	6

output: **6**

Fill the **trace table** 跟踪表 row by row – never run the whole loop in your head. Only even `i` (2 and 4) change `x`.

3 Notations and refinement

Three notations

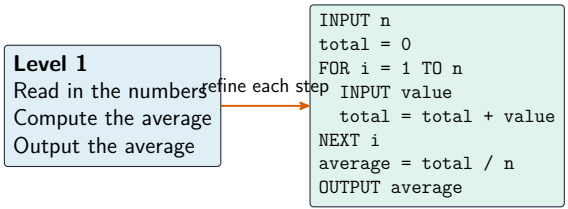


One algorithm, three ways:

- **structured English** 结构化英语 – high-level
- **flowchart** 流程图 – standard shapes
- **pseudocode** 伪代码 – closest to code

Each `IF` = a diamond; each loop = a back-arrow.

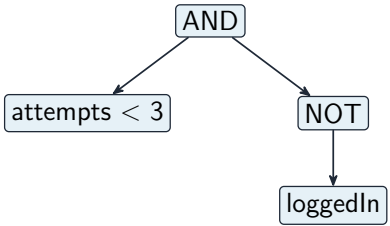
Stepwise refinement



Stepwise refinement 逐步求精 starts with a high-level outline and expands each step until it can be coded. "Compute the average" $\rightarrow$ a loop that sums, then divides by n.

4 Logic

Logic statements



NOT binds first, then AND

A **Boolean** 布尔 condition controls branching. **Precedence** 优先级: `NOT` > `AND` > `OR`.

- write `a = 1 OR a = 2` (not `a = 1 OR 2`)
- **De Morgan** 德摩根定律: `NOT (A AND B) = (NOT A) OR (NOT B)`

Logic precedence, De Morgan, and the initialising trap

precedence 优先级	`NOT`, then `AND`, then `OR` – and use brackets whenever it is not obvious
De Morgan's law 德摩根定律	`NOT (A AND B)` is the same as `(NOT A) OR (NOT B)`
and the other half	`NOT (A OR B)` is `(NOT A) AND (NOT B)`
why it is handy	for simplifying a condition – a negated compound becomes two simple negations
the marked design decision	initialising `Max`: it must start lower than any possible input
the safe way	set `Max` to the first element of the list rather than to zero – which fails on all-negative data

Initialising to zero is the classic bug: a list of negative temperatures returns a maximum of zero, and the program never errors.

Exam tips

- Define an **algorithm** as an unambiguous, finite, deterministic sequence of steps, independent of language.
- Use the three constructs correctly – **sequence, selection, iteration** – and keep an identifier table with data types.
- Break a problem down by **decomposition and abstraction**, then stepwise refinement.
- Write pseudocode that would actually run: declare variables and follow the exam's pseudocode style.

5 Recap

Topic 9 – key takeaways

1 Thinking

abstraction keeps essentials; decomposition splits

2 Constructs

sequence, selection, iteration

3 Notations

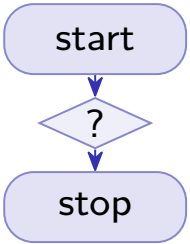
structured English, flowchart, pseudocode

4 Logic

NOT $>$ AND $>$ OR; De Morgan

Check yourself

1. Which technique drops irrelevant detail?
2. Which loop always runs at least once?
3. Flowchart shape for a decision?
4. Simplify `NOT (A AND B)`.



Answers **1.** abstraction **2.** `REPEAT...UNTIL` **3.** a diamond **4.** `(NOT A) OR (NOT B)`