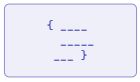
Programming Fundamentals

IGCSE Computer Science ▪ Topic 8

IGCSE Computer Science



What we will cover

1. Variables, constants, data types
2. The three structures
3. Operators & strings
4. Procedures & functions
5. Arrays
6. File handling

age

16

a variable is a named box that holds a value

1 Data

Variables, constants, data types

- **variable** 变量: a named store whose value can change
- **constant** 常量: a named value that is fixed

Five **data types** 数据类型: `INTEGER`, `REAL`, `CHAR`, `STRING`, `BOOLEAN`.

> Pick the smallest precise type: a whole count is `INTEGER`, a price is `REAL`, a yes/no is `BOOLEAN`.

integer	whole number: 7
real	decimal: 3.5
char	one letter: 'A'
string	text: "hello"
boolean	true or false

Variables, constants, and the data types

variable	a named store whose value can change while the program runs
constant	a value that never changes, like Pi – set in one place, so it is easy to read and to alter
declare 声明	state the name and type before use, so the computer reserves the right amount of memory
integer 整数 / real 实数	a whole number; a number with a decimal point
char 字符 / string 字符串	a single character; a sequence of them
Boolean 布尔	only TRUE or FALSE

> Use **meaningful identifiers** 有意义的标识符: `TotalPrice` rather than `t`. It is a marked criterion on the practical paper, not a style preference.

Variables and constants are named stores for values

Variables and constants are named stores for values, set in the program's code

While a program runs, its variables are held in the computer's memory (RAM)

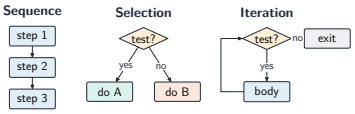
> Variables and constants are named stores for values, set in the program's code

Input and output

Input 输入 reads a value from the user.

Output 输出 shows a value on the screen.

The three basic structures



A **data type** 数据类型 says what kind of value a variable holds.

Every program is built from three control structures.

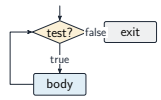
Sequence, selection, iteration

sequence	steps run in order, one after another
selection 选择	chooses which steps to run, based on a condition – `IF`, or `CASE` when there are many choices
iteration 迭代	a **loop** 循环 repeats steps – and there are three kinds
count-controlled 计数循环	`FOR` – repeats a known number of times
pre-condition	`WHILE` – tests before each pass, so it may run zero times
post-condition	`REPEAT UNTIL` – tests after, so it always runs at least once

Choose `WHILE` when the loop might not need to run at all, and `REPEAT` when it must run once before the test can be made.

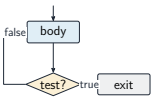
Loops and counting

WHILE (pre-condition)



tested first ⇒ may run **zero** times

REPEAT (post-condition)



tested last ⇒ runs **at least once**

- **totalling** 求和 – keep adding values to a running total: 'total ← total + value'.
- **counting** 计数 – add 1 to a counter each time: 'count ← count + 1'.

Three loops, and when each is right

Count-controlled loop	A **count-controlled loop** 计数循环 (FOR) runs a known number of times – when you know how many before you start.
Pre-condition loop	A **pre-condition loop** 前测循环 (WHILE) tests *before* the body, so it may run zero times. Use it when the data might already be finished.
Post-condition loop	A **post-condition loop** 后测循环 (REPEAT UNTIL) tests *after*, so it always runs at least once – right for a menu, or for validating input.

Pick the loop from the question: known count, might-not-run, or must-run-once.

Totalling and counting

```
count = count + 1    count up by 1
total = total + value    add to a running total
```

A counter counts up by 1; a total builds a running sum

```
total <- 0
count <- 0
FOR each value (4, 7, 5)
  total <- total + value
  count <- count + 1
```

total keeps a running sum; **count** adds 1 each pass - a **trace table** follows both

value	total	count
start	0	0
4	4	1
7	11	2
5	16	3

A trace table follows a totalling and counting loop pass by pass

A counter counts up by 1; a total builds a running sum

2 Operators and strings

Operators

arithmetic	comparison	logical
$+ \ - \ \times \ /$ DIV (whole), MOD (remainder)	$= \neq < > \leq \geq$	AND, OR, NOT

17 DIV 5 = 3 (whole part), 17 MOD 5 = 2 (remainder) – MOD is how you test "is it even?"

Operators, and string handling

arithmetic	add, subtract, multiply, divide; plus MOD and DIV for remainder and whole division
comparison	equal, not equal, less than, greater than, and the two combined forms
logical	AND, OR, NOT
length	how many characters a string contains
substring	take part of a string, from a starting position
upper case 大写 / lower case 小写	change letters to capitals, or to small letters – used to compare input regardless of how it was typed

Watch the numbering: the first character may be position 0 or 1 depending on the language, and the exam paper says which.

The three families of operators

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

The three families of operators: arithmetic, relational and logical

String handling

- LENGTH(s) – number of characters
- SUBSTRING(s, start, n) – part of a string
- UCASE / LCASE – change case
- & – **concatenation** 拼接 (join)

String positions count from 1, not 0. And a **nested** 嵌套 statement is just one structure inside another – an IF within a FOR.

Nested statements

A **nested statement** 嵌套语句 is one control structure placed **inside** another.

You will not have to write more than three levels of nesting.

3 Subroutines

Procedures and functions

- **procedure** 过程: a named block that does an action, returns nothing
- **function** 函数: a named block that returns a value

Library routines 库例程 are ready-made subroutines (`ROUND`, `RANDOM`).

> A function call sits inside an expression (it gives a value back); a procedure call is a statement on its own.

Procedures, functions, and where a variable lives

procedure	a named block of code that does something and returns nothing
function	a named block that returns a value, so it can be used inside an expression
parameter 参数	a value passed in, so the same routine works on different data
local variable 局部变量	exists only inside its routine – safer, because nothing else can change it
global variable 全局变量	visible everywhere – convenient, and a common source of hard-to-find bugs
why subroutines	write once, use many times; and each piece can be tested on its own

> Prefer local variables and pass what you need as parameters. That is exactly what makes a program maintainable, which the paper marks explicitly.

Writing a maintainable program

meaningful names
`score`, not `x`

comments
explain *why*, not the obvious

subroutines
split the work into named blocks

> Maintainable code is code the next person (or you, next month) can read and change without fear.

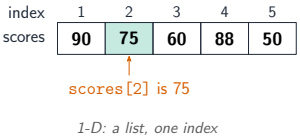
4 Data structures

Arrays

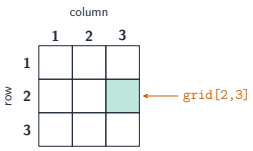
An **array** 数组 holds many values of the same type under one name, picked out by an **index** 索引.

> A 1-D array is a list (`Marks[3]`); a 2-D array is a grid (`Grid[2,3]`) – perfect for a `FOR` loop over every element.

Arrays, in detail



1-D: a list, one index



2-D: a table, [row, column]

An **array** 数组 holds many values of the same type under one name, picked out by an **index** 索引 – one index for a list, two for a table.

One- and two-dimensional arrays

1D array 一维数组	a single list – one index picks an element, as in `Names[3]`
2D array 二维数组	a table of rows and columns – two indexes, as in `Grid[2,5]`
why use one	one name for many values, so a loop can process them all
traversing a 1D array	one `FOR` loop over the indexes
traversing a 2D array	nested loops – the outer over rows, the inner over columns
the caution	going outside the declared bounds is an error the language will report

An array plus a loop is the pattern behind every totalling, counting, searching and sorting question on the paper.

Arrays in one and two dimensions

1D array	A **one-dimensional (1D) array** 一维数组 is a list: one index, `scores[3]`, and every element the same data type.
2D array	A **two-dimensional (2D) array** 二维数组 is a table: two indices, `grid[row, col]` – a seating plan, a game board, a set of results per student.
Traversing	One loop walks a 1D array; nested loops walk a 2D one, the outer over rows and the inner over columns.
Why use one	One name for many values, so a loop can process them all – which is impossible with separate variables.

Say what the index *means* before you write the loop: position in a list, or row and column in a table.

File handling

Store data on disk so it survives when the program ends:

- `OPENFILE` for `READ` / `WRITE`
- `READFILE` / `WRITEFILE`
- `CLOSEFILE` when done

Variables live in RAM and vanish at the end; a file keeps the data between runs. Always `CLOSEFILE` – unsaved writes are lost otherwise.

Worked example – total and average of 5 marks

A program must read 5 marks, then output the total and the average.

```
total ← 0
FOR i ← 1 TO 5
    INPUT mark
    total ← total + mark
NEXT i
average ← total / 5
OUTPUT total, average
```

Two lines carry the marks. `total ← 0` must sit **before** the loop – inside it, the total resets on every pass – and the division must sit **after** it, or the average is taken of an unfinished total.

Exam tips

- A **variable** can change while the program runs; a **constant** is fixed. Learn the five data types: integer, real, char, string, Boolean.
- Every program is built from three structures: **sequence**, **selection** (IF / CASE), and **iteration** (loops).
- A **WHILE** loop tests *before* the body, so it may run zero times; a **REPEAT … UNTIL** loop tests *after*, so it always runs at least once.
- `MOD` gives the remainder and `DIV` the whole-number part of a division: `17 MOD 5` is 2, `17 DIV 5` is 3.
- A **function** returns a value; a **procedure** does not. A **local** variable works only inside its block; a **global** one works anywhere.

5 Recap

Topic 8 – key takeaways

1. **Structures**
   sequence, selection, iteration
2. **Loops**
   FOR known; WHILE before; REPEAT after
3. **Subroutines**
   procedure acts; function returns a value
4. **Arrays & files**
   array = same type by index; file survives runs

Check yourself

1. Which loop may run zero times?
2. What is `17 MOD 5`?
3. Procedure or function: which returns a value?
4. From which index do string positions count?

```
{ ____
  ____ }
```

Answers **1.** WHILE **2.** 2 **3.** a function **4.** 1