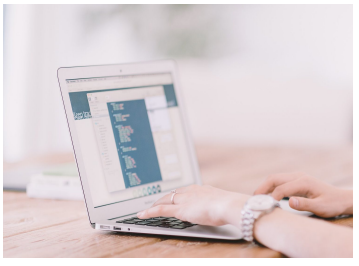
Programming

A-Level Computer Science

Programming basics

```
1 usage
public Hotel (Integer capacity) { this.capacity = capacity; }
1 usage
public synchronized boolean checkIn(AccommodationRequest request) {
    if (guests.size() < capacity) {
        guests.add(request);
        return true;
    }
    else {
        return false;
    }
}
```

Programming turns a design into instructions written as code

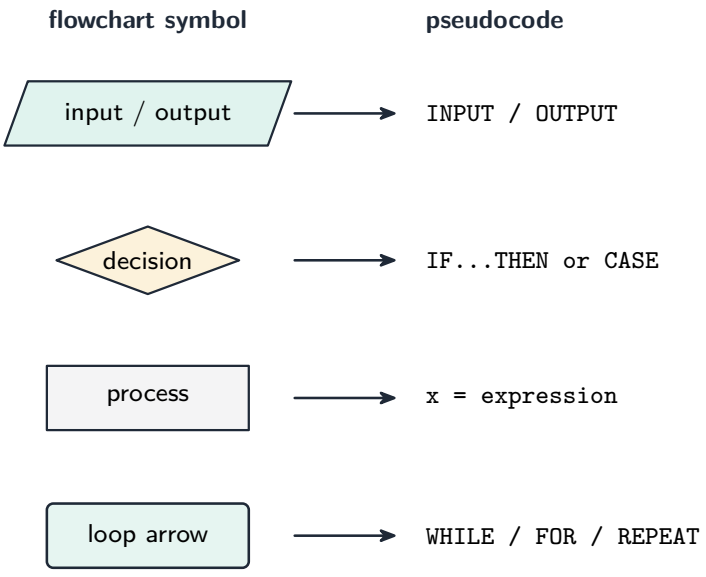


A programmer writes the code and tests it as they go

From design to code

You should be able to turn a design — a **flowchart** 流程图 (**program flowchart**) or **structured English** 结构化英语 — into **pseudocode** 伪代码, and then into a real language:

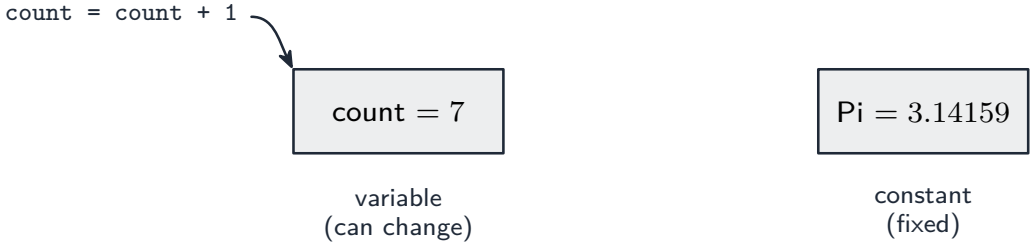
1. find the **variables** 变量 and their **data types** 数据类型.
2. turn input/output boxes into `INPUT` / `OUTPUT`.
3. turn decision diamonds into `IF...ELSE...ENDIF` (or `CASE`).
4. turn loop arrows into `WHILE`, `REPEAT...UNTIL`, or `FOR`.
5. turn process boxes into assignments or calculations.
6. check by tracing a small input.



Each flowchart symbol becomes a pseudocode keyword

Constants and variables

A **constant** 常量 holds a value that **never changes**; a variable holds one that may change. Declare them with a type:



A variable's value can change; a constant stays fixed

```
CONSTANT Pi ← 3.14159
DECLARE Radius : REAL
DECLARE Area : REAL

Radius ← 5
Area ← Pi * Radius * Radius
```

Use constants for fixed values that recur (`Pi`, `MaxScore`); they make code clearer and easy to change in one place.

In the exam, a constant is the answer to "identify a more appropriate way of representing" a fixed value, such as a tax rate or a maximum score, that appears at several places in the pseudocode. The benefits the scheme lists: the value is set once and **cannot be changed accidentally** by the program; a change is made **in one place** and reaches every statement that uses it; the identifier gives the value a **meaning** (`MaxScore` rather than `100`), so the code is easier to read and to check; and there is less risk of a typing error in a long value such as `3.14159`. A "state a value that could be replaced by a constant" question wants the literal from the pseudocode (`0.2`, `40`), not a new name.

Every variable is declared once, with an **identifier** 标识符 (its name) and a data type, before it is used. The six types in the 9618 pseudocode guide:

Type	Holds	Written in the code as	Typical use
`INTEGER`	whole numbers	`42`, `-3`	a count, an array index, a loop counter
`REAL`	numbers with a fractional part	`3.75`	a price, an average
`CHAR`	one character	`'A'` (single quotes)	a grade letter, a menu key
`STRING`	a sequence of characters	`"Hello"` (double quotes)	a name, a postcode
`BOOLEAN`	`TRUE` or `FALSE`	`TRUE`	a flag such as `Found`
`DATE`	a calendar date	`12/05/2026`	a date of birth

A "give the appropriate data type" question is answered from how the variable is **used** in the pseudocode: a value with a decimal point is `REAL`; something set to `TRUE` or `FALSE` is `BOOLEAN`; a value in single quotes is `CHAR`; a value used as an array index, or with `DIV` and `MOD`, is `INTEGER`. Write the type in capitals, spelled as the guide spells it.

Worked example. State the appropriate data type for each variable.

```
Found ← FALSE
Initial ← 'K'
Price ← 12.99
Count ← Count + 1
Name ← "Li Wei"
```

`Found` is `BOOLEAN` (it holds `FALSE`); `Initial` is `CHAR` (one character in single quotes); `Price` is `REAL` (a decimal value); `Count` is `INTEGER` (a counter that goes up by one); `Name` is `STRING` (text in double quotes).

Assignment and expressions

Use ← for **assignment** 赋值:

```
Total ← Total + 1
Average ← Sum / Count
```

Expressions use **operators** 运算符:

- arithmetic `+ - * /`, plus `DIV` (integer division) and `MOD` (remainder): `7 DIV 2 = 3`; `7 MOD 2 = 1`.
- comparisons `=`, `<>`, `<`, `>`, `<=`, `>=`.
- logic `AND`, `OR`, `NOT`.

Precedence 优先级 (highest to lowest): `NOT` → `* / DIV MOD` → `+ -` → comparisons → `AND` → `OR`. Use brackets when unsure.

Input and output

```
OUTPUT "Enter your name:"
INPUT Name
OUTPUT "Hello, ", Name
```

Built-in functions and library routines

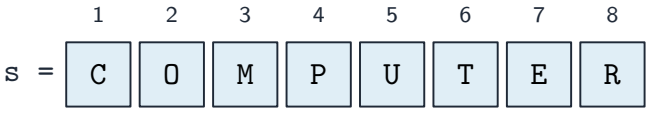
Many tasks have ready-made **library routines** 库例程, so you need not write them. The Paper 2 **insert** 附页 lists the ones you may use, with their exact names, parameters and return types; any other function a question needs is given in the question. The names below are the 9618 names — the IGCSE names (`UCASE`, `VAL`, `STR`) are not accepted.

A **program library** 程序库 holds routines that have already been written, compiled and tested; a program calls them instead of writing its own. The benefits the scheme accepts, for a "state three benefits" question: the routines are **already tested**, so they are less likely to contain errors; they **save development time**; they may do things the programmer could not write (complex statistics, graphics); they are written by experts and **reused** across many programs; and a routine with a fixed interface can be called from anywhere in the program.

Routine	Returns	Example
`LENGTH(s)`	the number of characters in `s`	`LENGTH("Hello") = 5`
`LEFT(s, n)` / `RIGHT(s, n)`	the first / last `n` characters	`RIGHT("Hello", 2) = "lo"`
`MID(s, start, n)`	`n` characters from position `start` (positions count from 1)	`MID("Hello", 2, 3) = "ell"`
`TO_UPPER(s)` / `TO_LOWER(s)`	`s` in capitals / in small letters	`TO_UPPER("ab1") = "AB1"`
`NUM_TO_STR(x)` / `STR_TO_NUM(s)`	a number as a string / a string as a number	`STR_TO_NUM("3.5") = 3.5`
`IS_NUM(s)`	`TRUE` if `s` is a valid number	`IS_NUM("12a") = FALSE`
`ASC(c)` / `CHR(n)`	the character code of `c` / the character with code `n`	`ASC('A') = 65`, `CHR(66) = 'B'`
`INT(x)`	the whole-number part of `x`	`INT(7.9) = 7`
`RAND(n)`	a random real number from 0 up to, but not including, `n`	`INT(RAND(6)) + 1` is a dice roll
`DAY(d)`, `MONTH(d)`, `YEAR(d)`	the parts of a `DATE`	`YEAR(TODAY())`
`DAYINDEX(d)`, `SETDATE(d, m, y)`, `TODAY()`	the day of the week (1 = Sunday); a date built from three integers; today's date	
`EOF(f)`	`TRUE` when the file `f` has no more lines to read	`WHILE NOT EOF("data.txt")`

Strings are joined with `&` (**concatenation** 连接): `"A" & "BC"` is `"ABC"`. Use the exact names from the insert, with the parameters in its order.

Dates and random numbers come up as one-line statements. `SETDATE(17, 11, 2007)` builds 17 November 2007; `12 - MONTH(MyDOB)` is the number of months from the month of birth to the end of the year; `IF DAYINDEX(MyDOB) = 5 THEN` tests for a Thursday, because Sunday is day 1. `RAND(n)` returns a real number from `0` up to, but not including, `n`, so a random **integer** from `Low` to `High` inclusive is `INT(RAND(High - Low + 1)) + Low`: `INT(RAND(21)) - 10` gives a value from `-10` to `10`.




```
LENGTH(s) = 8              RIGHT(s, 2) = "ER"
LEFT(s, 3) = "COM"         TO_UPPER(s) = "COMPUTER"
MID(s, 4, 3) = "PUT"       TO_LOWER(s) = "computer"
```

The common string routines acting on `s = "COMPUTER"` (positions 1–8)

Worked example. Evaluate each expression, given `Word ← "Program"`, `Code ← 'Q'` and `N ← 7`.

Expression	Value	Why
`LENGTH(Word)`	`7`	seven characters
`MID(Word, 4, 2)`	`"gr"`	two characters, starting at position 4
`LEFT(Word, 3) & "!"`	`"Pro!"`	joined with `&`
`TO_UPPER(RIGHT(Word, 2))`	`"AM"`	the inner function runs first
`ASC(Code) - ASC('A')`	`16`	`'Q'` is 81 and `'A'` is 65
`N DIV 2 + N MOD 2`	`4`	`3 + 1`
`NUM_TO_STR(N) & "th"`	`"7th"`	the number becomes a string first
`INT(N / 2)`	`3`	`3.5` cut to its whole part

Work from the inside out, and keep the quotes: `"7"` is a string and `7` is a number.

Worked example. Each statement may contain an error in its use of a function or operator. Describe the error, or write NO ERROR. (Assume every variable has the correct type.)

Statement	Error
`Result ← 2 & 4`	`&` joins strings; `2` and `4` are integers, so `+` is needed
`SubString ← MID("pseudocode", 4, 1)`	NO ERROR: one character from position 4, `"u"`
`IF x = 3 OR 4 THEN`	`OR` needs a Boolean on each side: `IF x = 3 OR x = 4 THEN`
`Result ← Status AND INT(x / 2)`	`AND` needs two Booleans; `INT(x / 2)` is an integer
`Message ← "Done" + LENGTH(MyString)`	`+` cannot add a string to an integer: `"Done" & NUM_TO_STR(LENGTH(MyString))`

Every operator works on particular types: `&` on strings, `+ - * / DIV MOD` on numbers, `AND OR NOT` on Booleans, and `= <>` on two values of the **same** type. An "evaluate

each expression, or write ERROR" table is marked the same way: `LENGTH(42)` and `"A" + 1` are ERROR, because the type does not match the function or the operator.

Worked example. With `Points ← 100`, `Active ← TRUE` and `Exempt ← FALSE`, evaluate each expression.

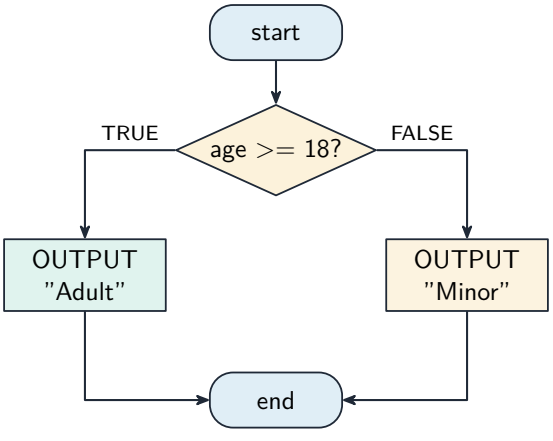
Expression	Value	Why
`(Points > 99) OR Active`	`TRUE`	both sides are true; one would do
`(Points MOD 2 = 0) OR Exempt`	`TRUE`	`100 MOD 2` is `0`
`(Points <= 75) AND (Active OR Exempt)`	`FALSE`	the first side is false, and `AND` needs both
`(Active OR NOT Active) AND NOT Exempt`	`TRUE`	`Active OR NOT Active` is always true

The last expression simplifies: `X OR NOT X` is `TRUE` whatever `X` is, so the whole expression is just `NOT Exempt`. Evaluate the brackets first, then `NOT`, then `AND`, then `OR`.

Selection

Selection 选择 chooses which steps run.

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



An IF…ELSE tests the condition once, then runs exactly one branch

For more than two cases you can use a **nested** 嵌套 IF, but deep nesting is hard to read — a `CASE` is cleaner when testing one value against several options:

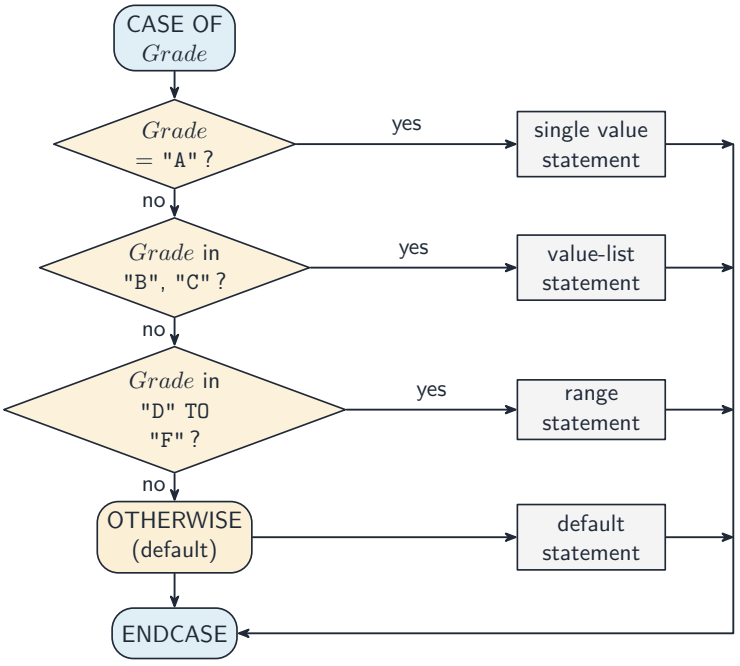
```
CASE OF Grade
    "A": OUTPUT "Excellent"
    "B": OUTPUT "Good"
    OTHERWISE: OUTPUT "Try again"
ENDCASE
```

Cambridge `CASE` allows single values, value lists (`1, 2, 3:`), and ranges (`1 TO 5:`).

A nested IF is an IF inside a branch of another IF. Each `IF` needs its own `ENDIF`, and the examiner checks that every construct is closed:

```
IF Mark >= 50 THEN
    IF Mark >= 80 THEN
        OUTPUT "Distinction"
    ELSE
        OUTPUT "Pass"
    ENDIF
ELSE
    OUTPUT "Fail"
ENDIF
```

Boundaries are where marks are lost. "A mark of 50 or more passes" is `Mark >= 50`, not `Mark > 50`; the last `CASE` branch, for "anything else", is written `OTHERWISE`, not a condition such as `> 200`. A wrong comparison here is a **logic error** 逻辑错误: the program runs, but gives the wrong output for some inputs — and a trace table with a boundary value such as `50` is how you find it.



A CASE statement runs the branch that matches the value

Worked example. Rewrite this with the same functionality, without using a CASE structure.

```
CASE OF MySwitch
    1: ThisChar ← 'a'
    2: ThisChar ← 'y'
    3: ThisChar ← '7'
    OTHERWISE: ThisChar ← '*'
ENDCASE
```

Each value becomes a branch of a chain of IFs, and `OTHERWISE` becomes the last `ELSE`:

```
IF MySwitch = 1 THEN
    ThisChar ← 'a'
ELSE
    IF MySwitch = 2 THEN
        ThisChar ← 'y'
    ELSE
        IF MySwitch = 3 THEN
            ThisChar ← '7'
        ELSE
            ThisChar ← '*'
        ENDIF
    ENDIF
```

```
ENDIF
```

Two clauses that assign the same value are merged into one clause with a value list: `1, 2: ThisChar ← 'a'`. The guards are tested **in order**: with ranges such as `1 TO 50:` followed by `40 TO 60:`, a value of `45` takes the first branch that matches, so an assignment in a later branch may **never be performed** — and when the earlier branches already cover every possible value, the `OTHERWISE` branch is never reached either.

Going the other way, nested IFs that test several Booleans are clearer as one condition per outcome: `IF A AND B AND C THEN CALL Sub1()`, then `IF A AND B AND NOT C THEN CALL Sub2()`, and so on. Joining tests with `AND` and `OR` removes the nesting, and `IF A THEN` is accepted in place of `IF A = TRUE THEN`.

Iteration

Iteration 迭代 repeats a block. Three loops differ in how many times the body runs.

Count-controlled (FOR) loop

A **count-controlled loop** 计数循环 — use it when you know how many times to repeat:

```
FOR i ← 1 TO 10
    OUTPUT i
NEXT i
```

A `STEP` can change the count (e.g. `FOR i ← 10 TO 1 STEP -1`). Best for a fixed number of repeats or processing each element of an **array** 数组.

Pre-condition (WHILE) loop

A **pre-condition loop** 前测循环 tests the condition **before** each pass, so it may run **zero** times:

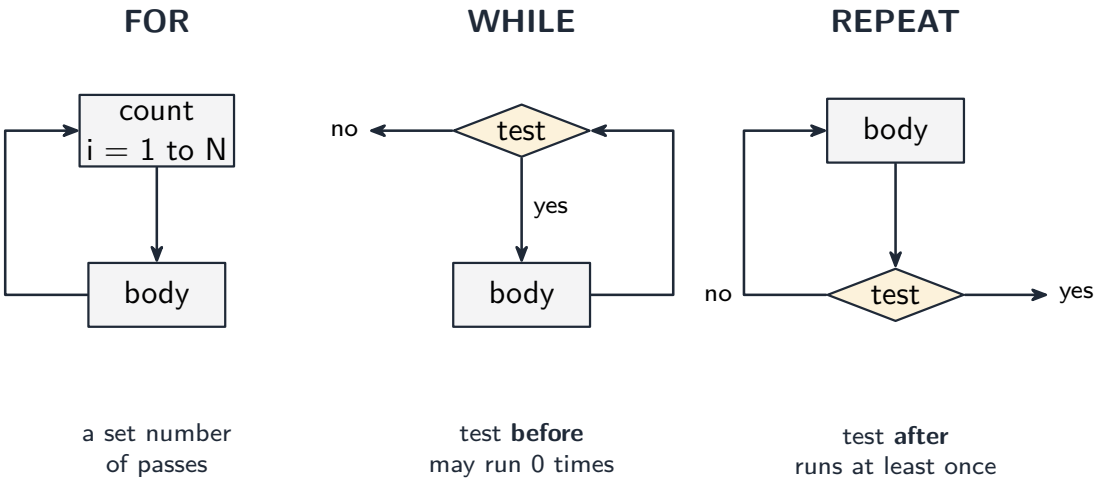
```
WHILE total < 100 DO
    INPUT n
    total ← total + n
ENDWHILE
```

Post-condition (REPEAT...UNTIL) loop

A **post-condition loop** 后测循环 tests the condition **after** each pass, so it always runs **at least once**:

```
REPEAT
    INPUT password
UNTIL password = correctPassword
```

Choosing the right loop



The three loops differ in where the condition is tested — before the body (WHILE), after it (REPEAT), or a set number of times (FOR)

- count known up front → **FOR**.
- may need zero passes → **WHILE**.
- always at least one pass → **REPEAT...UNTIL**.

Justify your choice by whether the count is known and whether the body must run at least once. A typical question gives a scenario ("ask for a password until correct, but always ask at least once") and asks which loop fits.

The two marks are for the **name** of the loop and the **reason**, in the scheme's words: *count-controlled, because the number of iterations is known before the loop starts*; *post-condition, because the loop body must be executed at least once*; *pre-condition, because the loop may not need to execute at all.* A loop over the four elements of an array that has been written as a `WHILE` with a counter is "not the most appropriate": the count, four, is known, so a `FOR` loop fits.

Worked example. Which loop suits each task? (a) print the 12 times table; (b) keep reading numbers until the user enters 0; (c) ask for a password until it is correct. Choose by asking **how many times** the body runs and **when the test happens**. (a) The count is known in advance (12), so use a **FOR** loop. (b) The count is unknown, and the very first input might already be 0 - so the test must come **before** the body: a **WHILE** loop, which runs **zero** or more times. (c) The count is unknown, but you must always ask **at least once** before there is anything to test - so the test comes **after** the body: a **REPEAT...UNTIL**, which runs **one** or more times. The deciding question is whether the body must run at least once: WHILE may run zero times, REPEAT always runs once.

Dry running with a trace table

A **trace table** 跟踪表 records the value of each variable as you **dry run** 手工跟踪 (work through by hand) an algorithm. It is how you test a loop on paper, and a six-mark question on most Paper 2s.

```
DECLARE Count, Total : INTEGER
Count ← 1
Total ← 0
WHILE Total < 10
    Total ← Total + Count * 2
    Count ← Count + 1
ENDWHILE
OUTPUT Count, Total
```

Count	Total	Total < 10	OUTPUT
1	0	TRUE	
2	2	TRUE	
3	6	TRUE	
4	12	FALSE	4, 12

Rules that earn the marks: one column per variable, in the order the question gives; write a value only when it **changes**; start a new row each time the loop repeats; evaluate the condition with the current values, and stop the moment it is `FALSE`; put the output in its own column, exactly as it would appear. Trace the algorithm as written, not the one you think was intended — if it never stops, say so.

Worked example. Which constructs does each line use — selection, iteration or a subroutine call?

Pseudocode	Selection	Iteration	Subroutine
`IF Ready = TRUE THEN CALL Start() ENDIF`	yes		yes
`FOR I ← 1 TO 20 ... NEXT I`		yes	
`WHILE NOT IsFull() ... ENDWHILE`		yes	yes
`CASE OF Key ... OTHERWISE ... ENDCASE`	yes		

`IF` and `CASE` are selection; `FOR`, `WHILE` and `REPEAT` are iteration; a name followed by brackets — `Start()`, `IsFull()` — is a call to a procedure or a function, wherever it appears, including inside a condition.

Procedures and functions

Structured programming 结构化编程 builds a program from small named **subroutines** 子程序, each with one job.

Procedure

A **procedure** 过程 is a named block that **does an action**; it may take **parameters** 参数 but does **not return a value**.

```
PROCEDURE Greet(name : STRING)
    OUTPUT "Hello, ", name
ENDPROCEDURE

CALL Greet("Ada")
```

Function

A **function** 函数 is like a procedure but it **returns a value** that becomes part of an expression.

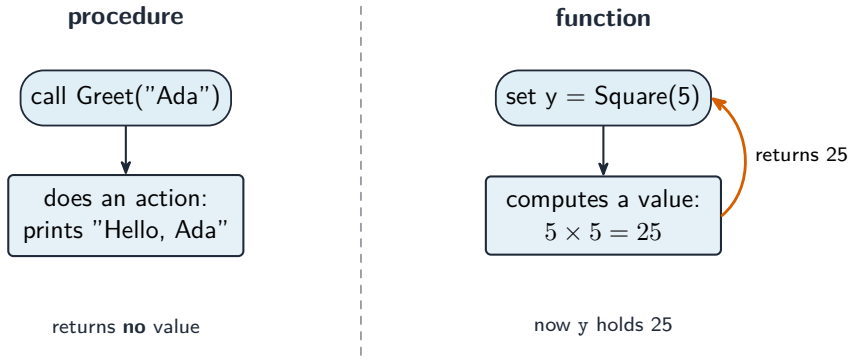
```
FUNCTION Square(x : INTEGER) RETURNS INTEGER
    RETURN x * x
ENDFUNCTION

result ← Square(5) + 1     // result = 26
```

Use a **procedure** when the subroutine performs an action; use a **function** when it computes a value for the caller.

The syllabus asks *where in the construction of an algorithm* each is appropriate. A procedure is appropriate where the same group of steps is needed at several points (validate an input, print a menu, swap two values): the steps are written once and

`CALL`ed by name. A function is appropriate where a single value must be calculated and then used in an expression — a total, a `TRUE`/`FALSE` result, the larger of two numbers — because the **return value** 返回值 replaces the call: `IF IsValid(Code) THEN`.

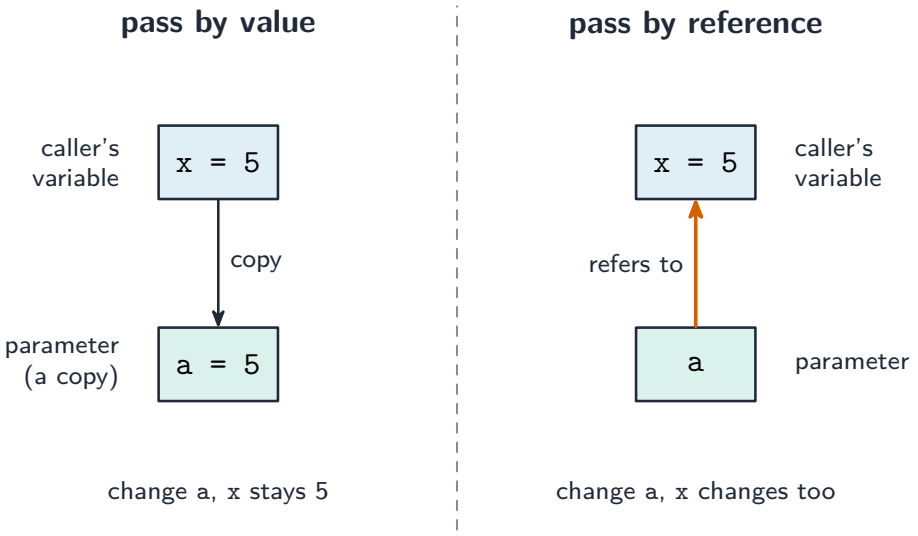


A procedure does an action and returns nothing; a function returns a value you use in an expression

Parameters

A **parameter** is a variable a subroutine declares to receive input; the values the caller supplies are **arguments** 实参. Two ways to pass them:

- **pass by value** 传值 — the routine gets a **copy**; changes inside it do not affect the caller. Use for inputs it only reads.
- **pass by reference** 传引用 — the routine gets a **reference** to the caller's variable; changes **do** affect the caller. Use when it must update a parameter.



Pass by value copies the value into a new box; pass by reference lets the routine change the caller's own variable

```
PROCEDURE Swap(BYREF a : INTEGER, BYREF b : INTEGER)
    DECLARE temp : INTEGER
    temp ← a
    a ← b
    b ← temp
ENDPROCEDURE
```

Cambridge pseudocode writes the mode in the header, `BYVAL` or `BYREF`, before each parameter. If neither is written, `BYVAL` is assumed, so a routine that must change the caller's variable — `Swap`, or a procedure that updates a running total — needs `BYREF` in its header.

Worked example. What is output?

```
PROCEDURE Adjust(BYREF X : INTEGER, BYVAL Y : INTEGER)
    X ← X + Y
    Y ← Y * 2
ENDPROCEDURE

A ← 5
B ← 3
CALL Adjust(A, B)
OUTPUT A, B
```

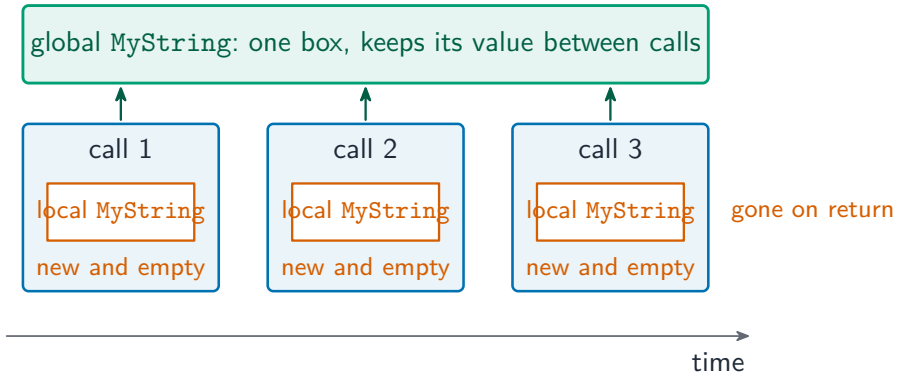
`X` is a reference to `A`, so `A` becomes `8`. `Y` is a copy of `B`, so doubling `Y` leaves `B` at `3`. The output is `8, 3`. Had the header said `BYVAL X`, `A` would still be `5`.

Local vs global variables

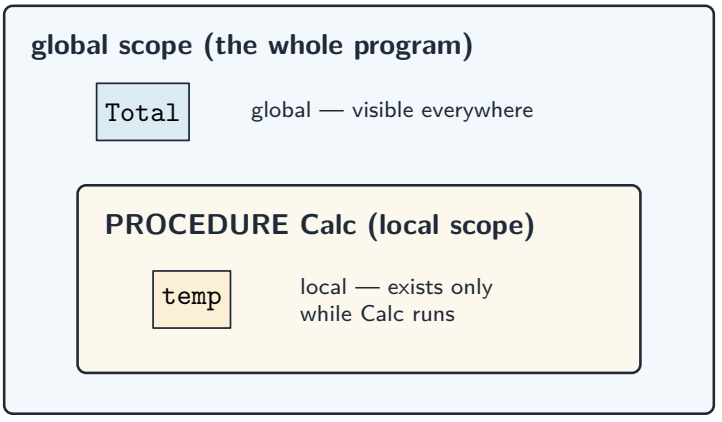
A **local variable** 局部变量 is declared inside a subroutine and exists only while it runs. A **global variable** 全局变量 is declared outside and is visible everywhere. Prefer locals and parameters — heavy use of globals makes code hard to follow and test. (The region where a name is visible is its **scope** 作用域.)

The one-line difference: a global variable can be accessed from anywhere in the program, a local variable only inside the subroutine that declares it. Benefits of local variables the scheme accepts: the same identifier can be used in another subroutine without a clash; the value cannot be changed accidentally by other parts of the program; the memory is released when the subroutine ends; and the subroutine is **self-contained**, so it can be tested on its own and reused in another program.

A local variable is created **each time** the subroutine is called and destroyed when it returns, so it cannot carry a value from one call to the next. A procedure that builds up a string over repeated calls therefore needs that string to be global (or passed `BYREF`). If `MyString` is changed from a global to a local declared inside `MyOutput()`, every call starts with a new, empty `MyString`, the text added by earlier calls is lost, and the procedure "does not work as expected".



A local variable is a new, empty box on every call; only a global variable (or a BYREF parameter) keeps a value between calls



A global variable is visible everywhere; a local variable exists only inside its own procedure

When to use a subroutine

Use a subroutine when:

- the same logic appears in **more than one place** — write it once, call it many times.
- a block has a **clear named purpose** — the name documents what it does.
- the program is **complex** — break it into parts (**decomposition** 分解).
- you want to **test a piece in isolation**.

Don't make them so tiny that the call costs more than the work inside.

Terminology

- **definition** — the `PROCEDURE ... ENDPROCEDURE` (or function) block.
- **call** — where it is invoked. **argument** — a value passed in. **parameter** — the variable that receives it.
- **return value** — what a function passes back.
- **procedure/function header** — the first line giving the name and parameters (`PROCEDURE Name(params)` or `FUNCTION Name(params) RETURNS type`).
- **procedure/function interface** / **signature** 签名 — name + parameters + return type: what a caller must know to use it.

Worked example. Describe each term used in the header `FUNCTION Pass2(Count : INTEGER) RETURNS BOOLEAN`.

Term	Meaning
`FUNCTION`	a subroutine that returns a value
`Pass2`	the identifier used to call it
`Count`	the parameter: the identifier that receives the argument passed in
`INTEGER`	the data type of the parameter
`RETURNS`	the data type of the value the function returns
`BOOLEAN`	

The two identifiers in `PROCEDURE MyProc(Count : INTEGER, Message : STRING)` are **parameters**: they receive the values passed in when the procedure is called, and are used inside it like local variables.

To convert a procedure into a function: change `PROCEDURE` to `FUNCTION` and add `RETURNS <type>`; replace the `OUTPUT` (or the `BYREF` parameter that carried the result out) with a `RETURN` statement; and change every call so that the returned value is used, `Result ← Unpack(Text)` instead of `CALL Unpack(Text, Result)`. For a "write the header" question, write the whole line: `FUNCTION Calculate(Expression : STRING) RETURNS INTEGER`. An array parameter is passed **by reference**, so a procedure that writes into an array changes the caller's array.

When a program gains a new module, the interface is what is agreed first: the name, the parameters (how many, in what order, of what type) and the return type, plus any global data the module reads or writes. A module that sends a reminder before a due date needs the record (or its index) as a parameter and returns nothing, so it is a procedure; the main program calls it once per record.

Writing a module for Paper 2

Half of Paper 2 is "write pseudocode for module X". The scheme awards a mark per feature, so a module that is not finished still scores for every correct part. The parts the examiner looks for:

```
FUNCTION CountAbove(BYVAL Limit : INTEGER) RETURNS INTEGER
    DECLARE Index, Count : INTEGER
    Count ← 0
    FOR Index ← 1 TO 50
        IF Score[Index] > Limit THEN
            Count ← Count + 1
        ENDIF
    NEXT Index
    RETURN Count
ENDFUNCTION
```

header: name, parameters, return type
local variables declared with a type
total initialised before the loop
loop over every element
the condition, with the right boundary
the update, inside the IF
every construct closed
the return value, after the loop

Each part of a module answer carries its own mark, so write all of them even when one is uncertain

1. **The header**, as the question describes it: `PROCEDURE Name(Param : TYPE)` or `FUNCTION Name(Param : TYPE) RETURNS TYPE`, with `BYREF` where the routine must change the argument.
2. **Local declarations**: `DECLARE` every local variable with its type, and initialise counters and totals (`Count ← 0`).
3. **The loop** that visits every element: `FOR Index ← 1 TO 50` for an array whose size is given; `WHILE NOT EOF(...)` for a file.
4. **The condition**, with the right comparison and boundary, on the right item: `IF Score[Index] > Limit THEN`.
5. **The update** inside the branch: the count increased, the value stored, or the message output.
6. **The end**: `RETURN` once, after the loop, in a function; `ENDFUNCTION` or `ENDPROCEDURE`; and every `IF`, `FOR` and `WHILE` closed.

Worked example. A global array `Score : ARRAY[1:50] OF INTEGER` holds test scores. Write a function `CountAbove(Limit : INTEGER)` that returns how many scores are greater than `Limit`.

```
FUNCTION CountAbove(BYVAL Limit : INTEGER) RETURNS INTEGER
    DECLARE Index, Count : INTEGER
    Count ← 0
    FOR Index ← 1 TO 50
        IF Score[Index] > Limit THEN
            Count ← Count + 1
        ENDIF
    NEXT Index
    RETURN Count
```

```
ENDFUNCTION
```

Marks: the header with its parameter and `RETURNS INTEGER`; `Count` declared and set to `0`; a loop over all 50 elements; the comparison `> Limit` (not `>=`); the count updated inside the `IF`; `RETURN Count` after the loop. The main program uses the return value in an expression or an output: `OUTPUT "Above 70: ", CountAbove(70)`.

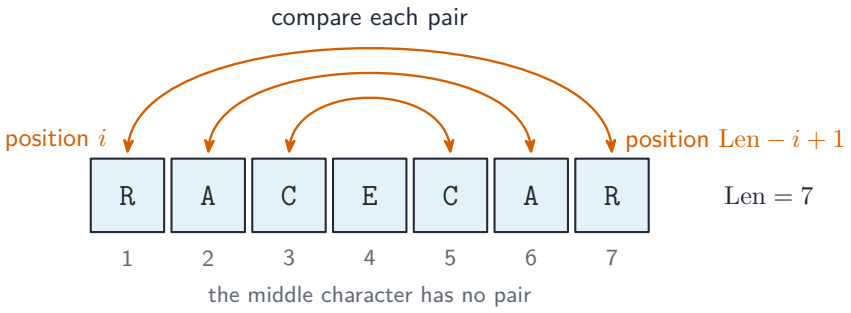
Worked example. Write a function `IsValid(Code : STRING)` that returns `TRUE` when `Code` is two capital letters followed by four digits — the **format** 格式 `AB1234` — and `FALSE` otherwise.

```
FUNCTION IsValid(BYVAL Code : STRING) RETURNS BOOLEAN
    DECLARE Index : INTEGER
    DECLARE Ch : STRING
    IF LENGTH(Code) <> 6 THEN
        RETURN FALSE
    ENDIF
    FOR Index ← 1 TO 6
        Ch ← MID(Code, Index, 1)
        IF Index <= 2 THEN
            IF Ch < "A" OR Ch > "Z" THEN
                RETURN FALSE
            ENDIF
        ELSE
            IF Ch < "0" OR Ch > "9" THEN
                RETURN FALSE
            ENDIF
        ENDIF
    NEXT Index
    RETURN TRUE
ENDFUNCTION
```

The length check comes first, so `MID` is never asked for a position that does not exist. **Validation** 验证 like this returns a `BOOLEAN` so the caller can write `IF IsValid(Entry) THEN ... ELSE OUTPUT "Invalid code" ENDIF`: a message to the user is output by the caller, not by the function — a function calculates, a procedure acts.

Worked example. Write a function `IsPalindrome(Word : STRING)` that returns `TRUE` when `Word` reads the same backwards, such as `"RACECAR"`.

Compare the characters from the two ends, moving inwards: position `Index` is paired with position `Len - Index + 1`, and only the first half needs testing.



A palindrome check pairs position `i` *with position* `Len - i + 1` *and stops at the middle*

```
FUNCTION IsPalindrome(BYVAL Word : STRING) RETURNS BOOLEAN
    DECLARE Len, Index : INTEGER
    Len ← LENGTH(Word)
    FOR Index ← 1 TO Len DIV 2
        IF MID(Word, Index, 1) <> MID(Word, Len - Index + 1, 1) THEN
            RETURN FALSE
        ENDIF
    NEXT Index
    RETURN TRUE
ENDFUNCTION
```

The same three tools — a `FOR` over the positions, `MID(s, i, 1)` to read one character, and `&` to build a new string — answer most string modules on Paper 2: counting how often a character occurs (`IF MID(s, i, 1) = Ch THEN Count ← Count + 1`), replacing every instance of a character (add either `NewChar` or the original character to `NewString` at each position), hiding all but the last four digits of a card number (add `'*'` for every position up to `Len - 4`), or writing your own `MID()` by joining the characters from `Start` to `Start + Length - 1`. Asking `MID` for a position past the end of the string is a **run-time error**, so check `LENGTH` first.

Files. Values in variables disappear when the program ends, so a module that must keep data for the next run writes it to a file: `OPENFILE "scores.txt" FOR WRITE`, one `WRITEFILE "scores.txt", NUM_TO_STR(Score[Index])` per line inside the loop, and `CLOSEFILE "scores.txt"` once, after the loop; reading back uses `FOR READ`, `READFILE` and `WHILE NOT EOF("scores.txt")`. Topic 10 has the full file section; here the marks are for opening in the right mode, the read or write inside the loop, and closing once after it.

Writing efficient pseudocode

Three features that make pseudocode easier to understand — the answer to a "state three features" question — are **meaningful identifiers** (`Total`, not `t`), **indentation** of the statements inside each construct, and **comments** (`// ...`) that explain the purpose; keywords in capitals, one statement per line and blank lines between sections are also accepted. Efficient pseudocode goes further:

- **move invariants out of loops** — if a value (an **invariant** 不变量) does not change with the loop counter, compute it once before the loop.
- **exit a loop early** when the answer is found (stop a **linear search** 线性查找 as soon as the target appears).
- **avoid redundant work** — store a result and reuse it instead of recomputing.
- **choose the right data structure** — an array beats many separate variables when the items belong together.
- **replace deep nested IFs with CASE** when testing one value against many.
- **comment the intent**, not the mechanics (`// validate the postcode`, not `// loop 6 times`).
- **use meaningful names** (`numberOfPupils`, not `n`) and **initialise variables** before use.

slower

```
FOR i = 1 TO n
 x = slow()  // every pass
 use(x, i)
NEXT i
```

faster

```
x = slow()  // once
FOR i = 1 TO n
 use(x, i)
NEXT i
```

Move unchanging work out of the loop so it runs once

Testing and errors

Three kinds of error, each found in a different way:

Error	What it is	Example	Found by
syntax error 语法错误	a statement that breaks the rules of the language	a missing `ENDIF`; `OUTPT "Hi"`	the translator, before the program runs
run-time error 运行时错误	the program runs, but a statement cannot be carried out	division by zero; an array index of 0 or 51; a function called with an invalid parameter; a loop that never ends, so the program "freezes"	while running: the program stops or hangs
logic error	the program runs to the end, but the output is wrong	`>` where `>=` was needed; a total never set to `0`	testing with a trace table and chosen test data

An **IDE** 集成开发环境 helps find the last two: a **breakpoint** 断点 stops the program at a chosen line; **single stepping** 单步执行 then runs one statement at a time; and the report (or watch) window shows the value of each variable at that moment, so the line where a value goes wrong is seen directly. Test methods and test data are in topic 12.

Definitions the examiner accepts

A definition question is marked against fixed wording. Learn these exactly.

Term	Definition
procedure	a subroutine that carries out a task (a sequence of steps) and does not return a value; it is called with `CALL`
function	a subroutine that returns a single value to the point where it was called, so it can be used in an expression
parameter	the identifier in a subroutine header that receives a value or a reference when the subroutine is called
argument	the value (or variable) supplied in the call, matched to a parameter
passing by value	a copy of the argument's value is given to the subroutine, so changes inside it do not affect the original variable
passing by reference	the address of the variable is given to the subroutine, so changes inside it change the original variable
header	the first line of a subroutine definition: its name, its parameters and, for a function, its return type
interface	what a calling program must know to use a subroutine: its name, its parameters (number, order, type) and its return type
return value	the value a function passes back to the expression that called it
local variable	declared inside a subroutine; it exists only while the subroutine runs and can be used only inside it
global variable	declared outside every subroutine; it can be used anywhere in the program
count-controlled loop	repeats a fixed number of times, controlled by a counter (`FOR ... NEXT`)
pre-condition loop	tests its condition before each iteration, so the body may never run (`WHILE ... ENDWHILE`)
post-condition loop	tests its condition after each iteration, so the body runs at least once (`REPEAT ... UNTIL`)
constant	a named value that cannot change while the program runs
subroutine	a self-contained block of code that performs a task and is called by name: a procedure or a function
library routine	a subroutine that has already been written and tested, and is available to be called from a program

Exam tips

- Distinguish a **procedure** (no return value) from a **function** (returns a value); know **pass by value vs by reference**.
- Choose the right loop: **count-controlled (FOR)** when the number of repeats is known, **condition-controlled (WHILE/REPEAT)** otherwise.

- Distinguish **local vs global** variables and scope; prefer local variables in reusable modules.
- Use the insert's exact routine names and parameter order; `UCASE` and `VAL` are IGCSE names and score nothing here.
- In a "write pseudocode" answer the header, the declarations, the loop, the condition, the update and the `RETURN` each carry a mark: write all six parts, even if one is uncertain.

Common mistakes

- Calling a function and not using what it returns. Assign the result, or use it in the expression or output: `Sorted ← BubbleSort(MyArray, 7)`.
- Passing a length one out: `6` for a seven-element array, or the last index where the length was wanted. Decide whether the parameter is a length or an index, and check that the last element is visited.
- Closing a file inside the loop that reads it. Open once, close once, after the loop.
- Using the input as a filename directly. Add the extension the question gave: `FileName ← Choice & ".txt"`.
- Leaving constructs open. Every `IF` needs its `ENDIF`, every `FOR` its `NEXT`, every `WHILE` its `ENDWHILE`, and every function its `RETURN`; the scheme has a mark for it.
- Wrong boundaries: `>` for "at least" (which is `>=`), or a `FOR` that starts at `0` for an array declared `[1:50]`.
- A counter or total that is never set to `0` before the loop.
- In a trace table, rewriting every variable on every row, or changing a value before the statement that changes it has run.
- Half a condition: `IF x = 3 OR 4` — each side of `OR` and `AND` must be a complete comparison. And `+` does not join strings; `&` does.
- Declaring as local a value that must survive between calls. A running total or a string built up over several calls is global or `BYREF`.