

Pseudocode Guide for Teachers

Cambridge
O Level

Cambridge O Level Computer Science

2210

For examination from 2016

In order to help us develop the highest quality Curriculum Support resources, we are undertaking a continuous programme of review; not only to measure the success of our resources but also to highlight areas for improvement and to identify new development needs.

We invite you to complete our survey by visiting the website below. Your comments on the quality and relevance of Cambridge Curriculum Support resources are very important to us.

<https://www.surveymonkey.co.uk/r/GL6ZNJB>

Do you want to become a Cambridge consultant and help us develop support materials?

Please follow the link below to register your interest.

<http://www.cie.org.uk/cambridge-for/teachers/teacherconsultants/>

Cambridge International Examinations retains the copyright on all its publications. Registered Centres are permitted to copy material from this booklet for their own internal use. However, we cannot give permission to Centres to photocopy any material that is acknowledged to a third party even for internal use within a Centre.

Contents

Introduction	4
How should teachers use this guide?	4
1. Pseudocode in examined components	5
1.1 Font style and size	5
1.2 Indentation	5
1.3 Case and italics	5
1.4 Lines and numbering	6
1.4 Comments	6
2. Variables, constants and data types	7
2.1 Atomic type names	7
2.2 Literals	7
2.3 Identifiers	7
2.4 Assignments	7
3. Arrays	9
3.1 Using arrays	9
4. Common operations	10
4.1 Input and output	10
4.2 Arithmetic operations	10
4.3 Logic operators	10
5. Selection	11
5.1 IF statements	11
5.2 CASE statements	12
6. Iteration	13
6.1 Count-controlled (FOR) loops	13
6.2 Post-condition (REPEAT UNTIL) loops	13
6.3 Pre-condition (WHILE) loops	14
7. Index of symbols and keywords	15

Introduction

How should teachers use this guide?

We advise teachers to follow this guide in their teaching and make sure that learners are familiar with the style presented here. This will enable learners to understand any pseudocode presented in examination papers and pre-release materials more easily. It will also give them a structure to follow so that they can present their algorithms more clearly in pseudocode when required.

Teachers should be aware that learners are not *required* to follow this guide in their examination answers or any other material they present for assessment. By definition, pseudocode is not a programming language with a defined, mandatory syntax. Any pseudocode presented by candidates will only be assessed for the logic of the solution presented – where the logic is understood by the Examiner, and correctly solves the problem addressed, the candidate will be given credit regardless of whether the candidate has followed the style presented here. Using a recommended style will, however, enable the candidate to communicate their solution to the Examiner more effectively.

1. Pseudocode in examined components

The following information sets out how pseudocode will appear within the examined components and is provided to allow you to give learners familiarity before the exam.

1.1 Font style and size

Pseudocode is presented in a monospaced (fixed-width) font such as `Courier New`. The size of the font will be consistent throughout.

1.2 Indentation

Lines are indented by four spaces to indicate that they are contained within a statement in a previous line.

Where it is not possible to fit a statement on one line any continuation lines are indented by two spaces. In cases where line numbering is used, this indentation may be omitted. Every effort will be made to make sure that code statements are not longer than a line of code, unless this is absolutely necessary.

Note that the `THEN` and `ELSE` clauses of an `IF` statement are indented by only two spaces (see Section 5.1). Cases in `CASE` statements are also indented by only two places (see Section 5.2).

1.3 Case and italics

Keywords are in uppercase, e.g. `IF`, `REPEAT`, `PROCEDURE`. (Different keywords are explained in later sections of this guide.)

Identifiers are in mixed case (sometimes referred to as camelCase or Pascal case) with uppercase letters indicating the beginning of new words, for example `NumberOfPlayers`.

Meta-variables – symbols in the pseudocode that should be substituted by other symbols – are enclosed in angled brackets `< >` (as in Backus-Naur Form). This is also used in this guide.

Example – meta-variables

```
REPEAT
    <Statements>
UNTIL <condition>
```

1.4 Lines and numbering

Where it is necessary to number the lines of pseudocode so that they can be referred to, line numbers are presented to the left of the pseudocode with sufficient space to indicate clearly that they are not part of the pseudocode statements.

Line numbers are consecutive, unless numbers are skipped to indicate that part of the code is missing. This will also be clearly stated.

Each line representing a statement is numbered. However when a statement runs over one line of text, the continuation lines are not numbered.

1.4 Comments

Comments are preceded by two forward slashes `//`. The comment continues until the end of the line. For multi-line comments, each line is preceded by `//`.

Normally the comment is on a separate line before, and at the same level of indentation as, the code it refers to. Occasionally, however, a short comment that refers to a single line may be at the end of the line to which it refers.

2. Variables, constants and data types

2.1 Atomic type names

The following keywords are used to designate atomic data types:

- `INTEGER` : A whole number
- `REAL` : A number capable of containing a fractional part
- `CHAR` : A single character
- `STRING` : A sequence of zero or more characters
- `BOOLEAN`: The logical values `TRUE` and `FALSE`

2.2 Literals

Literals of the above data types are written as follows:

- Integers : Written as normal in the denary system, e.g. `5`, `-3`
- Real : Always written with at least one digit on either side of the decimal point, zeros being added if necessary, e.g. `4.7`, `0.3`, `-4.0`, `0.0`
- Char: A single character delimited by single quotes, e.g. `'x'`, `'C'`, `'@'`
- String: Delimited by double quotes. A string may contain no characters (i.e. the empty string) e.g. `"This is a string"`, `""`
- Boolean: `TRUE`, `FALSE`

2.3 Identifiers

Identifiers (the names given to variables, constants, procedures and functions) are in mix case. They can only contain letters (`A-Z`, `a-z`) and digits (`0-9`). They must start with a letter and not a digit. Accented letters and other characters, including the underscore, should not be used.

As in programming, it is good practice to use identifier names that describe the variable, procedure or function they refer to. Single letters may be used where these are conventional (such as `i` and `j` when dealing with array indices, or `X` and `Y` when dealing with coordinates) as these are made clear by the convention.

Keywords identified elsewhere in this guide should never be used as variables.

Identifiers should be considered case insensitive, for example, `Countdown` and `CountDown` should not be used as separate variables.

2.4 Assignments

The assignment operator is `←`.

Assignments should be made in the following format:

```
<identifier> ← <value>
```

The identifier must refer to a variable (this can be an individual element in a data structure such as an array or an abstract data type). The value may be any expression that evaluates to a value of the same data type as the variable.

Example – assignments

```
Counter ← 0  
Counter ← Counter + 1  
TotalToPay ← NumberOfHours * HourlyRate
```

3. Arrays

3.1 Using arrays

In the main pseudocode statements, only one index value is used for each dimension in the square brackets.

Example – using arrays

```
StudentNames[1] ← "Ali"  
NoughtsAndCrosses[2] ← 'X'  
StudentNames[n+1] ← StudentNames[n]
```

Arrays can be used in assignment statements (provided they have same size and data type). The following is therefore allowed:

Example – assigning an array

```
SavedGame ← NoughtsAndCrosses
```

A statement should **not**, however, refer to a group of array elements individually. For example, the following construction should not be used.

```
StudentNames [1 TO 30] ← ""
```

Instead, an appropriate loop structure is used to assign the elements individually. For example:

Example – assigning a group of array elements

```
FOR Index ← 1 TO 30  
    StudentNames[Index] ← ""  
NEXT Index
```

4. Common operations

4.1 Input and output

Values are input using the `INPUT` command as follows:

```
INPUT <identifier>
```

The identifier should be a variable (that may be an individual element of a data structure such as an array, or a custom data type).

Values are output using the `OUTPUT` command as follows:

```
OUTPUT <value(s)>
```

Several values, separated by commas, can be output using the same command.

Example – INPUT and OUTPUT statements

```
INPUT Answer
OUTPUT Score
OUTPUT "You have ", Lives, " lives left"
```

Note that the syllabus for IGCSE (0478) gives `READ` and `PRINT` as examples for `INPUT` and `OUTPUT`, respectively.

4.2 Arithmetic operations

Standard arithmetic operator symbols are used:

- + Addition
- – Subtraction
- * Multiplication
- / Division

Care should be taken with the division operation: the resulting value should be of data type `REAL`, even if the operands are integers.

The integer division operators `MOD` and `DIV` can be used. However, their use should be explained explicitly and not assumed.

Multiplication and division have higher precedence over addition and subtraction (this is the normal mathematical convention). However, it is good practice to make the order of operations in complex expressions explicit by using parentheses.

4.3 Logic operators

The only logic operators (also called relational operators) used are `AND`, `OR` and `NOT`. The operands and results of these operations are always of data type `BOOLEAN`.

In complex expressions it is advisable to use parentheses to make the order of operations explicit.

5. Selection

5.1 IF statements

IF statements may or may not have an ELSE clause.

IF statements without an else clause are written as follows:

```
IF <condition>
  THEN
    <statements>
ENDIF
```

IF statements with an else clause are written as follows:

```
IF <condition>
  THEN
    <statements>
  ELSE
    <statements>
ENDIF
```

Note that the THEN and ELSE clauses are only indented by two spaces. (They are, in a sense, a continuation of the IF statement rather than separate statements).

When IF statements are nested, the nesting should continue the indentation of two spaces. In particular, run-on THEN IF and ELSE IF lines should be avoided.

Example – nested IF statements

```
IF ChallengerScore > ChampionScore
  THEN
    IF ChallengerScore > HighestScore
      THEN
        OUTPUT ChallengerName, " is champion and highest scorer"
      ELSE
        OUTPUT Player1Name, " is the new champion"
      ENDIF
    ELSE
      OUTPUT ChampionName, " is still the champion"
      IF ChampionScore > HighestScore
        THEN
          OUTPUT ChampionName, " is also the highest scorer"
        ENDIF
      ENDIF
    ENDIF
```

5.2 CASE statements

CASE statements allow one out of several branches of code to be executed, depending on the value of a variable.

CASE statements are written as follows:

```
CASE OF <identifier>
  <value 1> : <statement>
  <value 2> : <statement>
  ...
ENDCASE
```

An OTHERWISE clause can be the last case:

```
CASE OF <identifier>
  <value 1> : <statement>
  <value 2> : <statement>
  ...
  OTHERWISE <statement>
ENDCASE
```

It is best practice to keep the branches to single statements as this makes the pseudocode more readable. Similarly single values should be used for each case. If the cases are more complex, the use of an IF statement, rather than a CASE statement, should be considered.

Each case clause is indented by two spaces. They can be seen as continuations of the CASE statement rather than new statements.

Note that the case clauses are tested in sequence. When a case that applies is found, its statement is executed and the CASE statement is complete. Control is passed to the statement after the ENDCASE. Any remaining cases are not tested.

If present, an OTHERWISE clause must be the last case. Its statement will be executed if none of the preceding cases apply.

Example – formatted CASE statement

```
INPUT Move
CASE OF Move
  'W': Position ← Position - 10
  'S': Position ← Position + 10
  'A': Position ← Position - 1
  'D': Position ← Position + 1
  OTHERWISE : Beep
ENDCASE
```

6. Iteration

6.1 Count-controlled (FOR) loops

Count-controlled loops are written as follows:

```
FOR <identifier> ← <value1> TO <value2>
  <statements>
NEXT
```

The identifier must be a variable of data type `INTEGER`, and the values should be expressions that evaluate to integers.

The variable is assigned each of the integer values from `value1` to `value2` inclusive, running the statements inside the `FOR` loop after each assignment. If `value1 = value2` the statements will be executed once, and if `value1 > value2` the statements will not be executed.

It is good practice to repeat the identifier after `NEXT`, particularly with nested `FOR` loops.

An increment can be specified as follows:

```
FOR <identifier> ← <value1> TO <value2> STEP <increment>
  <statements>
NEXT
```

The increment must be an expression that evaluates to an integer. In this case the identifier will be assigned the values from `value1` in successive increments of `increment` until it reaches `value2`. If it goes past `value2`, the loop terminates. The increment can be negative.

Example – nested FOR loops

```
Total ← 0
FOR Row ← 1 TO MaxRow
  RowTotal ← 0
  FOR Column ← 1 TO 10
    RowTotal ← RowTotal + Amount[Row,Column]
  NEXT Column
  OUTPUT "Total for Row ", Row, " is ", RowTotal
  Total ← Total + RowTotal
NEXT Row
OUTPUT "The grand total is ", Total
```

6.2 Post-condition (REPEAT UNTIL) loops

Post-condition loops are written as follows:

```
REPEAT
  <Statements>
UNTIL <condition>
```

The condition must be an expression that evaluates to a Boolean.

The statements in the loop will be executed at least once. The condition is tested after the statements are executed and if it evaluates to `TRUE` the loop terminates, otherwise the statements are executed again.

Example – REPEAT UNTIL statement

```
REPEAT
  OUTPUT "Please enter the password"
  INPUT Password
UNTIL Password = "Secret"
```

6.3 Pre-condition (WHILE) loops

Pre-condition loops are written as follows:

```
WHILE <condition> DO
  <statements>
ENDWHILE
```

The condition must be an expression that evaluates to a Boolean.

The condition is tested before the statements, and the statements will only be executed if the condition evaluates to TRUE. After the statements have been executed the condition is tested again. The loop terminates when the condition evaluates to FALSE.

The statements will not be executed if, on the first test, the condition evaluates to FALSE.

Example – WHILE loop

```
WHILE Number > 9 DO
  Number ← Number - 9
ENDWHILE
```

7. Index of symbols and keywords

- , 10
* , 10
/ , 10
// , 6
+ , 10
← , 7
AND , 10
ARRAY , 9

Cambridge International Examinations
1 Hills Road, Cambridge, CB1 2EU, United Kingdom
t: +44 1223 553554 f: +44 1223 553558
e: info@cie.org.uk www.cie.org.uk

® IGCSE is a registered trademark.
© Cambridge International Examinations 2017
Version 1.0

