

AQA Computer Science AS Level
3.4.1 Abstraction and automation
Advanced Notes



Specification:

3.4.1.1 Problem-solving:

Be able to develop solutions to simple logic problems.

Be able to check solutions to simple logic problems

3.4.1.2 Following and writing algorithms:

Understand the term algorithm.

Be able to express the solution to a simple problem as an algorithm using pseudocode, with the standard constructs:

- sequence
- assignment
- selection
- iteration

Be able to hand-trace algorithms.

Be able to convert an algorithm from pseudocode into high level language program code.

Be able to articulate how a program works, arguing for its correctness and its efficiency using logical reasoning, test data and user feedback.

3.4.1.3 Abstraction:

Be familiar with the concept of abstraction as used in computations and know that:

- representational abstraction is a representation arrived at by removing unnecessary details
- abstraction by generalisation or categorisation is a grouping by common characteristics to arrive at a hierarchical relationship of the 'is a kind of' type

3.4.1.4 Information hiding:

Be familiar with the process of hiding all details of an object that do not contribute to its essential characteristics.



3.4.1.5 Procedural abstraction:

Know that procedural abstraction represents a computational method.

3.4.1.6 Functional abstraction :

Know that for functional abstraction the particular computation method is hidden.

3.4.1.7 Data abstraction:

Know that details of how data are actually represented are hidden, allowing new kinds of data objects to be constructed from previously defined types of data objects.

3.4.1.8 Problem abstraction/reduction:

Know that details are removed until the problem is represented in a way that is possible to solve, because the problem reduces to one that has already been solved.

3.4.1.9 Decomposition:

Know that procedural decomposition means breaking a problem into a number of sub-problems, so that each sub-problem accomplishes an identifiable task, which might itself be further subdivided.

3.4.1.10 Composition:

Know how to build a composition abstraction by combining procedures to form compound procedures.

Know how to build data abstractions by combining data objects to form compound data, for example tree data structure.

3.4.1.11 Automation:

Understand that automation requires putting models (abstraction of real world objects/ phenomena) into action to solve problems. This is achieved by:

- creating algorithms
- implementing the algorithms in program code (instructions)
- implementing the models in data structures
- executing the code



Problem Solving

Problem solving is the process of **finding a solution** to a difficult or complex issue.

In an exam, you might be given a **series of statements** from which you have to find the answer to a question.

Example: Given the two statements

George is a student
and
All students like chocolate

which of the following conclusions could be drawn?

George lives in Finland



We can't tell anything about where George lives from the statements, so this conclusion can't be made. This doesn't mean that George doesn't live in Finland, we just don't know for sure.

All chocolate is eaten by students



This could be true, because we're not told that anyone other than students eat chocolate, but we can't say for sure.

George likes chocolate



This must be true. We're told that George is a student and that all students (including George) like chocolate.

Exam questions often contain **more than two** statements, but the process of forming a reasonable conclusion is the same.

Harder example: Alice, Bob and Charlie are each wearing a hat, cannot see their own hat and can see the others' hats. They are then told that each of their hats is either green or yellow and that they don't all have the same colour hat. Charlie then says "*I know that my hat is yellow*".

What colour is Bob's hat?

The answer is on the next page.



Bob's hat is green.

Charlie can see **both Alice and Bob's hats**. For Charlie to be able to say that **she knows** the colour of her hat, Alice and Bob **must have the same colour** hats. Because Charlie has been told that **it's not possible for all three to have the same colour**, she can work out that her hat is **the colour that Alice and Bob's hats are not**. Therefore Charlie works out the colour of her hat is **yellow**. This means that Bob's hat is **not yellow**, so must be green.

Algorithms

An algorithm is a **sequence of steps** that can be followed to complete a task. An algorithm **always terminates** rather than going on forever in a loop.

Algorithms can be written in **pseudocode**: a way of describing instructions that is independent of any particular programming language. Pseudocode allows different programmers, who may not all understand the same languages, to be able to communicate algorithms to one another.

Assignment in pseudocode

Assignment is the process of **giving a value to a variable or constant**. In pseudocode, assignment is represented using an arrow pointing towards the variable or constant that is being given a value.

```
counter ← 27  
name ← "Sarah"
```

The pseudocode above assigns the value 27 to the variable counter and the value Sarah to the variable name.

Sequence in pseudocode

Sequence is the name given to instructions that **follow on from one another**.

```
counter ← 18  
counter ← counter + 1  
remainingIterations ← 20 - counter
```

In the pseudocode above, the variable counter is **set** to 18 and then **incremented** by one. Following that, the variable remainingIterations is **set** to twenty minus the value of counter. The operations will be executed **in the order that they appear**.



Selection in pseudocode

Selection is the process of **choosing an action to take based on the result of a comparison** of values.

```
IF name = "Brian" THEN
    OUTPUT "Hello Brian"
ELSE
    OUTPUT "Hello user"
END IF
```

The pseudocode above compares the value of the variable name to the value "Brian" and outputs different values **depending on the result** of the comparison.

In pseudocode, the statements IF, ELSE IF, ELSE and END IF can all be used.

Iteration in pseudocode

Iteration is the process of **repeating an operation**. Iteration structures include FOR and WHILE loops.

```
FOR number ← 6 to 12
    OUTPUT number / 2
END FOR
```

```
WHILE number < 18
    Number ← number + (number / 4)
END WHILE
```

The code within an iteration structure is **indented**, allowing for **easy identification** of different loops.

Synoptic Link

Indentation is used in high-level languages to identify different structures.

Indentation is covered in the notes for **programming** under **fundamentals of programming**.



Abstraction

Abstraction is the name given to the process of **omitting unnecessary details** from a problem.

When solving a problem, abstraction can be used to **simplify the problem** which can in turn make finding a solution **easier**.

There are two distinct forms of abstraction: **representational abstraction** and **abstraction by generalisation / categorisation**.

Representational abstraction

A representation of a problem arrived at by **removing unnecessary details** from the problem.

Abstraction by generalisation / categorisation

A grouping by **common characteristics** to arrive at a **hierarchical relationship** of the “is a kind of” type.

The definitions of these two forms of abstraction are **often asked for** in exams, so it's worth learning them.

Information hiding

Information hiding is defined as the process of **hiding all details of an object that do not contribute to its essential characteristics**. For example, if you're designing a program that works out how many cars can fit onto a ferry, information about the manufacturer or the colour of a car can be disregarded and just information about the size and weight of cars retained.

Procedural abstraction

Procedural abstraction involves **breaking down a complex model** into a **series of reusable procedures**. The actual values used in a computation are abstracted away and a computational method is achieved.

For example: To calculate the area of a rectangle, this procedure could be used:
CalculateArea = width * height

Functional abstraction

Procedural abstraction results in a procedure. Abstracting further **disregards the particular method** of a procedure and **results in just a function**.

For example: Abstracting the procedure from the previous example leaves us with a function: RectangleArea = CalculateArea()



Data abstraction

In data abstraction, **specific details** of how data is **actually represented** are abstracted away, allowing new kinds of data structures to be created from previously defined data structures. Data abstraction forms the basis of **abstract data types**.

Problem abstraction / reduction

In problem abstraction (which is sometimes called **reduction**), **details are removed** from a problem **until it is represented in a way that is solvable**. This works because a simplified problem is often similar to a problem that has **already been solved**, meaning that a solution for the problem can be found.

Decomposition

When using decomposition, a problem is **divided into a series of smaller sub-problems**. These smaller problems can be **solved individually** or **further divided** until all parts of the original problem have been solved.

Composition

When dealing with a complex problem, composition can be used to **combine procedures** to form a larger system. Composition is used in **abstract data types**, where a complex abstract data type is formed for smaller and simpler data types.

Automation

Automation is the process of **putting abstractions of real world phenomena** (which are referred to as **models**) **into action** to solve problems. Automation is achieved by **creating algorithms** which are later **implemented in code**, implementing **models in data structures** and finally **executing the code** on the data structures.

Synoptic Link

An **abstract data type** does not exist as a data type in its own right, but is formed from other data types.

Abstract data types are covered in the notes for **data structures and abstract data types** under **fundamentals of data structures**.

