Methods of Algorithm Description

Second Edition

◆

to accompany the

2 Unit (General)

2/3 Unit (Common)

3 Unit (Additional)

Computing Studies Syllabuses

BOARD OF STUDIES
NEW SOUTH WALES

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Introduction

This revised document was written in conjunction with the Board of Studies Information and Communication Technologies Syllabus Committee. It contains suitable methods of algorithm description for use in the implementation of the following courses in Computing Studies:

2 Unit (General) Computing Studies

2/3 Unit (Common) Computing Studies

3 Unit (Additional) Computing Studies.

This document presents two methods for describing algorithms for use in Computing Studies courses in NSW schools. It shows, through the use of examples, how the methods of algorithm description of pseudocode and flowcharts can be used to describe solutions to problems.

There are many definitions of methods of algorithm description in existence, some with many special symbols and keywords defined for special purposes. This document attempts to define a minimum set that will be useful in terms of the syllabuses in Computing Studies.

In assessing the quality of algorithm descriptions, general criteria such as the correctness of the algorithm, the clarity of the description, the use of appropriate control structures and the embodiment of structured methods, rather than the specific features of any method, should be taken into consideration.

Clarity of description and consistency in the use of the components of the method chosen are of far more importance than the actual shape of a flowchart element or the specific wording of a pseudocode statement.

The document presents standards that students should aim for in publishing solutions to problems. The same standards should be used by teachers when presenting algorithms to students. In many cases there are alternatives that could be used and it should be noted that students can expect to see methods of algorithm description with many differences in detail published in books and magazines. Teachers should ensure that the approach presented in textbooks, worksheets and examinations does not contradict the standards that students use.

Structure of the Document

The preliminary section consists of a description of the *programming process* and some definitions of an *algorithm* presented in the form of overhead transparency originals. In the following section are descriptions of the main features of two methods of algorithm description: *pseudocode* and *flowcharts*. Descriptions and specific examples of the programming structures of *sequence, selection*, *repetition* and *subprograms* (*procedures* or *subroutines*) are given.

The most substantial section of the document contains sample problems and worked solutions that show the use of each of the methods of algorithm description. The solutions do not purport to describe the 'ultimate' solution, but rather one (or more) possible solutions to the problem.

It will become obvious from reading the document that not all solutions are directly suited to implementation on a computer. The reason for this is that an aim of the document is to show how solutions to problems can be expressed through the use of sample problems to which most people already know some solution.

There is a new section in this edition which provides possible descriptions of the searching and sorting algorithms required by Core Topic 2: Algorithm Design in the 2/3 Unit (Common) Computing Studies course.

It must be noted that alternative solutions are possible. In some cases different solutions are provided expressed in each of the two prescribed methods. These can be used as models for expressing the same solution in the other method and should extend the reader's understanding of the topic.

The final section has a collection of problems for which no solutions are given. These are provided to give you some practice using the methods of algorithm description.

What is Programming?

Programming is the total creative process that involves these stages:

- **clearly define the problem**
- **analyse the problem**
- **design a solution**
- **implement the solution**
- **test the solution**
- **document the solution.**

In the appropriate circumstances we should also:

- **compare alternative solutions.**

What is an Algorithm?

An algorithm consists of a set of explicit and unambiguous finite steps which, when carried out for a given set of initial conditions, produce the corresponding output and terminate in finite time.

How to Solve it by Computer, RG Dromey, Prentice Hall UK, 1982

An algorithm is a finite, definite, effective procedure, with some output.

Computer Science, D Woodhouse et al, Jacaranda Wiley, 1984

The series of steps that you develop to solve a problem is known as a solution algorithm. There are many different algorithms for almost any problem.

Understanding Information Technology, K Behan and D Holmes,
Prentice Hall Australia, 1986
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Algorithm: a step-by-step procedure for solving a problem; programming languages are essentially a way of expressing algorithms.

Understanding Computers: Computer Languages,
by the editors of Time-Life Books, © 1988
Time-Life Books Inc.

In order that a task be carried out on a computer, a method or technique for the task must be described very precisely in terms of the different steps. An algorithm is a description of the steps of a task, using a particular technique. Writing an algorithm is one of the first steps taken in preparing a task to be done by a computer.

Computing Science, Peter Bishop, Thomas Nelson UK, 1982

Informally, an algorithm is a collection of instructions which, when performed in a specific sequence, produce the correct result. The study of algorithms is at the heart of computer science.

Problem Solving and Computer Programming,
Peter Grogono & Sharon H Nelson,
© 1982 Addison-Wesley Publishing Company Inc.
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Overview of Two Methods

Pseudocode

Pseudocode essentially is English with some defined rules of structure and some keywords that make it appear a bit like program code. Some guidelines for writing pseudocode are as follows.

Pseudocode Guidelines

- The keywords used for pseudocode in this document are:

  for start and finish
  BEGIN MAINPROGRAM, END MAINPROGRAM

  for initialisation
  INITIALISATION, END INITIALISATION

  for subprogram
  BEGIN SUBPROGRAM, END SUBPROGRAM

  for selection
  IF, THEN, ELSE, ENDIF

  for multi-way selection
  CASEWHERE, OTHERWISE, ENDCASE

  for pre-test repetition
  WHILE, ENDWHILE

  for post-test repetition
  REPEAT, UNTIL

- Keywords are written in capitals.

- Structural elements come in pairs, eg for every BEGIN there is an END, for every IF there is an ENDIF, etc.

- Indenting is used to show structure in the algorithm.

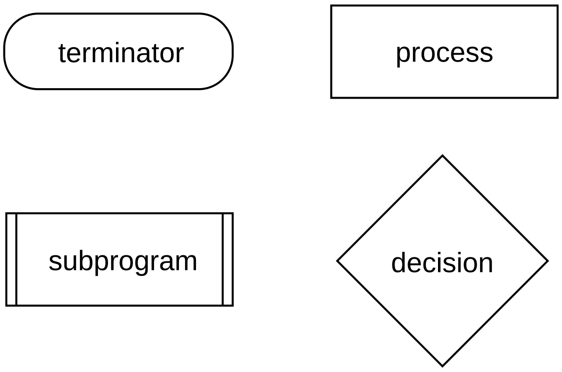
- The names of subprograms are underlined. This means that when refining the solution to a problem, a word in an algorithm can be underlined and a subprogram developed. This feature is to assist the use of the 'top-down' development concept.

Flowcharts

Flowcharts are a diagrammatic method of representing algorithms. They use an intuitive scheme of showing operations in boxes connected by lines and arrows that graphically show the flow of control in an algorithm. The Australian Standards for flowcharting indicate that the main direction of flow is accepted as being top to bottom and left to right.

Flowchart Elements

Flowcharts are made up of the following box types connected by lines with arrowheads indicating the flow. It is common practice only to show arrowheads where the flow is counter to that stated above.



These should be thought of as the characters of flowcharts. Just as ordinary characters must be put together in certain ways to produce well-formed words, and words must be put together in certain ways to produce well-structured sentences, these flowchart elements must be connected in certain ways to form accepted structures and the structures connected in certain ways to form well-structured algorithms. The flowcharting structures for *sequence*, *selection* and *repetition* are given in the next section of this document.

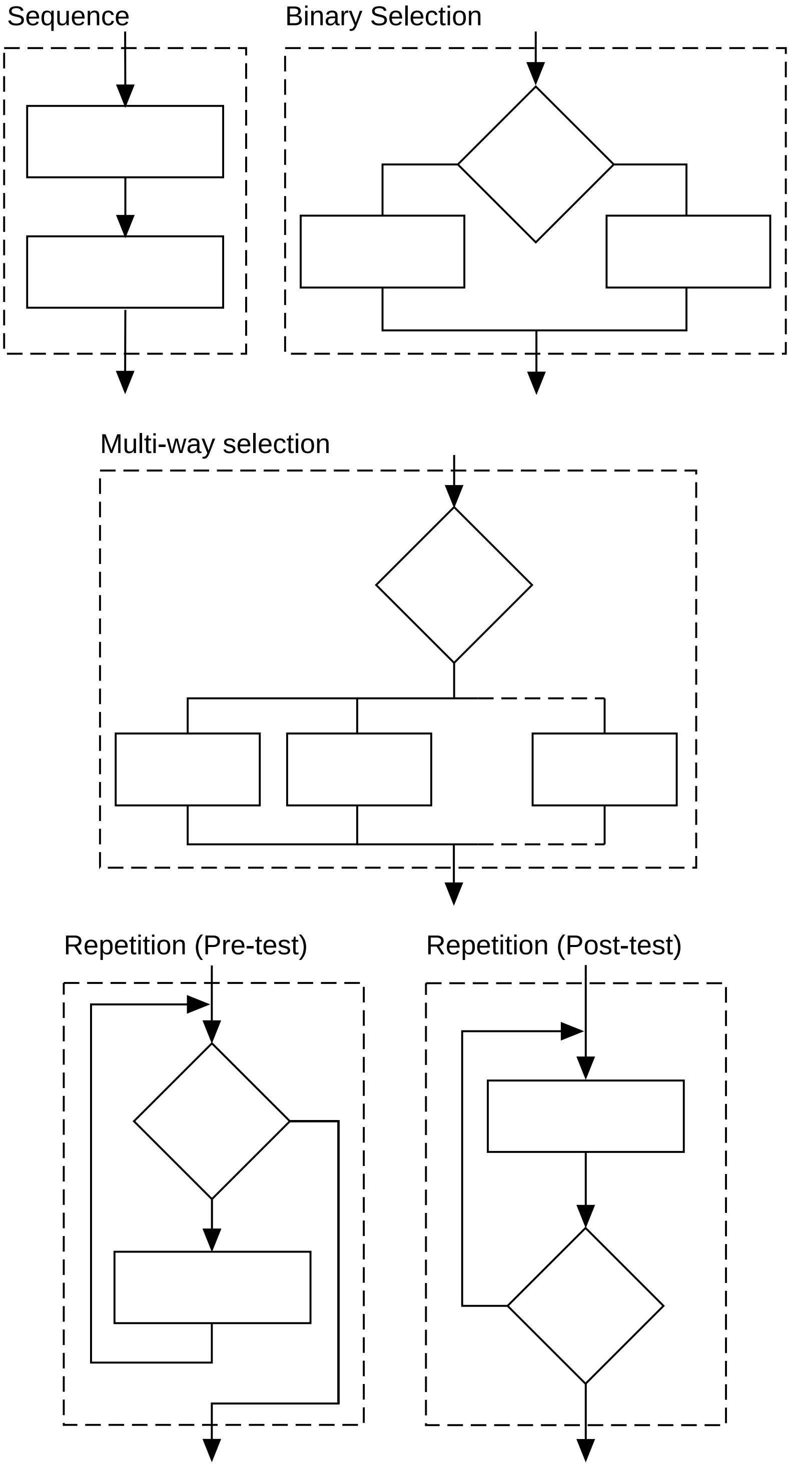
It is considered good practice for a single flowchart never to exceed the bounds of one page. If a flowchart does not fit on one page, this is one instance in which the better solution is to use refinement which results in the creation of subprograms. Subprograms on separate pages are more desirable than using a connector to join flowcharts over more than one page. A flowchart expressing the solution to an involved problem may have the main program flowchart on one page with subprograms continuing the problem solution on subsequent pages. An example of this situation is given in the last solved problem in this document — the Auto Teller problem on page 54.

Programming Structures

The Computing Studies syllabuses mention the programming structures of *sequence, selection, repetition* and *subprograms*. A description of each of these structures, together with examples of their use, follows.

The Structures

Each of the five acceptable structures can be built from the basic elements as shown below.



In all cases note there is only one entry point to the structure and one exit point as indicated by the dashed boxes.

Since each structure can be thought of as a *process* (as shown by the dashed boxes containing the structure), more complex algorithms can be constructed by replacing any single *process* by one or other of the structures.

Sequence

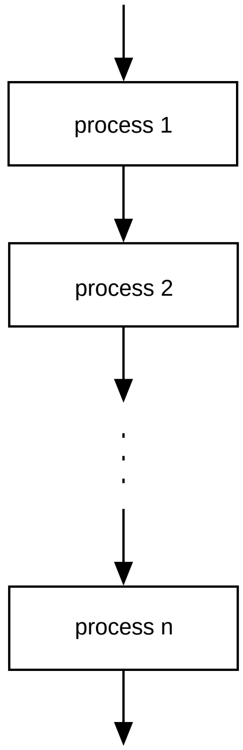
In a computer program or an algorithm, sequence involves simple steps which are to be executed one after the other. The steps are executed in the same order in which they are written.

In pseudocode, sequence is expressed as:

```
process 1

process 2
   …
   …

process n
```

In a flowchart, sequence is expressed as:

(The arrowheads are optional if the flow is top-to-bottom.)



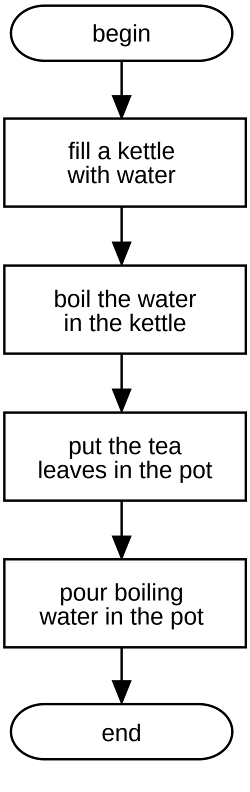
An Example Using Sequence

Problem: Write a set of instructions that describe how to make a pot of tea.

Pseudocode

```
BEGIN
fill a kettle with water
boil the water in the kettle
put the tea leaves in the pot
pour boiling water in the pot
END
```

Flowchart


begin
fill a kettle with water
boil the water in the kettle
put the tea leaves in the pot
pour boiling water in the pot
end

Selection

Selection is used in a computer program or algorithm to determine which particular step or set of steps is to be executed. A selection statement can be used to choose a specific path dependent on a condition. There are two types of selection: binary (two-way branching) selection and multi-way (many way branching) selection. Following is a description of each.

Binary Selection

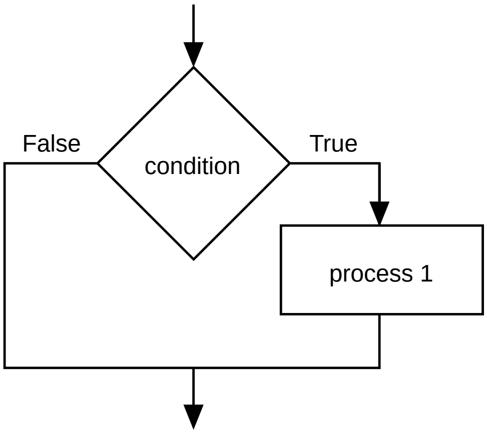
As the name implies, binary selection allows the choice between two possible paths. If the condition is met then one path is taken, otherwise the second possible path is followed. In each of the examples below, the first case described requires a process to be completed only if the condition is true. The process is ignored if the condition is false. In other words there is only one path that requires processing to be done, so the processing free path is left out rather than included saying 'do nothing'.

In pseudocode, binary selection is expressed in the following ways:

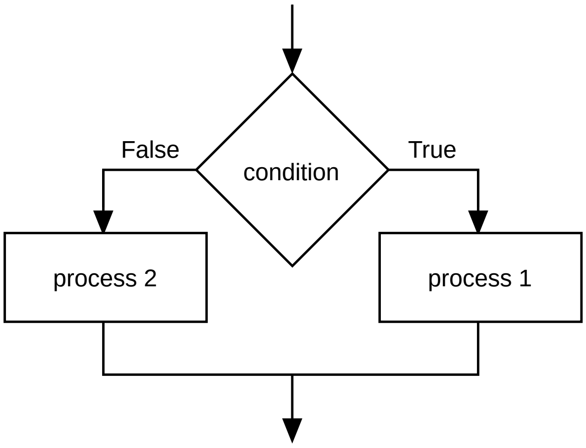
```
1.  IF condition THEN
        process 1
    ENDIF

2.  IF condition THEN
        process 1
    ELSE
        process 2
    ENDIF
```

In flowcharts, binary selection is expressed in the following ways:

1.



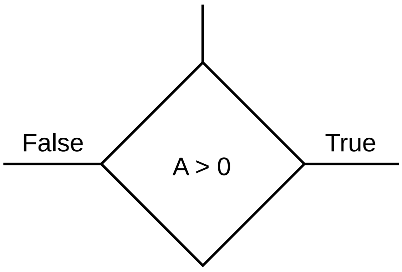
2.



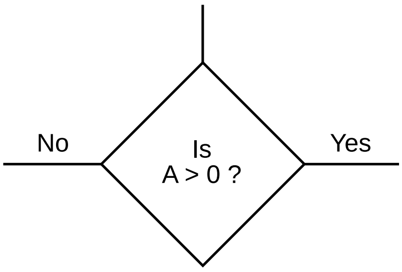
Note: In a flowchart it is most important to indicate which path is to be followed when the condition is true, and which path to follow when the condition is false. Without these indications the flowchart is open to more than one interpretation.

Note: There are two acceptable ways to represent a decision in all of the structures.

1. The **condition** is expressed as a **statement** and the two possible outcomes are indicated by True, False.



2. The **condition** is expressed as a **question** and the two possible outcomes are indicated by Yes, No.



Either method is acceptable. For consistency, the former method is used throughout the document.

Multi-way Selection

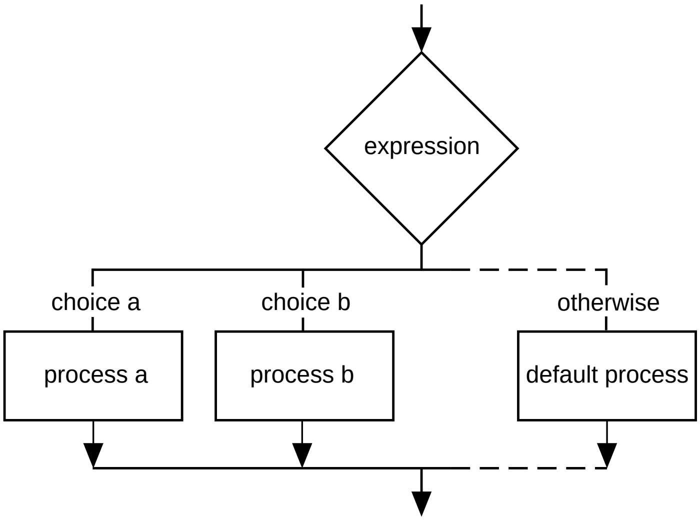
Multi-way selection allows for any number of possible choices, or cases. The path taken is determined by the selection of the choice which is true. Multi-way selection is often referred to as a case structure.

In pseudocode, multiple selection is expressed as:

```
CASEWHERE expression evaluates to
   choice a        :       process a
   choice b        :       process b
       .                       .
       .                       .
       .                       .
   OTHERWISE   :   default process
ENDCASE
```

Note: As the flowchart version of the multi-way selection indicates, **only one** process on each pass is executed as a result of the implementation of the multi-way selection.

In a flowchart, multi-way selection is expressed as:



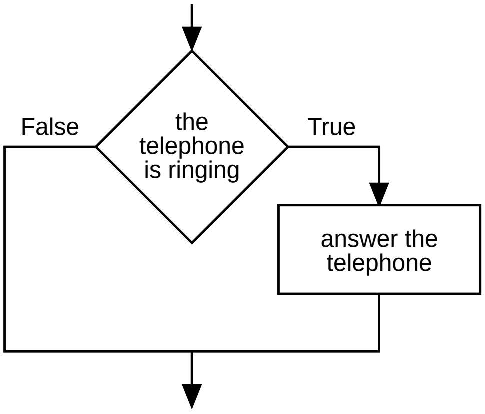
Examples Using Binary Selection

Problem 1: Write a set of instructions to describe when to answer the phone.

Pseudocode

```
IF the telephone is ringing THEN
    answer the telephone
ENDIF
```

Flowchart

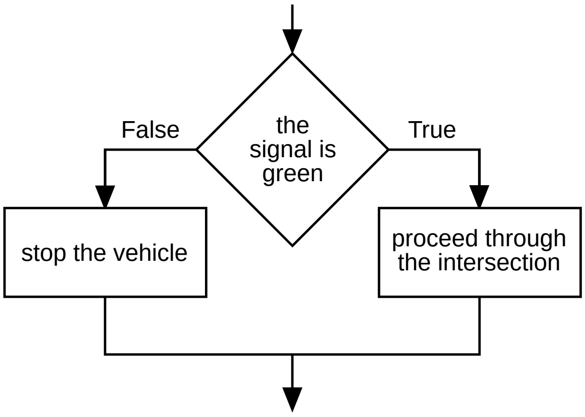


Problem 2: Write a set of instructions to follow when approaching a set of traffic control lights.

Pseudocode

```
IF the signal is green THEN
    proceed through the intersection
ELSE
    stop the vehicle
ENDIF
```

Flowchart



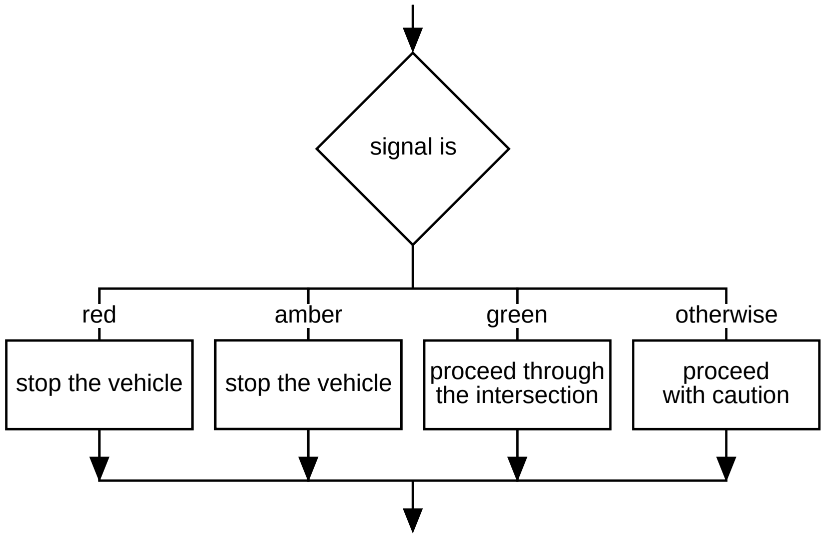
An Example Using Multi-way Selection

Problem: Write a set of instructions that describes how to respond to all possible signals at a set of traffic control lights.

Pseudocode

```
CASEWHERE signal is
    red          :   stop the vehicle
    amber        :   stop the vehicle
    green        :   proceed through the intersection
    OTHERWISE    :   proceed with caution
ENDCASE
```

Flowchart



Repetition

Repetition allows for a portion of an algorithm or computer program to be done any number of times dependent on some condition being met. An occurrence of repetition is usually known as a loop.

An essential feature of repetition is that each loop has a termination condition to stop the repetition, or the obvious outcome is that the loop never completes execution (an infinite loop). The termination condition can be checked or tested at the beginning or end of the loop, and is known as a pre-test or post-test respectively. Following is a description of each of these types of loop.

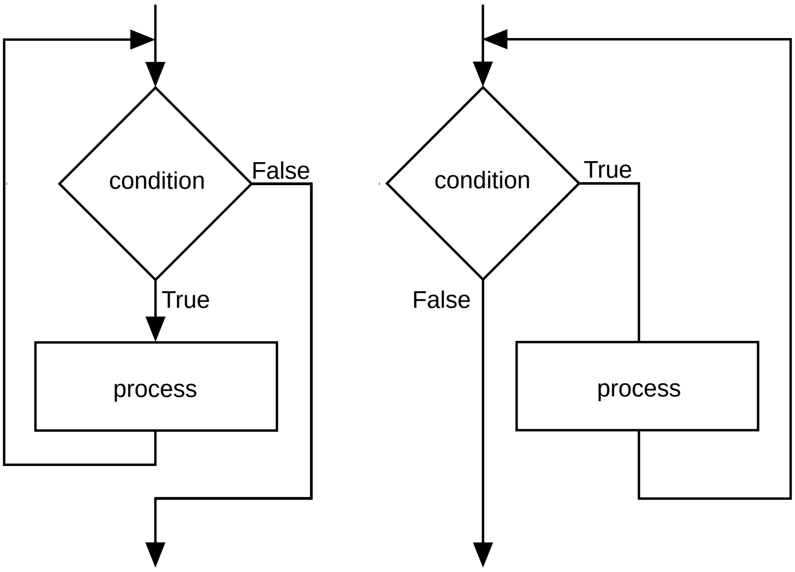
Repetition: Pre-Test

A pre-tested loop is so named because the condition has to be met at the very beginning of the loop or the body of the loop is not executed. This construct is often called a *guarded loop*. The body of the loop is executed repeatedly while the termination condition is true.

In pseudocode pre-test repetition is expressed as:

```
WHILE condition is true
   process(es)
ENDWHILE
```

In flowcharting pre-test repetition is expressed as:



Although these two flowcharts are topologically the same and represent the same programming structure, the left-hand example above is used throughout this document.

Repetition: Post-Test

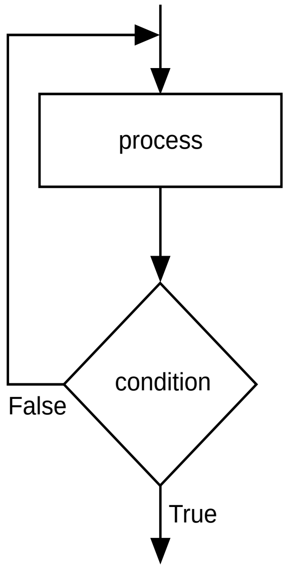
A post-tested loop executes the body of the loop before testing the termination condition. This construct is often referred to as an *unguarded loop*. The body of the loop is repeatedly executed until the termination condition is true.

An important difference between a pre-test and post-test loop is that the statements of a post-test loop are executed at least once even if the condition is originally true, whereas the body of the pre-test loop may never be executed if the termination condition is originally true. A close look at the representations of the two loop types makes this point apparent.

In pseudocode, post-test is expressed as:

```
REPEAT
    process
UNTIL condition is true
```

In a flowchart, post-test is expressed as:



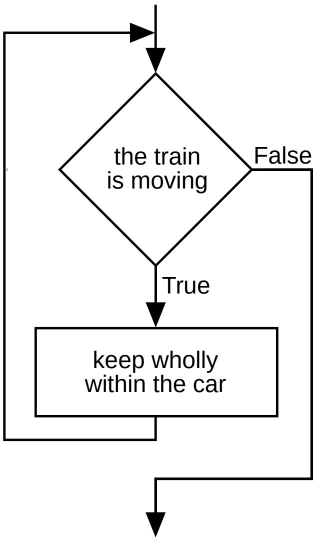
An Example Using Pre-Test Repetition

Problem: Determine a safety procedure for travelling in a carriage on a moving train.

Pseudocode

```
WHILE the train is moving
    keep wholly within the carriage
ENDWHILE
```

Flowchart



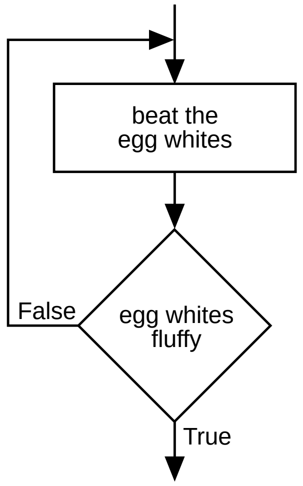
An Example Using Post-Test Repetition

Problem: Determine a procedure to beat egg whites until fluffy.

Pseudocode

```
REPEAT
    beat the egg whites
UNTIL fluffy
```

Flowchart



Subprograms

Subprograms, as the name implies, are complete part-programs that are used from within the main program section. They allow the process of refinement to be used to develop solutions to problems that are easy to follow. Sections of the solution are developed and presented in understandable chunks, and because of this, subprograms are particularly useful when using the top-down method of solution development.

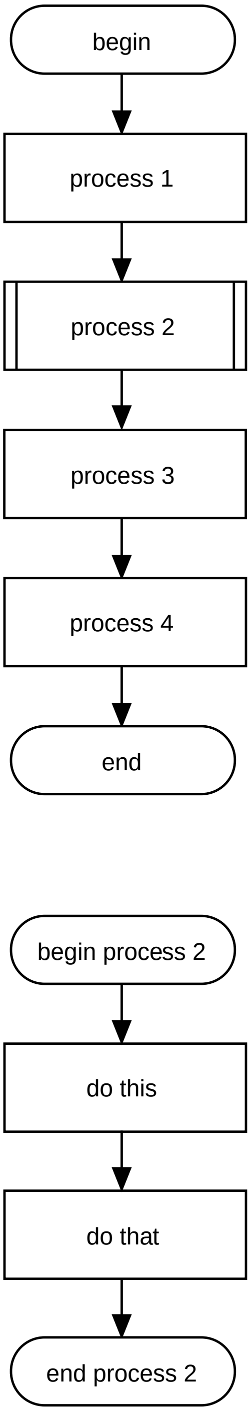
When using subprograms it is important that the solution expression indicates where the main program branches to a subprogram. It is equally important to indicate exactly where the subprogram begins. In pseudocode, the statement in the main program that is expanded in a subprogram is underlined to indicate that further explanation follows. The expanded subprogram section should be identified by using the keywords BEGIN SUBPROGRAM followed by the underlined title used in the main program. The end of the subprogram is marked by the keywords END SUBPROGRAM and the underlined title used in the main program.

When using flowcharts, a subprogram is shown by an additional vertical line on each side of the process box. This indicates that the subprogram is expanded elsewhere. The start and end of the subprogram flowchart uses the name of the subprogram in the termination boxes.

Example of Using Subprograms in Pseudocode

```
BEGIN MAINPROGRAM
process l
process 2
process 3
process 4
END MAINPROGRAM

BEGIN SUBPROGRAM process 2
do this
do that
END SUBPROGRAM process 2
```

Example of Using Subprograms in Flowcharts



In many cases a subprogram can be written to do the same task at two or more points in an algorithm. Each time the subprogram is called, it may operate on different data. To indicate the data to be used one or more *parameters* are used. The parameters allow the author to write a general algorithm using the *formal parameters*. When the subprogram is executed, the algorithm carries out its task on the *actual parameters* given at the call.

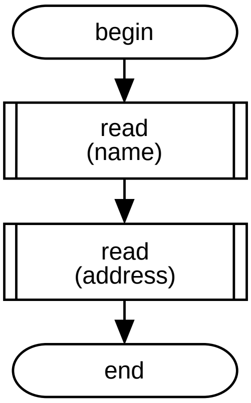
The parameters to be used by a subprogram are provided as a list in parentheses after the name of the subprogram. There is no need to include them at the end of the algorithm.

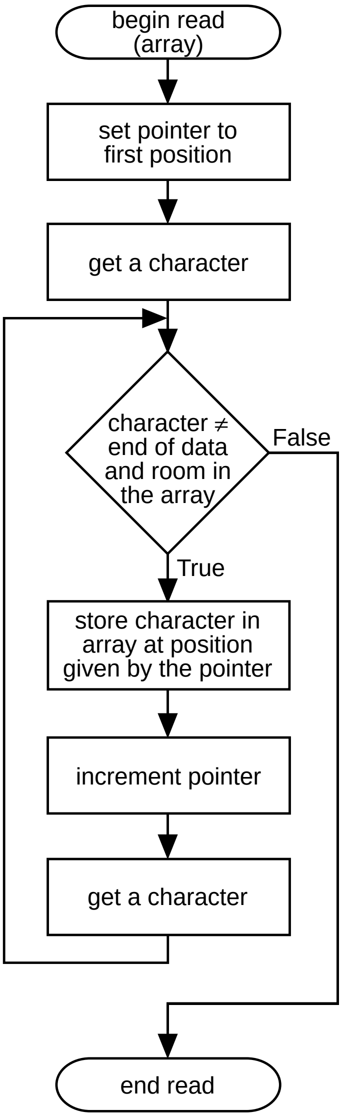
Example of Using Subprograms with one Parameter in Pseudocode

```
BEGIN MAINPROGRAM
read (name)
read (address)
END MAINPROGRAM

BEGIN SUBPROGRAM read (array)
set pointer to first position
get a character
WHILE character is not the end of data AND there is room in the array
          store character in the array at the position given by the pointer
          increment the pointer
          get a character
ENDWHILE
END SUBPROGRAM read
```

At the first call of this subprogram the characters are read into the array called ‘name’, at the second call the characters are read into the array called ‘address’.

Example of Using Subprograms with one Parameter in Flowcharts





Solved Problems

Table Indicating Programming Structures Used in the Sample Problems

Problem	Sequence	Binary Selection (if-then)	Multiple Selection (case)	Repetition: (while)	Repetition: (repeat-until)	Subprogram
Lift Solution 1	✓				✓	
Lift Solution 2	✓			✓		
Temperature Control	✓		✓	✓		
Toll Gate	✓	✓		✓	✓	✓
Squash Scoring	✓	✓			✓	✓
Record Separation Solution 1	✓		✓	✓		
Record Separation Solution 2	✓	✓			✓	
Record Separation Solution 3	✓			✓		
Guess the Number	✓	✓			✓	✓
Income Tax	✓	✓				
Telephone Dialler	✓	✓	✓	✓	✓	✓
Auto-Teller	✓	✓	✓	✓	✓	✓

Lift Problem

Problem

A lift remains positioned at the ground floor level of a building with the doors shut whenever it is not in use. When a call button is pressed on any floor, the lift moves to the required floor and the lift doors open. Write an algorithm to express the logic of controlling the lift.

Solution 1

This solution uses *sequence* and *repeat-until* structures.

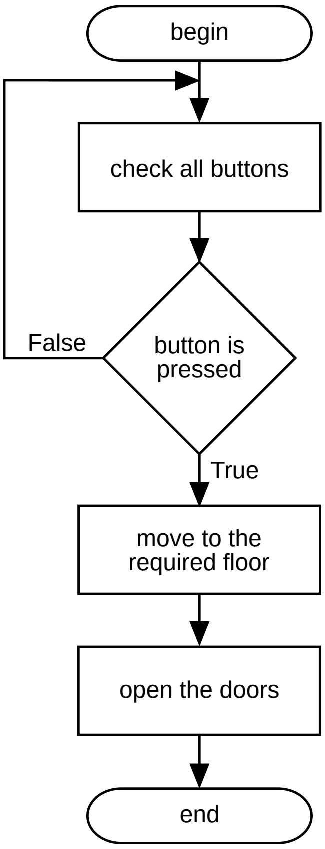
Pseudocode

An algorithm to express the logic of controlling a lift

```
BEGIN MAINPROGRAM

REPEAT
    check all buttons
UNTIL a button is pressed

move to the required floor
open the doors

END MAINPROGRAM
```

Flowchart

An algorithm to express the logic of controlling a lift



Solution 2

This solution uses *sequence* and *while* structures.

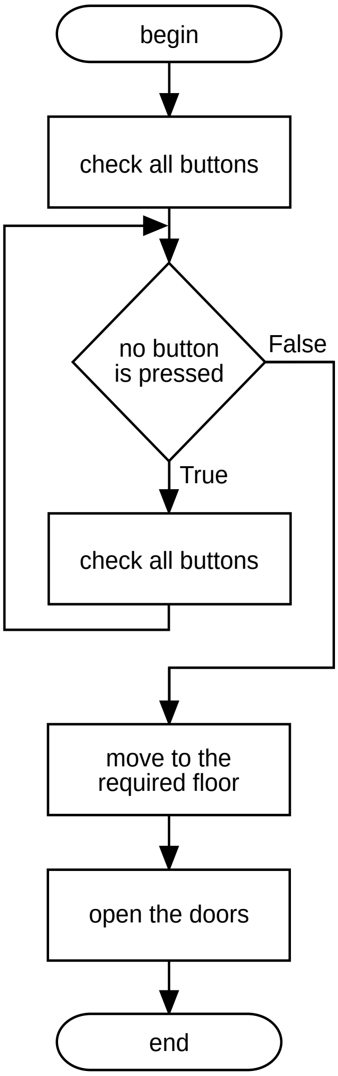
Pseudocode

An algorithm to express the logic of controlling a lift

```
BEGIN MAINPROGRAM
check all buttons
WHILE no button has been pressed
    check all buttons
ENDWHILE
move to the required floor
open the doors
END MAINPROGRAM
```

Flowchart

An algorithm to express the logic of controlling a lift



Temperature Control Problem

Problem

At a NSW coastal town the maximum annual temperature range is typically 12–34 degrees Celsius. An air conditioning company is installing a heating/cooling system in a new shopping centre in that town. The system checks the temperature every five minutes and adjusts the air temperature by using a combination of two heating and two cooling units. These units operate according to these temperature ranges:

0–15 degrees C	–	2 heating units
16–20 degrees C	–	1 heating unit
21–28 degrees C	–	1 cooling unit
> 29 degrees C	–	2 cooling units

Write an algorithm that could be used to control the air conditioning system.

Solution

This solution uses *sequence, while* and *case* structures.

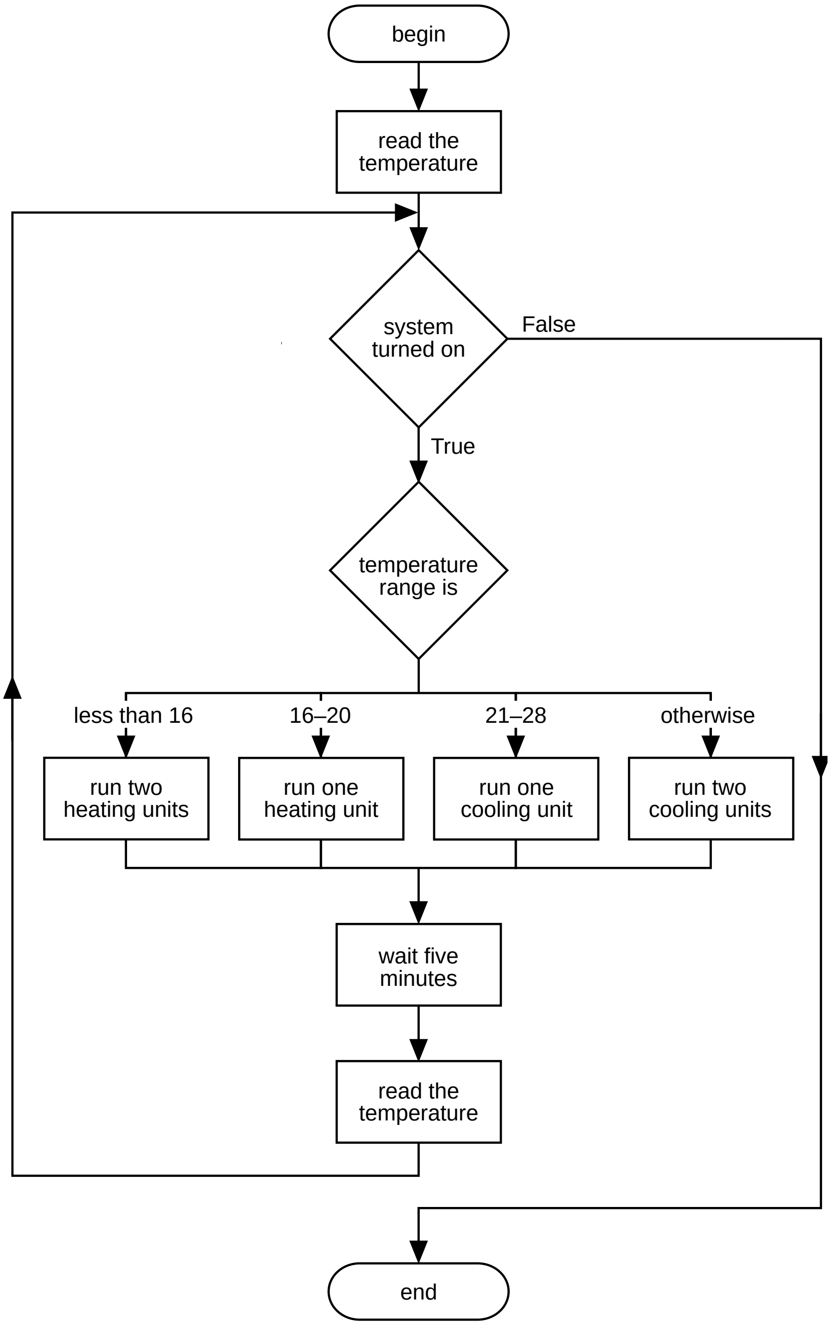
Pseudocode

An algorithm to describe the control of an air conditioning system. The input comes from sensors in the shopping centre.

```
BEGIN MAINPROGRAM
read the temperature

WHILE the system is turned on

   CASEWHERE temperature
      < 16          :   run two heating units
      16 to 20      :   run one heating unit
      21 to 28      :   run one cooling unit
      OTHERWISE     :   run two cooling units
   ENDCASE

   wait five minutes
   read the temperature
ENDWHILE

END MAINPROGRAM
```

Flowchart

An algorithm to describe the control of an air conditioning system. The input comes from sensors in the shopping centre.



Toll Gate Problem

Problem

When operational a toll gate operates by having a boom gate obstructing the road, and a sensor detecting when a vehicle is present. After coins to the value of $1.00 have been deposited in the basket, the boom gate opens and stays open until a vehicle has gone through. Amounts greater than $1.00 are accepted but no change is given. Individual coins less than 10 cents are ignored.

Write an algorithm to describe the control of the toll gate.

Solution

This solution uses *sequence*, *if-then*, *repeat-until*, *while*, and *subprogram* structures.

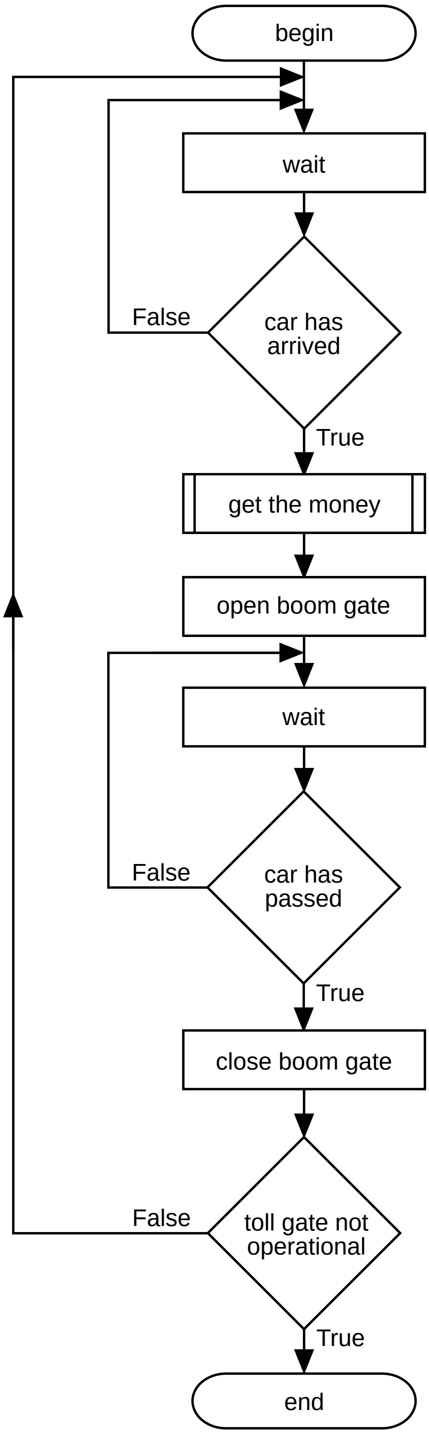
Pseudocode

An algorithm used to describe the operation of a toll gate that has a boom gate, a vehicle sensor, and a coin collection basket.

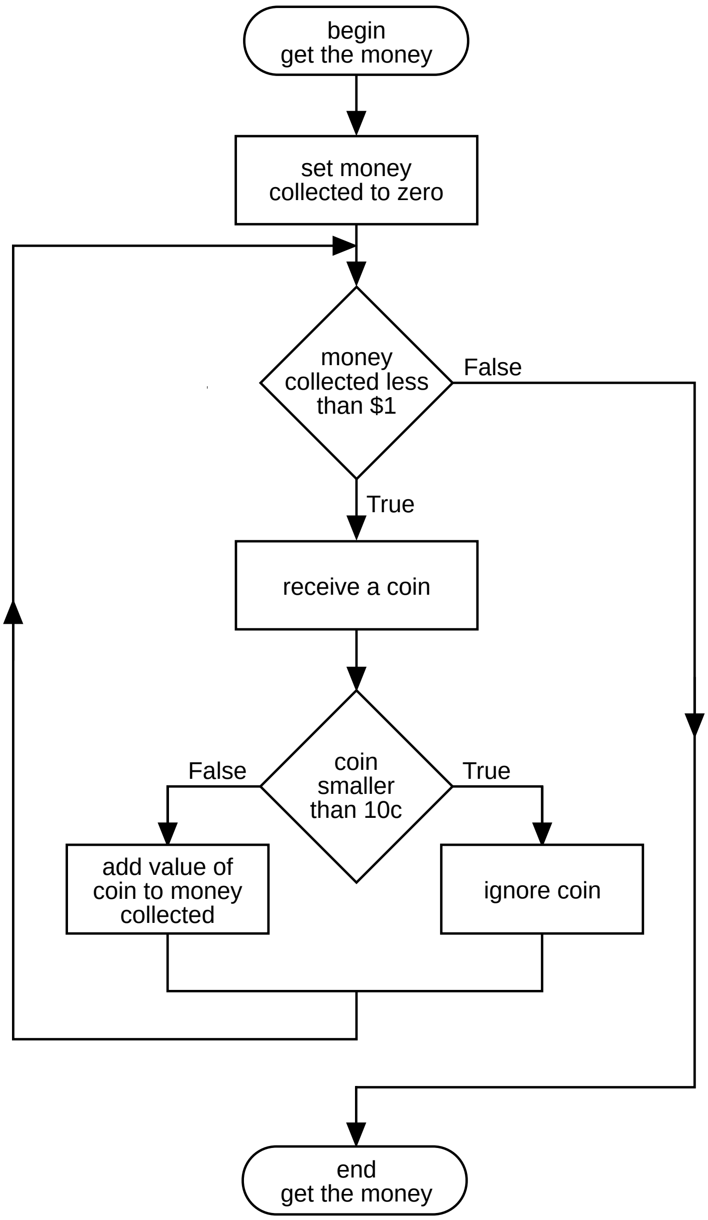
```
BEGIN MAINPROGRAM

REPEAT

    REPEAT
        wait
    UNTIL car has arrived

    get the money
    open boom gate

    REPEAT
        wait
    UNTIL car has passed

    close boom gate
UNTIL toll gate is not operational

END MAINPROGRAM


BEGIN SUBPROGRAM get the money

INITIALISATION
money collected is set to 0
END INITIALISATION

WHILE money collected is less than $1
    receive coin

    IF coin is less than 10 cents THEN
        ignore coin
    ELSE
        add the value of the coin to the money collected
    ENDIF

ENDWHILE

END SUBPROGRAM get the money
```

Flowchart

An algorithm used to describe the operation of a toll gate that has a boom gate, a vehicle sensor, and a coin collection basket.



Subprogram


begin
get the money
set money collected to zero
money collected less than $1
False
True
receive a coin
coin smaller than 10c
False
True
add value of coin to money collected
ignore coin
end
get the money

‘Squash’ Scoring Problem

Problem

Write an algorithm to describe how to score a ball game, which is similar to squash. This ball game is scored as follows: the server gets one point for winning a rally. If the server loses the rally they lose the right to serve the next ball, but lose no points. The receiver gains the right to serve (but no point) if they win a rally. To win the game a player must win nine points.

Solution

This solution uses *sequence*, *repeat-until*, *if-then* and *subprogram* structures.

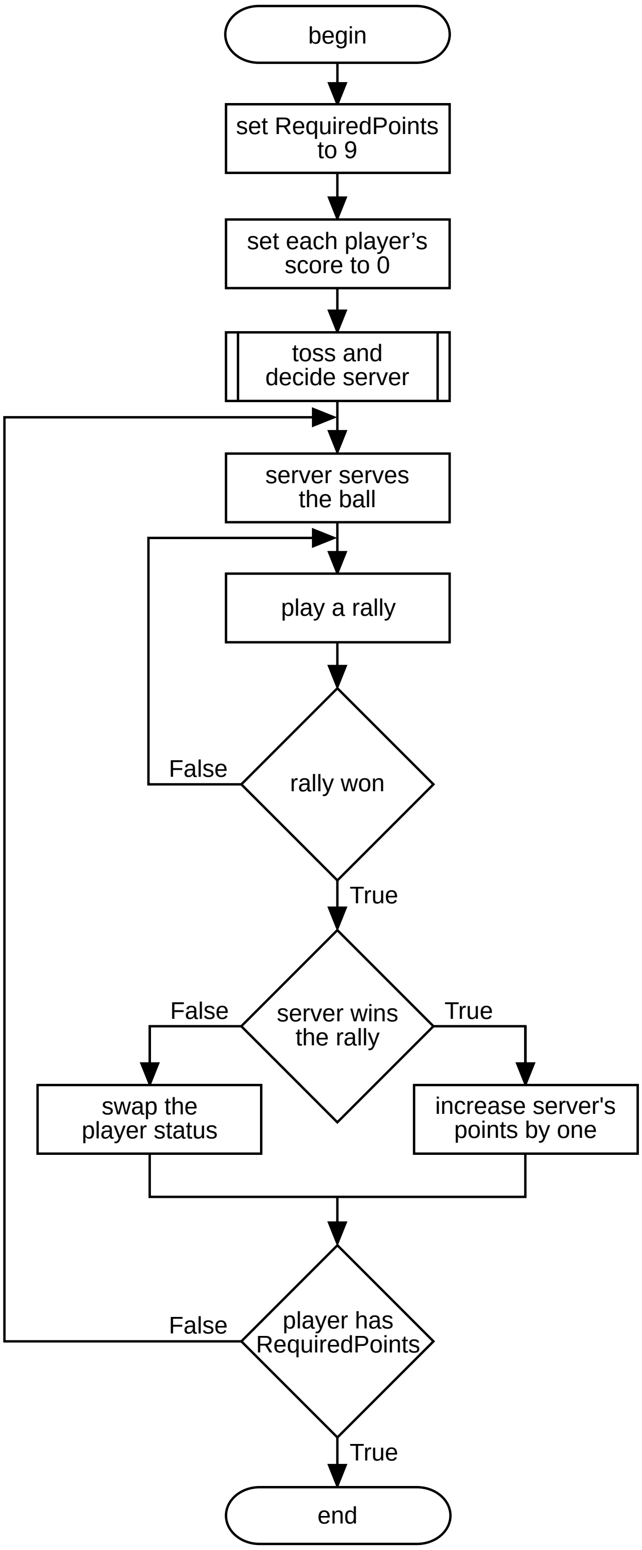
Pseudocode

An algorithm to describe the logic for scoring a ball game similar to squash.

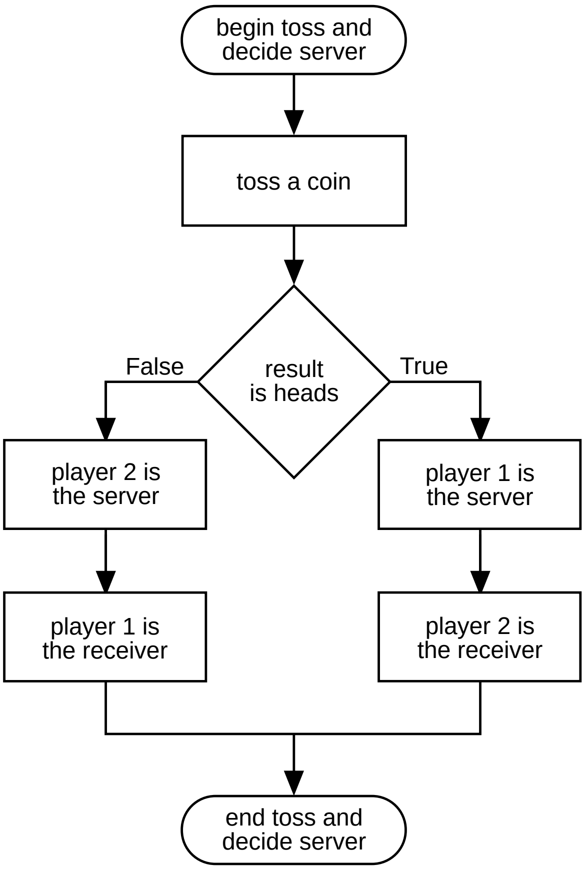
```
BEGIN MAINPROGRAM

INITIALISATION
set RequiredPoints to 9
set each player’s points to 0
END INITIALISATION

toss and decide the server

REPEAT
    server serves the ball

    REPEAT
        play the rally
    UNTIL rally is won

    IF the server wins the rally THEN
       increment the server’s points by 1
    ELSE

        swap player status
    ENDIF

UNTIL a player has won RequiredPoints

declare the winner

END MAINPROGRAM


BEGIN SUBPROGRAM toss and decide the server
toss a coin

IF heads THEN
    player 1 is the server
    player 2 is the receiver
ELSE
    player 2 is the server
    player 1 is the receiver
ENDIF

END SUBPROGRAM toss and decide the server
```

Flowchart

An algorithm to describe the logic for scoring a ball game similar to squash.



Subprogram


begin toss and decide server
toss a coin
result is heads
False
True
player 2 is the server
player 1 is the server
player 1 is the receiver
player 2 is the receiver
end toss and decide server

Record Separation Problem

Problem

Let us assume that a particular database program manages a simple mailing list which consists of one record for each person on the list, and a number of fields containing information about each person (their name, address, etc). The program can read in data produced by a word processor provided that data is structured in the following way:

Each record to be read must be a single paragraph terminated by a return character, and each field within a record is separated by a tab character. For example:

Colin Jameson*tab*33 Falcon Street*tab*Waverly*tab*NSW*tab*2113*return*

would be read as one record containing five fields. The end of the data is marked with a # (hash) character which immediately follows the *return* ending the last paragraph.

Assuming that there is at least one line of valid data at the start of the input file, describe an algorithm that the program might use to read such data one character at a time and place the information into separate fields and records. The algorithm reports the number of records read when all the records have been processed.

Solution 1

This solution uses *sequence*, *while* and *case* structures.

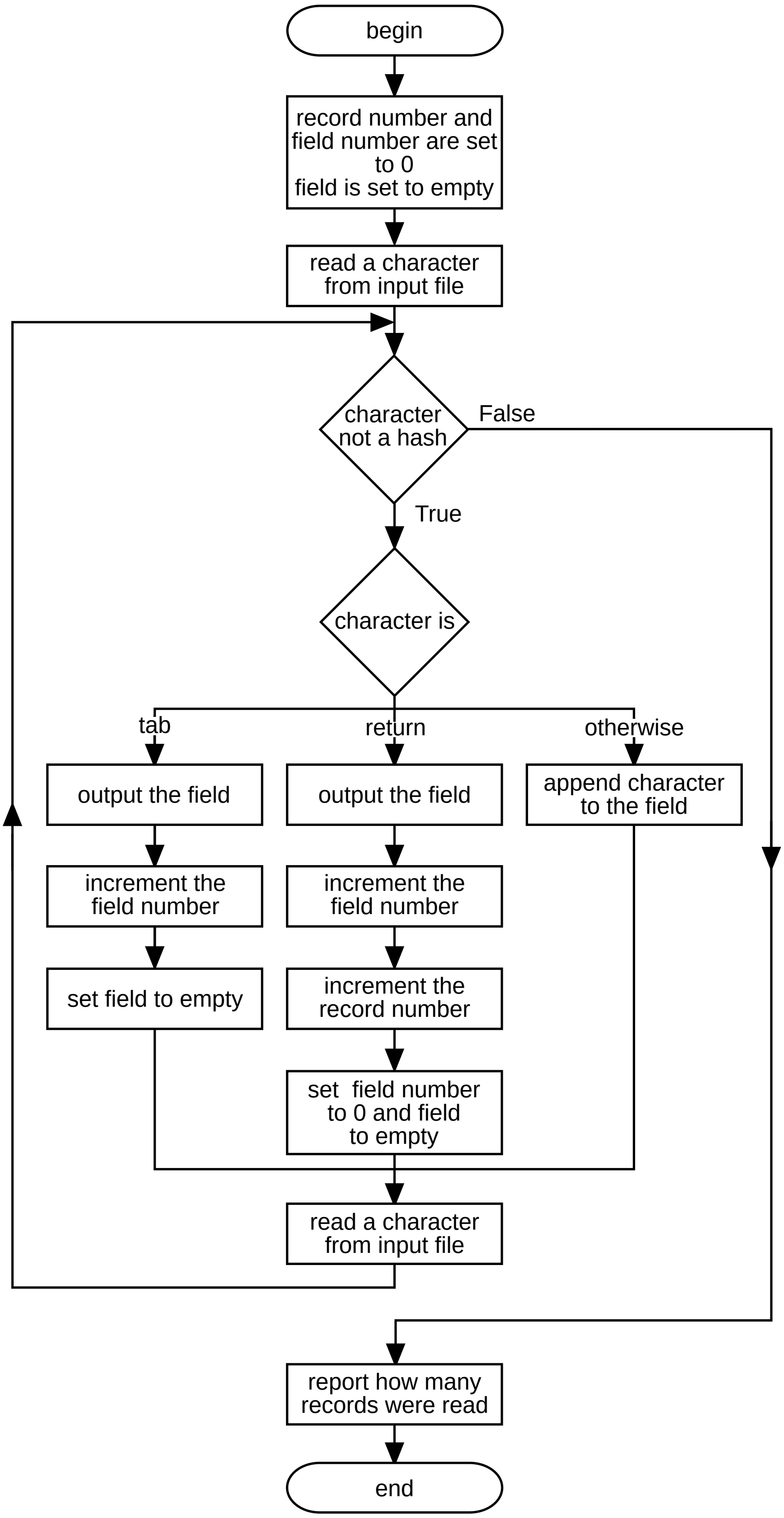
Pseudocode

An algorithm to describe the separation of a string of formatted data into fields and records to be used as input to a database.

```
BEGIN MAINPROGRAM

INITIALISATION
set record number to 0
set field number to 0
set field to empty
END INITIALISATION

read a character from the input file

WHILE character is not a hash

    CASEWHERE character is

        tab:           output the field to the database
                       increment the field number
                       set the field to empty

        return:        output the field to the database
                       increment the field number
                       increment the record number
                       set field number to 0
                       set the field to empty

        OTHERWISE:     append the character to the field

    ENDCASE

    read a character from the input file

ENDWHILE

report how many records were read

END MAINPROGRAM
```

Flowchart

An algorithm to describe the separation of a string of formatted data into fields and records to be used as input to a database.


begin
record number and field number are set to 0 field is set to empty
read a character from input file
character not a hash
False
True
character is
tab
return
otherwise
output the field
output the field
append character to the field
increment the field number
increment the field number
set field to empty
increment the record number
set field number to 0 and field to empty
read a character from input file
report how many records were read
end

Solution 2

This solution uses *sequence, repeat-until* and *if-then-else* structures.

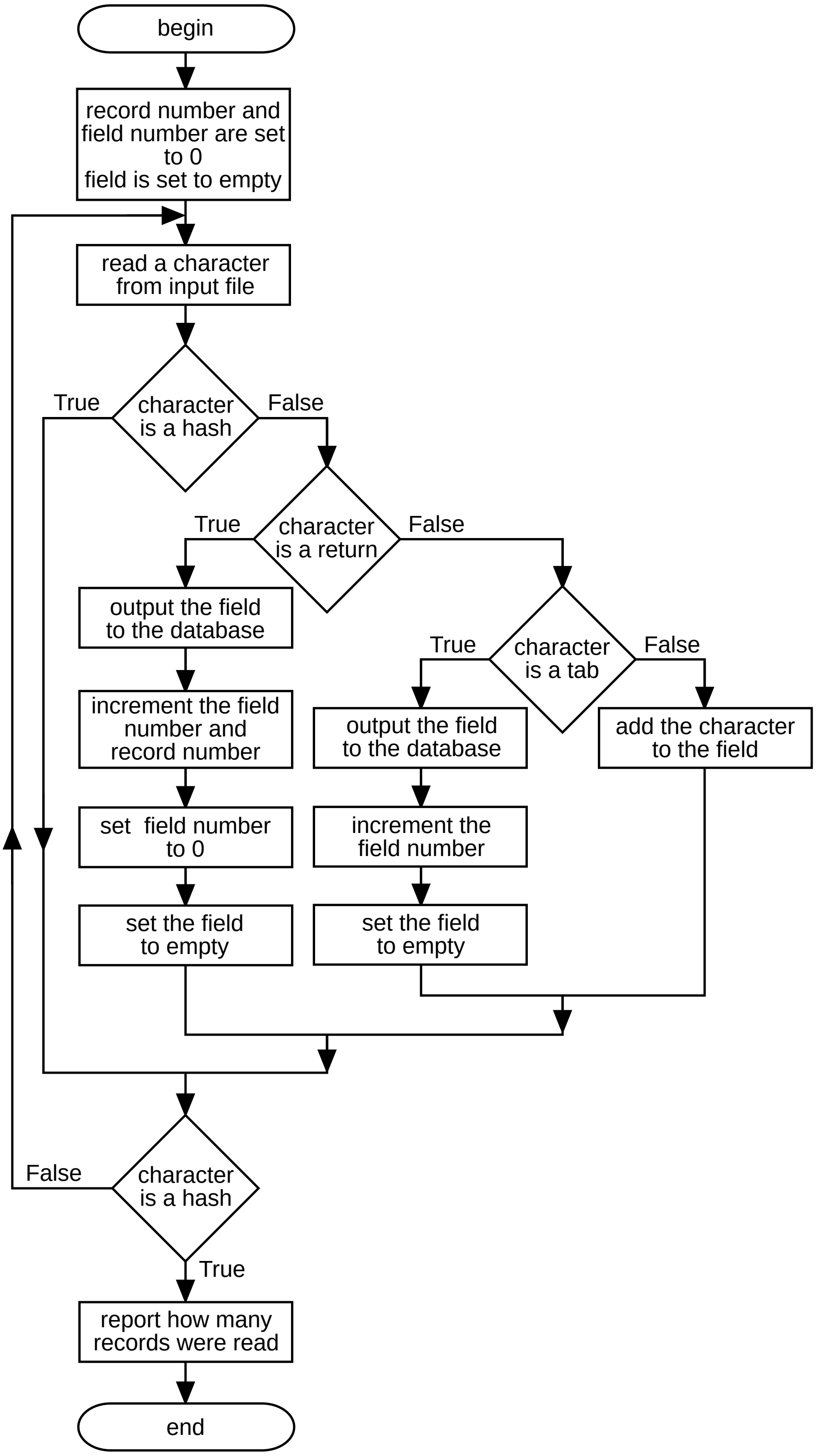
Pseudocode

An algorithm to describe the separation of a string of formatted data into fields and records to be used as input to a database.

```
BEGIN MAINPROGRAM

INITIALISATION
record number is set to 0
field number is set to 0
field is set to empty
END INITIALISATION

REPEAT
    read a character from the file

    IF the character is a hash THEN
        don’t do anything
    ELSE

        IF the character is a return THEN
            output the field to the database
            increment the field number
            increment the record number
            set the field number to 0
            set the field to empty
        ELSE

            IF the character is a tab THEN
                output the field to the database
                increment the field number
                set the field to empty
            ELSE
                append the character to the field
            ENDIF

        ENDIF

    ENDIF
UNTIL the character is a hash

report how many records were read

END MAINPROGRAM
```

Flowchart

An algorithm to describe the separation of a string of formatted data into fields and records to be used as input to a database.


begin
record number and field number are set to 0 field is set to empty
read a character from input file
character is a hash
True
False
character is a return
True
False
output the field to the database
increment the field number and record number
set field number to 0
set the field to empty
character is a tab
True
False
output the field to the database
increment the field number
set the field to empty
add the character to the field
character is a hash
False
True
report how many records were read
end

Solution 3

This solution uses *sequence* and *while* structures.

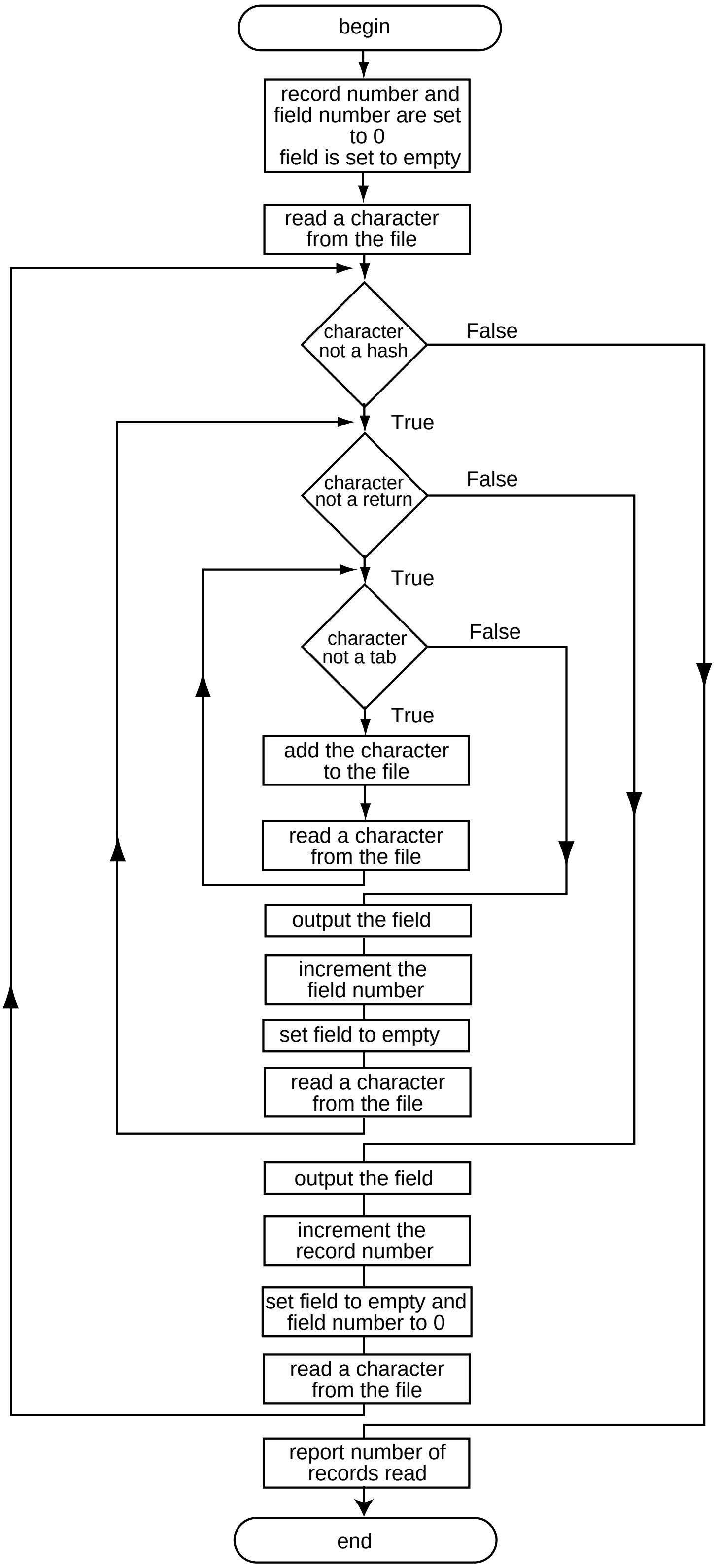
Pseudocode

An algorithm to describe the separation of a string of formatted data into fields and records, which are to be used as input to a database. It assumes the data are correct.

```
MAINPROGRAM

INITIALISATION
set record number to 0
set field number to 0
set field to empty
END INITIALISATION
read a character from the file
WHILE the character is not a hash
    WHILE the character is not a return
        WHILE the character is not a tab
                  append the character to the field
                  read a character from the file
        ENDWHILE
        output the field to the database
        increment the field number
        set field to empty
        read a character from the file
    ENDWHILE
    output the field to the database
    increment the record number
    set field number to 0
    set the field to empty
    read a character from the file
ENDWHILE
report how many records were read
END MAINPROGRAM
```

Flowchart

An algorithm to describe the separation of a string of formatted data into fields and records, which are to be used as input to a database. It assumes the data are correct.


begin
record number and field number are set to 0 field is set to empty
read a character from the file
character not a hash
False
True
character not a return
False
True
character not a tab
False
True
add the character to the file
read a character from the file
output the field
increment the field number
set field to empty
read a character from the file
output the field
increment the record number
set field to empty and field number to 0
read a character from the file
report number of records read
end

Guess the Number Problem

Problem

In a simple number game your opponent thinks of a secret number between l and 100. In no more than 10 guesses you have to try to guess the number. After each guess your opponent tells you if your guess was too high, too low or correct. Your opponent also keeps track of how many guesses you have had and tells you the game is over when you use all of your ten guesses or when you guess the number correctly.

Describe an algorithm which takes the role of your opponent in this game. Include in your solution a subprogram which checks for illegal guesses (those less than l or greater than 100). Include also the subprogram which generates a secret number between 1 and 100. Do not expand this but assume it is available.

Solution

This solution uses *sequence*, *repeat-until*, *if-then-else* and *subprogram* structures.

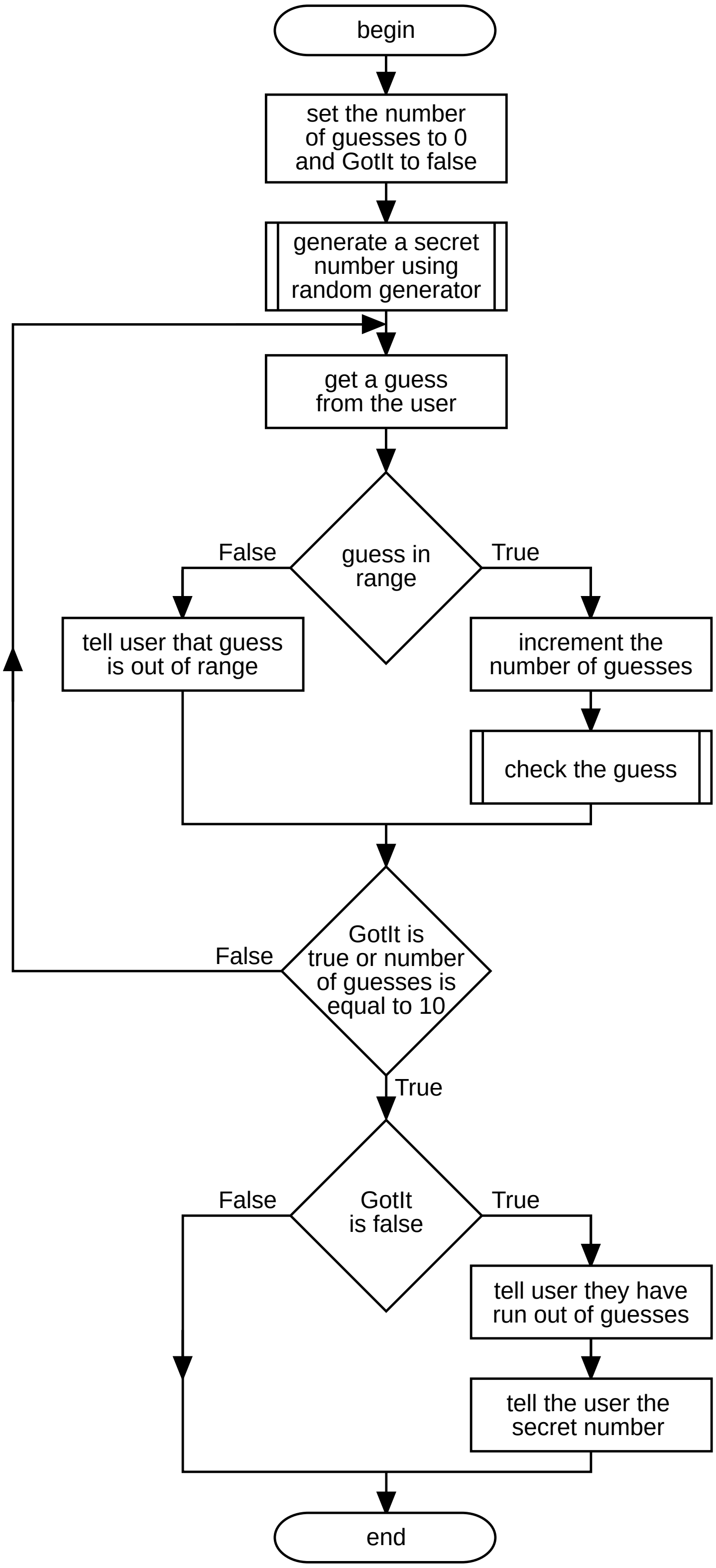
Pseudocode

An algorithm to describe a game in which the user tries to guess a number between 1 and 100, using no more than ten guesses.

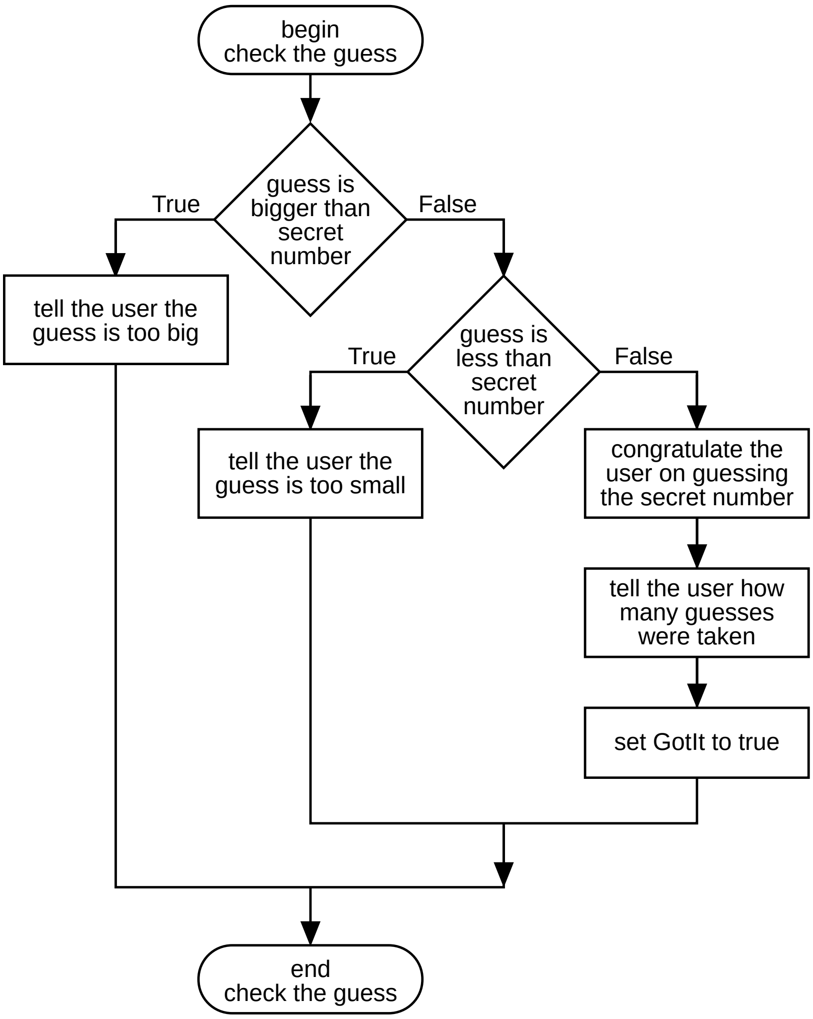
```
BEGIN MAINPROGRAM

INITIALISATION
number of guesses is set to 0
GotIt is set to false
END INITIALISATION

generate a secret number using random number generator

REPEAT
    get a guess from the user

    IF the guess is in range THEN
        increment the number of guesses
        check the guess

    ELSE
         tell the user the guess is out of range

    ENDIF

UNTIL guess is correct (GotIt is true) or number of guesses is 10

IF the guess is incorrect (GotIt is false) THEN
    tell the user they have run out of guesses (=10)
    tell the user the secret number

ENDIF

END MAINPROGRAM


BEGIN SUBPROGRAM check the guess

IF guess > secret number THEN
    tell the user their guess is too big

ELSE
    IF guess < secret number THEN
        tell the user their guess is too small

    ELSE
         congratulate the user on a correct guess
         tell them how many guesses they took
         set GotIt to true
    ENDIF
ENDIF

END SUBPROGRAM check the guess
```

Flowchart

An algorithm to describe a game in which the user tries to guess a number between 1 and 100, using no more than ten guesses.


begin
set the number of guesses to 0 and GotIt to false
generate a secret number using random generator
get a guess from the user
guess in range
False
True
tell user that guess is out of range
increment the number of guesses
check the guess
GotIt is true or number of guesses is equal to 10
False
True
GotIt is false
False
True
tell user they have run out of guesses
tell the user the secret number
end

Subprogram


begin
check the guess
guess is bigger than secret number
True
False
tell the user the guess is too big
guess is less than secret number
True
False
tell the user the guess is too small
congratulate the user on guessing the secret number
tell the user how many guesses were taken
set GotIt to true
end
check the guess

Income Tax Problem

Problem

To calculate the income tax payable on any income based on the income tax scales shown below. The taxable income is to be entered and the tax payable calculated.

Tax Scales

Taxable Income ($)	Tax payable
$1–5400	Nil
$5401–20 700	Nil plus 20 cents for each $1 over $5400
$20 701–36 000	$3060 plus 38 cents for each $1 over $20 700
$36 001–50 000	$8874 plus 46 cents for each $1 over $36 000
$50 001 and over	$15 314 plus 47 cents for each $1 over $50 000

Solution

This solution uses *sequence* and *if-then* structures.

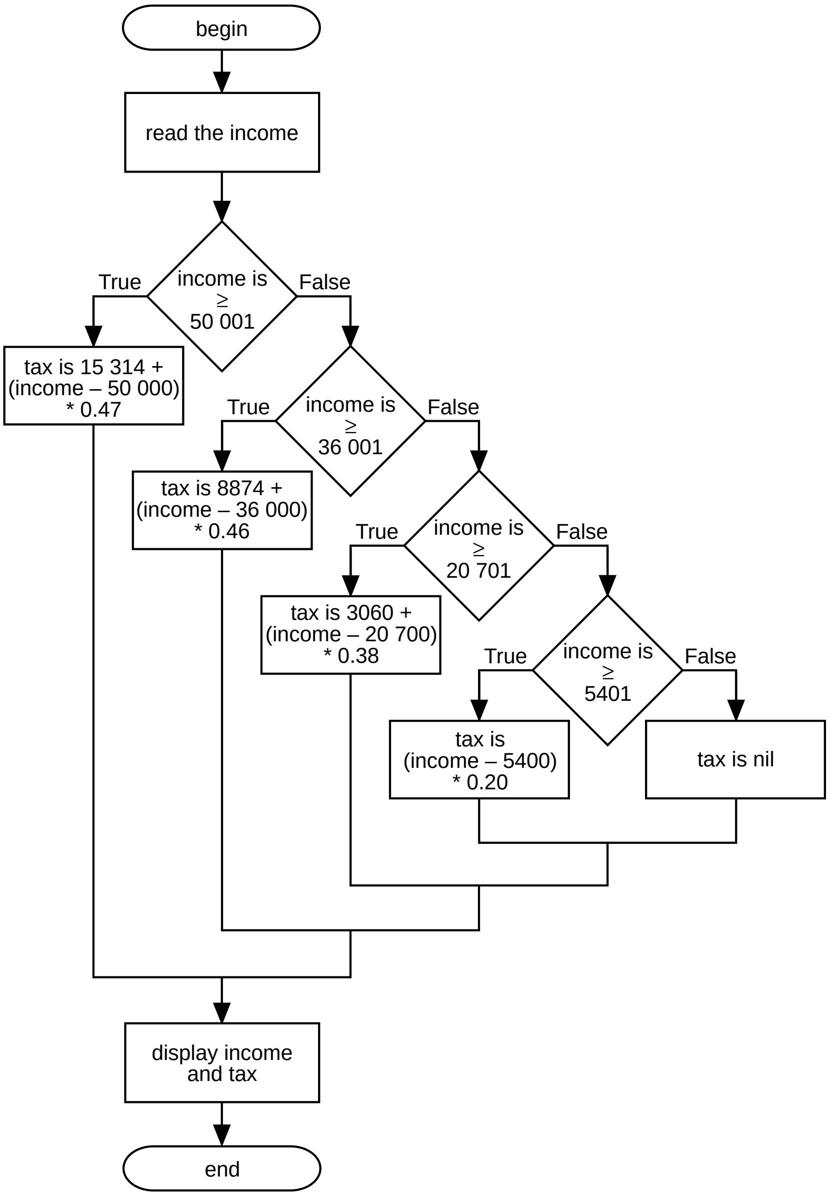
Pseudocode

An algorithm used to calculate the tax payable on any income using taxation rates set in the given table.

```
BEGIN MAINPROGRAM
input income
IF income greater than or equal to 50 001 THEN
   tax is 15 314 + (income – 50 000) * 0.47
ELSE
    IF income greater than or equal to 36 001 THEN
       tax is 8874 + (income – 36 000) * 0.46
    ELSE
        IF income greater than or equal to 20 701 THEN
           tax is 3060 + (income – 20 700) * 0.38
        ELSE
            IF income greater than or equal to 5401 THEN
               tax is (income – 5400) * 0.20
            ELSE
                tax is nil
            ENDIF
        ENDIF
    ENDIF
ENDIF
display income and tax payable
END MAINPROGRAM
```

Flowchart

An algorithm used to calculate the tax payable on any income using taxation rates set in the given table.

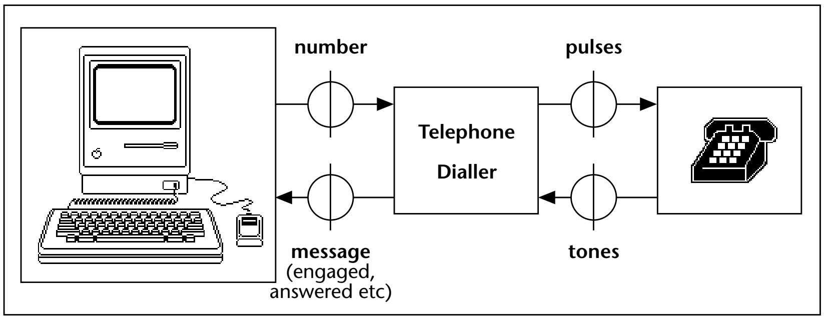


Another valid method of solving this problem is to use the multiple selection or 'case' structure.

Telephone Dialler Problem

Problem

A telephone dialler is connected between a computer and a telephone (see the diagram below). Its purpose is to dial a telephone number entered via the computer keyboard, establish a connection if it can and report on its progress and degree of success. The whole telephone number is entered via the computer keyboard at one time and is stored in a buffer in the computer.



The dialler 'dials' a digit by sending pulses along the telephone line. To dial 2 it sends two pulses, to dial 5 it sends five pulses etc. In the special case of a zero it sends ten pulses. There is a gap of 2 seconds between the set of pulses representing a digit of a telephone number.

The dialler will not operate unless the line is clear, in which case it will provide a message that it allows a dial tone then dials the number. Before sending the next digit it will check for a response, this takes into account the different lengths of phone numbers. The dialler will provide a message that the phone is 'ringing', 'engaged' or 'answered'.

Write an algorithm to describe the operation of the telephone dialler.

Solution

This solution used *sequence, repeat-until, if-then, while, case* and *subprogram* structures.

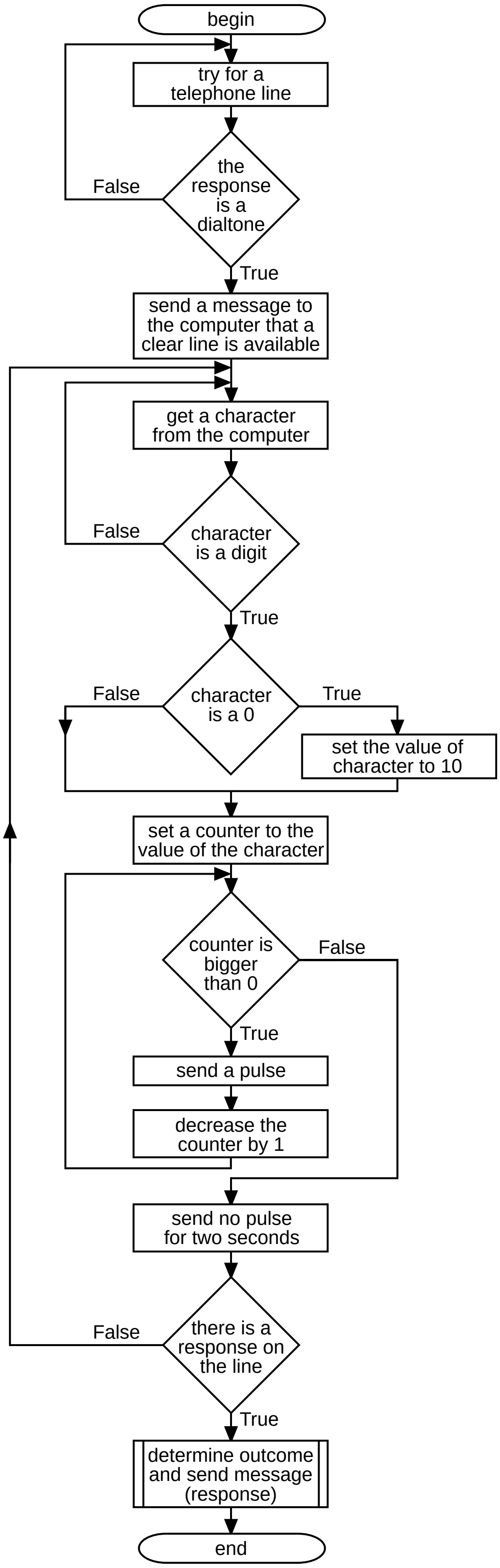
Pseudocode

An algorithm to describe the control of a telephone dialler.

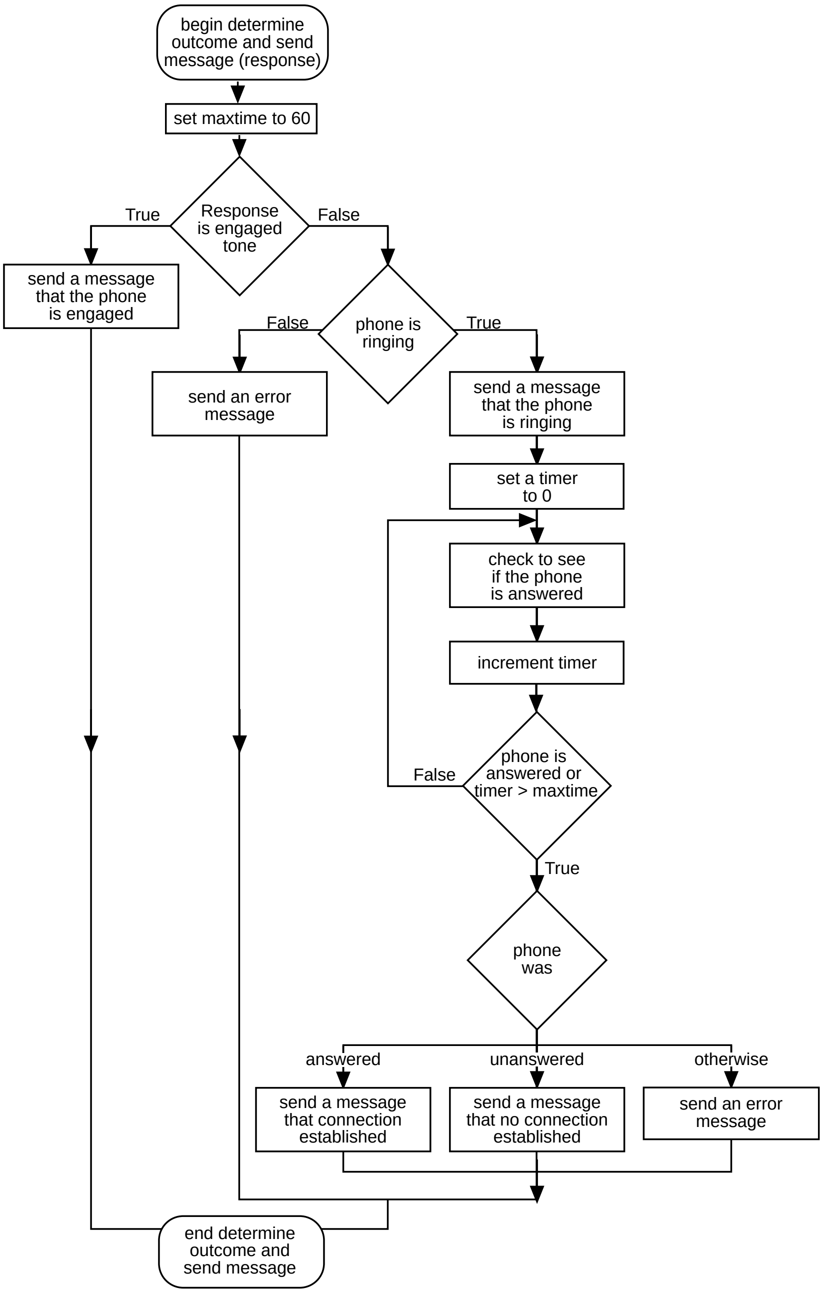
```
BEGIN MAINPROGRAM
REPEAT
    try for phone line
UNTIL the response is a dial tone
send a message to the computer that a clear telephone line is available
REPEAT
    REPEAT
        get a character from the computer
    UNTIL the character is a digit
    IF the character is a 0 THEN
       set the digit value of the character to 10
    ENDIF
    assign the digit value of the character to a counter
    WHILE counter is greater than 0
        send a pulse
        decrement the counter
    ENDWHILE
    send no pulse for two seconds
UNTIL there is a response
determine outcome and send message (response)
END MAINPROGRAM

BEGIN SUBPROGRAM determine outcome and send
                 message (response)
INITIALISATION
set maxtime to 60
END INITIALISATION
IF response is an engaged tone THEN
   send a message that the phone is engaged
ELSE
    IF response indicates the phone is ringing THEN
       send a message that the phone is ringing
       set a timer to 0
        REPEAT
            check to see if the phone has been answered
            increment the timer
        UNTIL the phone is answered OR timer is greater than maxtime
        CASEWHERE the phone was
            answered     :  send a message that a connection has
                            been established
            unanswered   :  send a message that no connection has
                            been established
            OTHERWISE    :  send an error message
        ENDCASE
    ELSE
        send an error message
    ENDIF
ENDIF
END SUBPROGRAM determine outcome and send message
```

Flowchart

An algorithm to describe the control of a telephone dialler.


begin
try for a telephone line
the response is a dialtone
False
True
send a message to the computer that a clear line is available
get a character from the computer
character is a digit
False
True
character is a 0
False
True
set the value of character to 10
set a counter to the value of the character
counter is bigger than 0
False
True
send a pulse
decrease the counter by 1
send no pulse for two seconds
there is a response on the line
False
True
determine outcome and send message (response)
end

Subprogram


begin determine outcome and send message (response)
set maxtime to 60
Response is engaged tone
True
False
send a message that the phone is engaged
phone is ringing
False
True
send an error message
send a message that the phone is ringing
set a timer to 0
check to see if the phone is answered
increment timer
phone is answered or timer > maxtime
False
True
phone was
answered
unanswered
otherwise
send a message that connection established
send a message that no connection established
send an error message
end determine outcome and send message

Auto Teller Problem

Problem

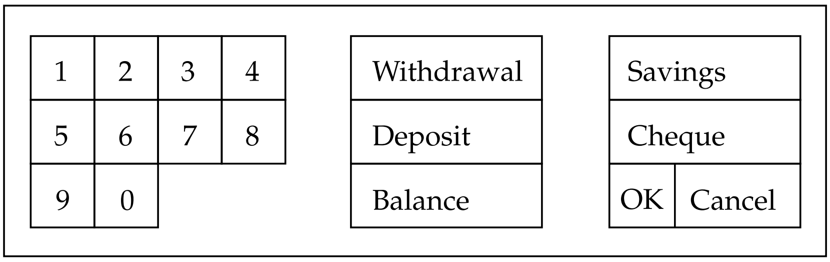
An automatic teller machine has a console as shown in the diagram below. The teller machine follows this sequence to assist a customer:

1. The customer will insert their card and enter a PIN. A customer is allowed at most three tries at their PIN. If they get it wrong three times the whole process ends without ejecting the card.
2. If the PIN is correct they will then select an action button (withdraw, deposit or balance).
3. Next they will select the account type (savings or cheque).
4. Finally, they will enter the amount in whole dollars (if appropriate), and press OK to confirm it, and the transaction will be processed.

The auto teller will eject the customer's card and stop the process if the customer presses the 'Cancel' button.

Describe an algorithm which the auto teller could use to accept the details from the customer and act on them.

Auto Teller Console



Solution

This solution uses *sequence*, *if-then*, *repeat-until*, *while*, *case* and *subprogram* structures.

Pseudocode

An algorithm to describe the control of an automatic teller machine. Input comes from the buttons on the console, output through a small video screen.

```
BEGIN MAINPROGRAM
INITIALISATION
set Action to an empty string
set Account to an empty string
set Amount to 0
END INITIALISATION
wait for the card to be inserted
get the PIN and check it (Action)
IF  action is 'cancel' THEN
    eject card
ELSE
    IF  action is not 'keep card' THEN
        get action required (Action)
        IF  action is not 'cancel' THEN
            get account to be used (Action, Account)
            do the transaction
        ENDIF
        eject card
    ENDIF
ENDIF
END MAINPROGRAM

BEGIN SUBPROGRAM wait for the card to be inserted
WHILE no card has been inserted
    wait
ENDWHILE
END SUBPROGRAM wait for the card to be inserted
```

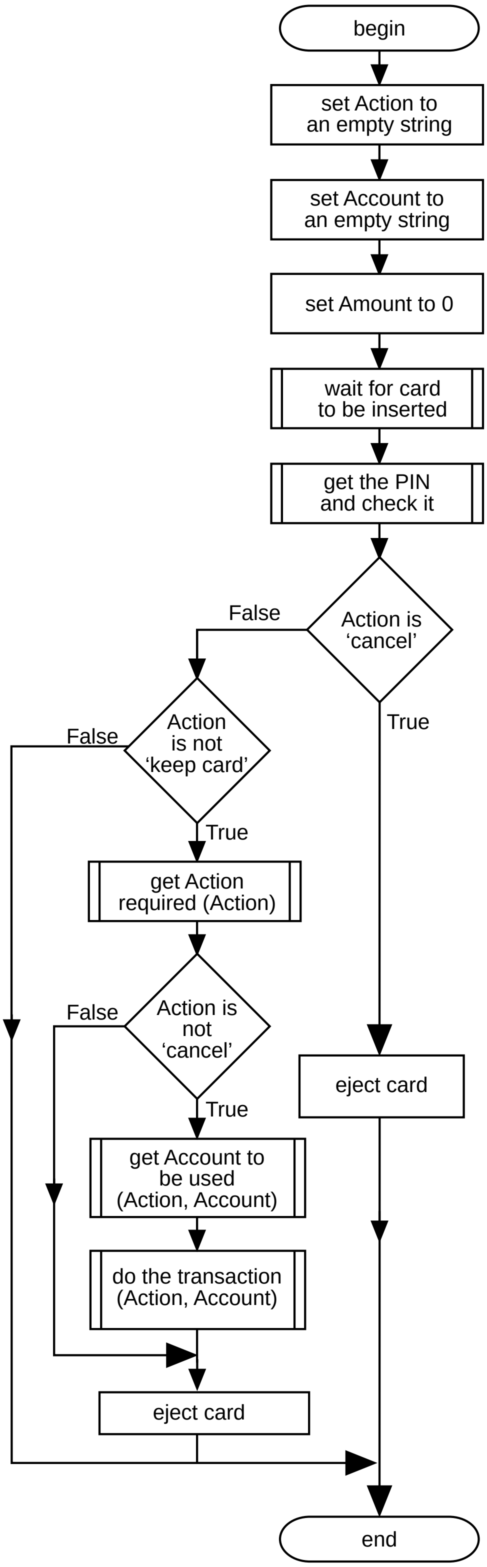
```
BEGIN SUBPROGRAM get the PIN and check it (Action)

INITIALISATION
set OK to FALSE
set NumberOfTries to 3

END INITIALISATION

IF  cancel button has been pressed THEN
    set Action to ‘cancel’
ELSE
    REPEAT
        accept a four digit number
        decrement NumberOfTries
        IF  correct PIN THEN
            set OK to TRUE
        ENDIF
    UNTIL OK OR number of tries is 0

    IF NOT OK THEN
        set Action to ‘keep card’
    ENDIF

ENDIF

END SUBPROGRAM get the PIN and check it


BEGIN SUBPROGRAM get action required (Action)

IF  cancel button has been pressed THEN
    set Action to ‘cancel’
ELSE

    REPEAT
        prompt user for action key
        get a key press
    UNTIL key press is an action key

    CASEWHERE keypress is
        Withdrawal  :   set Action to ‘withdraw’
        Deposit     :   set Action to ‘deposit’
        Balance     :   set Action to ‘show balance’
        Cancel      :   set Action to ‘cancel’

    ENDCASE

ENDIF

END SUBPROGRAM get action required
```

```
BEGIN SUBPROGRAM get account to be used (Action, Account)
IF  cancel button is pressed THEN
    set Action to ‘cancel’
ELSE
    REPEAT
        prompt for account type key
        get a keypress
    UNTIL keypress is acceptable
    CASEWHERE keypress is
        savings account    :   set Account to ‘savings account’
        cheque account     :   set Account to ‘cheque account’
        cancel             :   set Action to ‘cancel’
    ENDCASE
ENDIF
END SUBPROGRAM get account to be used

BEGIN SUBPROGRAM get the amount in dollars (Action, Amount)
INITIALISATION
set OK to FALSE
END INITIALISATION
IF  the cancel button has been pressed THEN
    set Action to ‘cancel’
ELSE
    REPEAT
        REPEAT
            prompt for a keypress
            get a keypress
        UNTIL keypress is acceptable
        CASEWHERE keypress is
            OK       :   set OK to TRUE
            cancel   :   set Action to ‘cancel’
                         set OK to TRUE
            number   :   set Amount to 10 times the amount
                         plus digit value of number
        ENDCASE
    UNTIL OK
ENDIF
END SUBPROGRAM get the amount in dollars
```

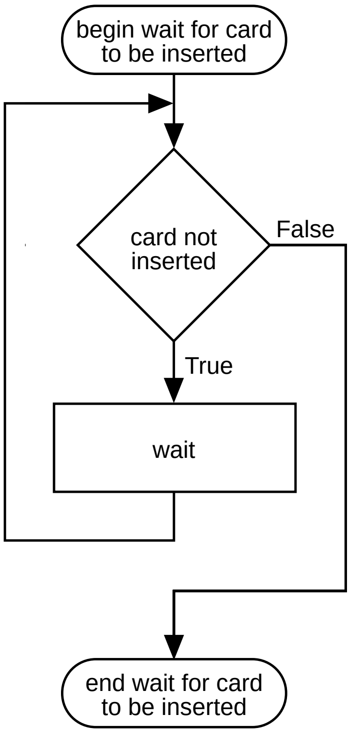
```
BEGIN SUBPROGRAM do the transaction (Action, Account)
IF  the cancel button has been pressed THEN
    set Action to 'cancel'
ENDIF
    CASEWHERE Action is
        cancel:      set Amount to 0
                     set Account to empty string
        deposit:     get the amount in dollars (Action, Amount)
                     IF  Action is not 'cancel' THEN
                         IF Account is 'cheque' THEN
                              add Amount to cheque account
                         ELSE
                              add Amount to savings account
                         ENDIF
                     ENDIF
        withdraw:    get the amount in dollars (Action, Amount)
                     IF  Action is not 'cancel' THEN
                         IF   Account is 'cheque' THEN
                              subtract Amount from cheque account
                         ELSE
                              subtract Amount from savings account
                         ENDIF
                     ENDIF
        balance:     IF  Account is 'cheque' THEN
                         display balance of cheque account
                     ELSE
                         display balance of savings account
                     ENDIF
ENDCASE
END SUBPROGRAM do the transaction
```

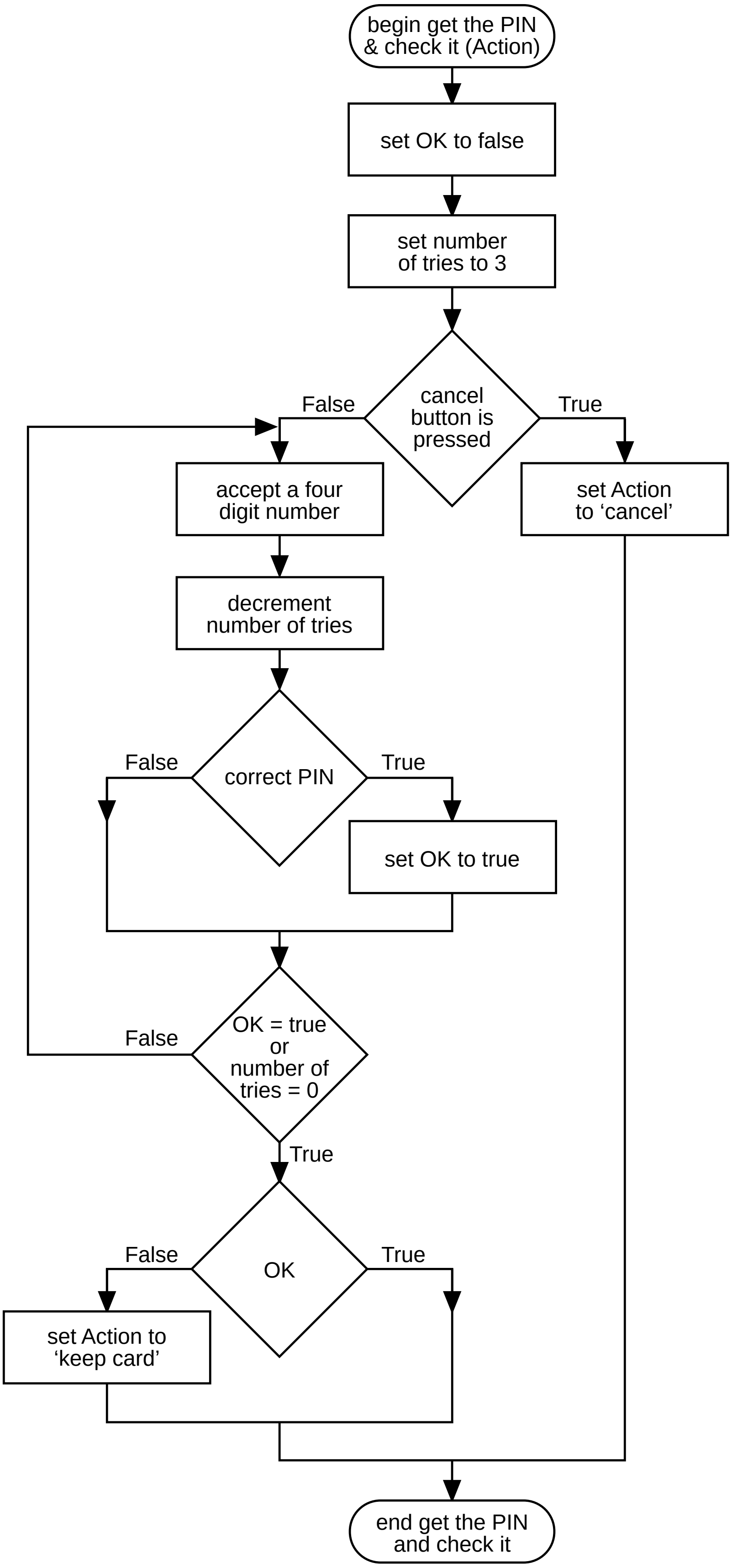
Flowchart

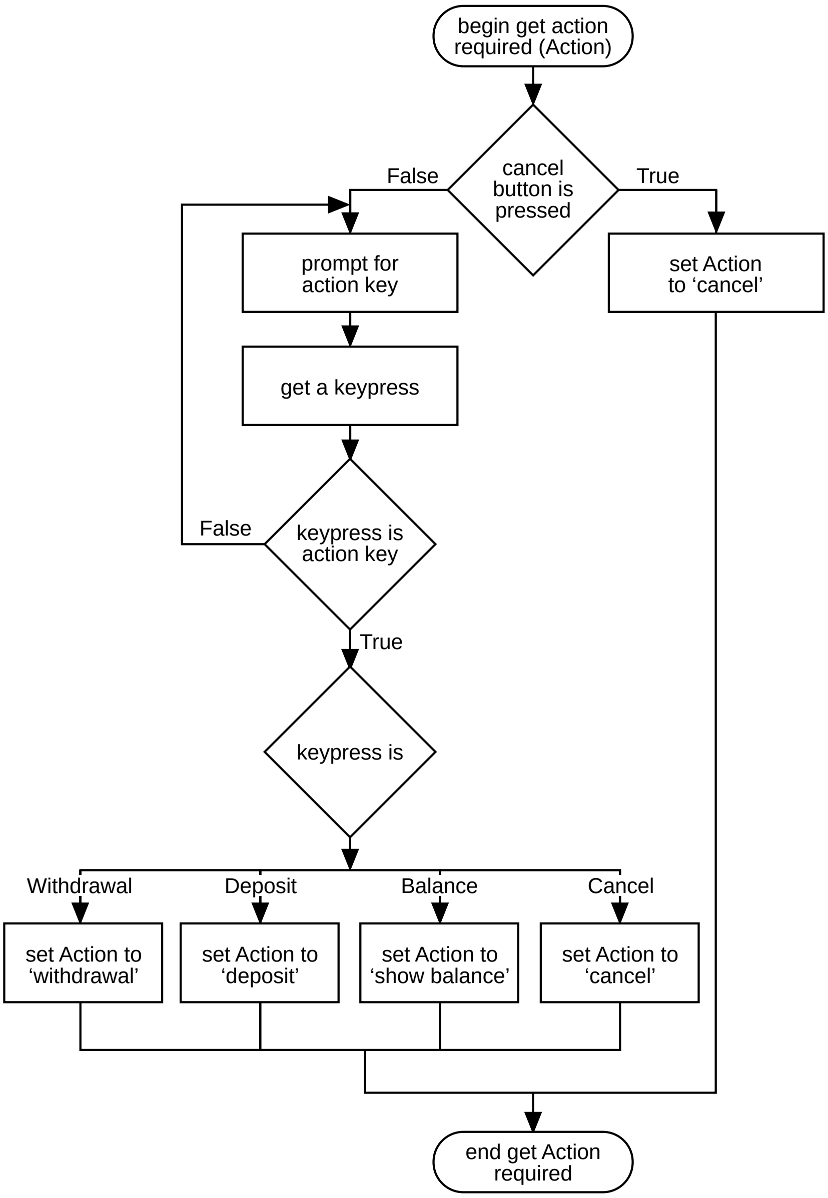
An algorithm to describe the control of an automatic teller machine. Input comes from the buttons on the console, output through a small video screen.

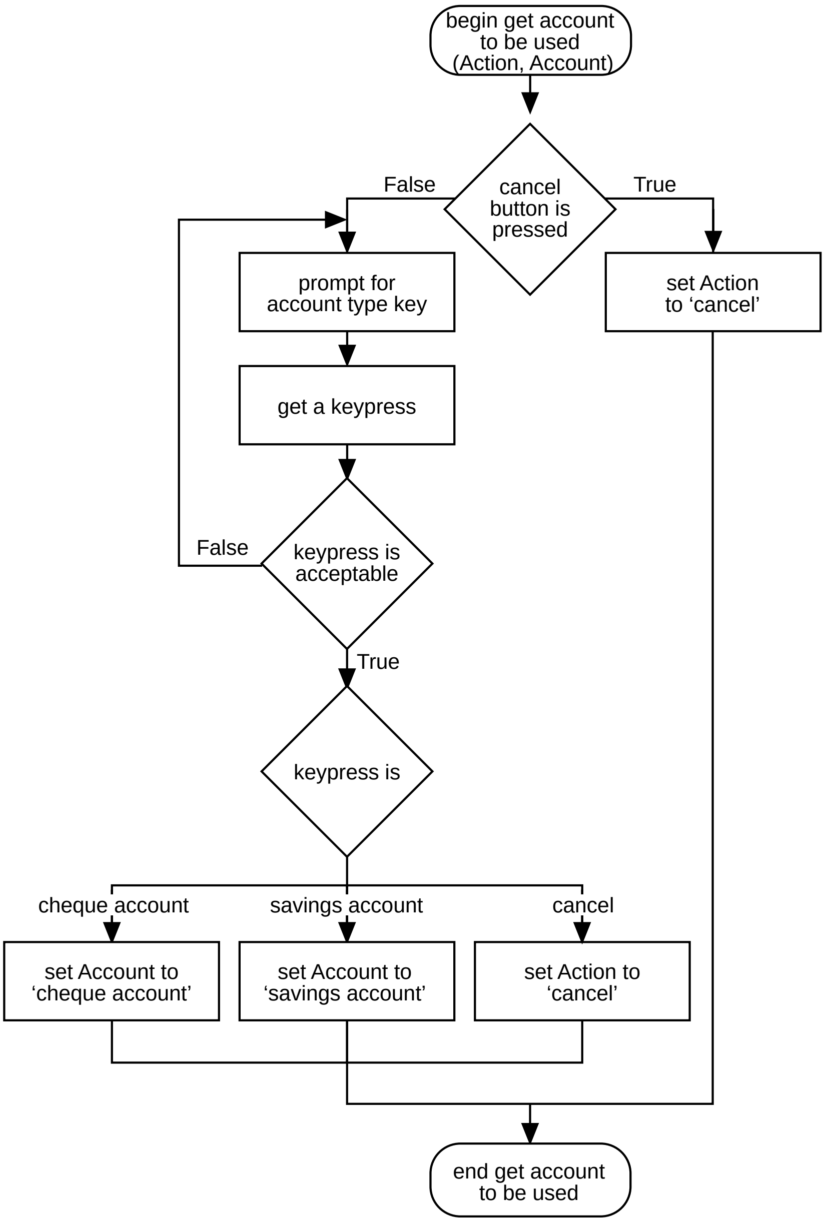

begin
set Action to an empty string
set Account to an empty string
set Amount to 0
wait for card to be inserted
get the PIN and check it
Action is 'cancel'
False
True
Action is not 'keep card'
False
True
get Action required (Action)
Action is not 'cancel'
False
True
get Account to be used (Action, Account)
do the transaction (Action, Account)
eject card
eject card
end

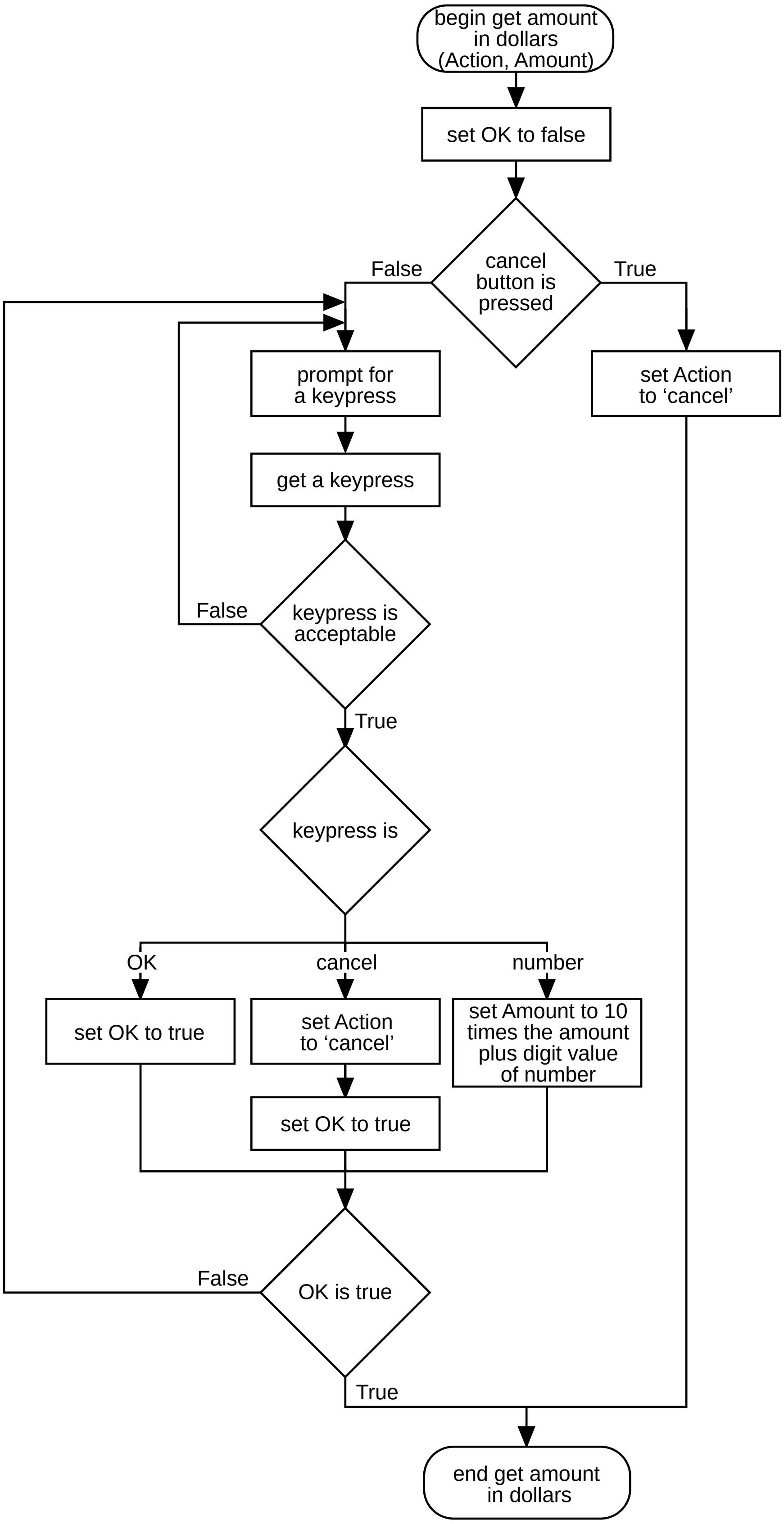
Subprograms

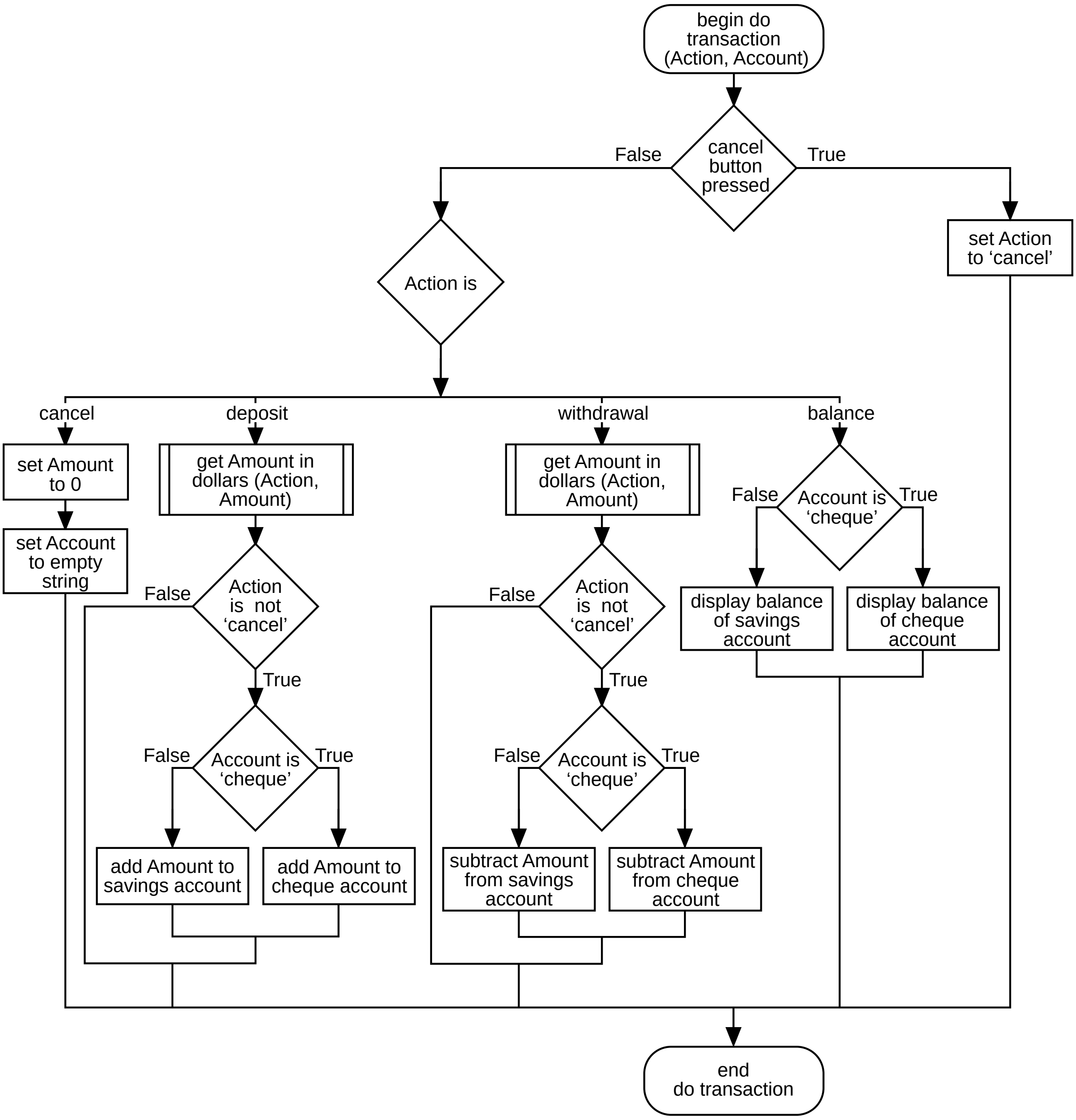

begin wait for card to be inserted
card not inserted
False
True
wait
end wait for card to be inserted


begin get the PIN & check it (Action)
set OK to false
set number of tries to 3
cancel button is pressed
False
True
accept a four digit number
set Action to 'cancel'
decrement number of tries
correct PIN
False
True
set OK to true
OK = true or number of tries = 0
False
True
OK
False
True
set Action to 'keep card'
end get the PIN and check it


begin get action required (Action)
cancel button is pressed
False
True
prompt for action key
set Action to ‘cancel’
get a keypress
False
keypress is action key
True
keypress is
Withdrawal
Deposit
Balance
Cancel
set Action to ‘withdrawal’
set Action to ‘deposit’
set Action to ‘show balance’
set Action to ‘cancel’
end get Action required


begin get account to be used (Action, Account)
cancel button is pressed
False
True
prompt for account type key
set Action to 'cancel'
get a keypress
keypress is acceptable
False
True
keypress is
cheque account
savings account
cancel
set Account to 'cheque account'
set Account to 'savings account'
set Action to 'cancel'
end get account to be used


begin get amount
in dollars
(Action, Amount)
set OK to false
cancel
button is
pressed
False
True
set Action
to 'cancel'
prompt for
a keypress
get a keypress
False
keypress is
acceptable
True
keypress is
OK
cancel
number
set OK to true
set Action
to 'cancel'
set Amount to 10
times the amount
plus digit value
of number
set OK to true
False
OK is true
True
end get amount
in dollars


begin do transaction (Action, Account)
cancel button pressed
False
True
set Action to ‘cancel’
Action is
cancel
deposit
withdrawal
balance
set Amount to 0
set Account to empty string
get Amount in dollars (Action, Amount)
get Amount in dollars (Action, Amount)
Account is ‘cheque’
False
True
False
Action is not ‘cancel’
True
False
Action is not ‘cancel’
True
display balance of savings account
display balance of cheque account
False
Account is ‘cheque’
True
False
Account is ‘cheque’
True
add Amount to savings account
add Amount to cheque account
subtract Amount from savings account
subtract Amount from cheque account
end do transaction

Algorithms for Searching and Sorting

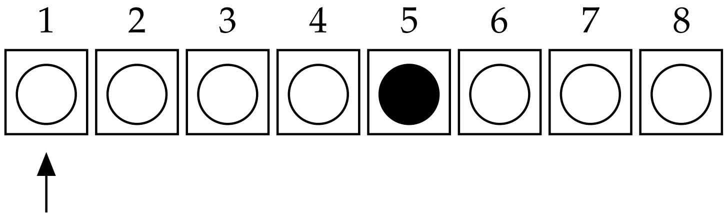
Algorithms for Searching

To give some assistance with understanding the standard algorithms for searching and sorting, as required in the *2/3 Unit (Common) Computing Studies Syllabus*, the following examples are provided.

Linear Search

Problem

In a theatre there is a row of seats. Each seat is numbered consecutively starting at 1. A person occupies each of the seats. Describe an algorithm which an usher could follow to find the seat number of the first person in the row who is wearing a red jumper (indicated by the dark circle).



Solution

This solution implements a linear (sequential) search which will work whether or not the persons are seated in a given order or at random.

The solution uses *sequence, while* and *if-then-else* structures.

Pseudocode

An algorithm to describe a linear (sequential) search to find the seat number of the first person wearing a red jumper from a set of persons sitting in a row of seats.

```
BEGIN MAINPROGRAM
INITIALISATION
stand in front of the first seat
set FoundIt to FALSE
set MoreSeats to TRUE
END INITIALISATION
get the description of the wanted person
WHILE FoundIt is FALSE AND MoreSeats
    IF the person in front of you is not the wanted person THEN
        stand in front of the next seat
    ELSE
        set FoundIt to TRUE
    ENDIF
ENDWHILE
IF FoundIt THEN
    report the seat number of the wanted person
ELSE
    report that the wanted person is not present
ENDIF
END MAINPROGRAM
```

Problem

A user has stored a set of numbers in a one-dimensional array. Each element of the array contains a unique number. Describe an algorithm the person could follow to find the element of the array which contains a particular number.

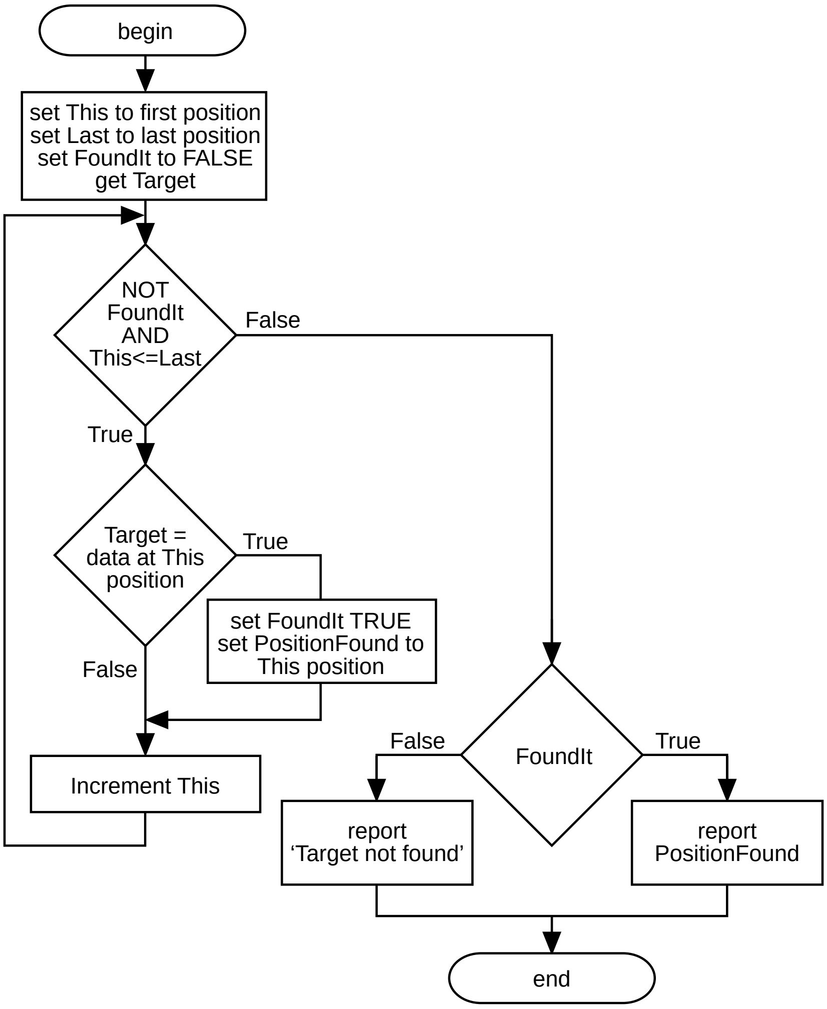
1	2	3	4	5	6	7	8
14	34	12	19	41	26	45	16

Solution

This solution implements a linear (sequential) search which will work whether or not the numbers are stored in order or at random.

The solution uses *sequence*, *while*, *if-then* and *if-then-else* structures.

Flowchart


begin
set This to first position
set Last to last position
set FoundIt to FALSE
get Target
NOT FoundIt AND This<=Last
False
True
Target = data at This position
True
set FoundIt TRUE
set PositionFound to This position
False
Increment This
FoundIt
False
True
report 'Target not found'
report PositionFound
end

Binary Search

The task is to determine whether or not a particular data value (the target) is present in a set of data. If the target is found the position of its first occurrence is reported and the search ends.

Note: that binary search will only work on sorted data.

General Idea of the Algorithm

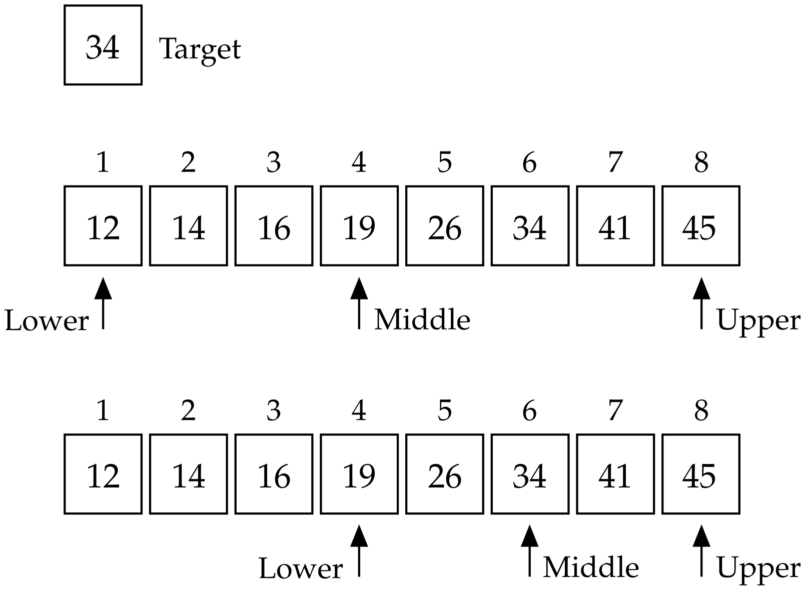
Binary search divides the data set into two parts and determines in which part the element is likely to be found. The other part of the data set is discarded and the retained part is divided into two parts. The process is continued until either the value is found or there are no more elements in the data set to be checked. If a match is found then the position of the match is reported otherwise a message is written telling the user that the target is not present in the data.

At each division there are three possibilities for the target (if it exists in the data set):

(1) the target lies at the division point;

(2) the target lies to the left of the division point

(3) the target lies to the right of the division point.



Problem

A user wants to find the telephone number of a person in the Sydney Telephone Directory. The names are listed alphabetically. Each set of data for a person is stored as an element of a one-dimensional array. One way would be to carry out a linear search starting with the first name in the listing and checking each one until either the target is found or the end of the directory is reached. Describe a more efficient algorithm which the person could use to find the telephone number of the particular person.

Solution

This solution implements a binary search which will work only if the names are in strict alphabetical order.

The solution uses *sequence, repeat-until, if-then-else* and *subprogram* structures.

Pseudocode

```
BEGIN MAINPROGRAM

INITIALISATION
set Lower to first position
set Upper to last position
set FoundIt to FALSE
get the Target name
END INITIALISATION

REPEAT
    calculate the Middle position

    IF Target = data at Middle position THEN
       set FoundIt to TRUE
       set PositionFound to Middle
    ELSE
        IF Target < data at Middle position THEN
           set Upper to Middle – 1
        ELSE
           set Lower to Middle + 2
        ENDIF
    ENDIF
UNTIL FoundIt OR Lower > Upper

IF FoundIt THEN
   report PositionFound
ELSE
    report 'Target not present'
ENDIF

END MAINPROGRAM


BEGIN SUBPROGRAM calculate the Middle position
    set Middle to (Upper + Lower) divided by 2
    set Middle to integer part of Middle
END SUBPROGRAM calculate the Middle position
```

Algorithms for Sorting

Bubble Sort

The task is to sort a set of data into either ascending order or descending order as determined when the algorithm is written. In this case the order chosen is ascending order.

General Idea of the Algorithm

The data elements are compared in pairs and the larger of the pair 'bubbles' towards the top of the structure. On each pass, one element (the largest in the unsorted part) will be moved to its correct position in the sorted part.

1	2	3	4	5	6	
42	32	23	12	19	54	Compare first with second and Swap
32	**42**	23	12	19	54	Compare second with third and Swap
32	23	**42**	12	19	54	Compare third with fourth and Swap
32	23	12	**42**	19	54	Compare fourth with fifth and Swap
32	23	12	19	**42**	54	Compare fifth with sixth and leave
32	23	12	19	**42**	54	Data set at end of first pass

Problem

A person wants to sort a set of marks into ascending order. Each mark is stored as an element of a one-dimensional array. Describe an algorithm which will sort the marks by 'bubbling' the largest mark in the unsorted part to the 'top' of the unsorted part. This will result in the sorted part getting larger each time through and the unsorted part getting smaller. The algorithm need not stop even if the person realises that the marks become sorted before the algorithm has finished.

Solution

This solution implements a bubble sort on an array of marks.

The solution uses *sequence, while, if-then* and *subprogram* structures.

Pseudocode

```
BEGIN MAINPROGRAM

INITIALISATION
set End to last position
END INITIALISATION

WHILE End > first position
    set Current to first position

    WHILE Current is less than End

        IF data at Current > data at (Current + 1) THEN
            Swap (Current, Current + 1)
        ENDIF

        increment Current

    ENDWHILE

    decrement End

ENDWHILE

END MAINPROGRAM
```

Note: that the parameters to the subprogram when it is called by the MAINPROGRAM are Current and Current + 1 but in the definition of the SUBPROGRAM general names are used for the parameters. When the SUBPROGRAM is called it substitutes the names of the actual parameters for those of the formal parameters used in the definition.

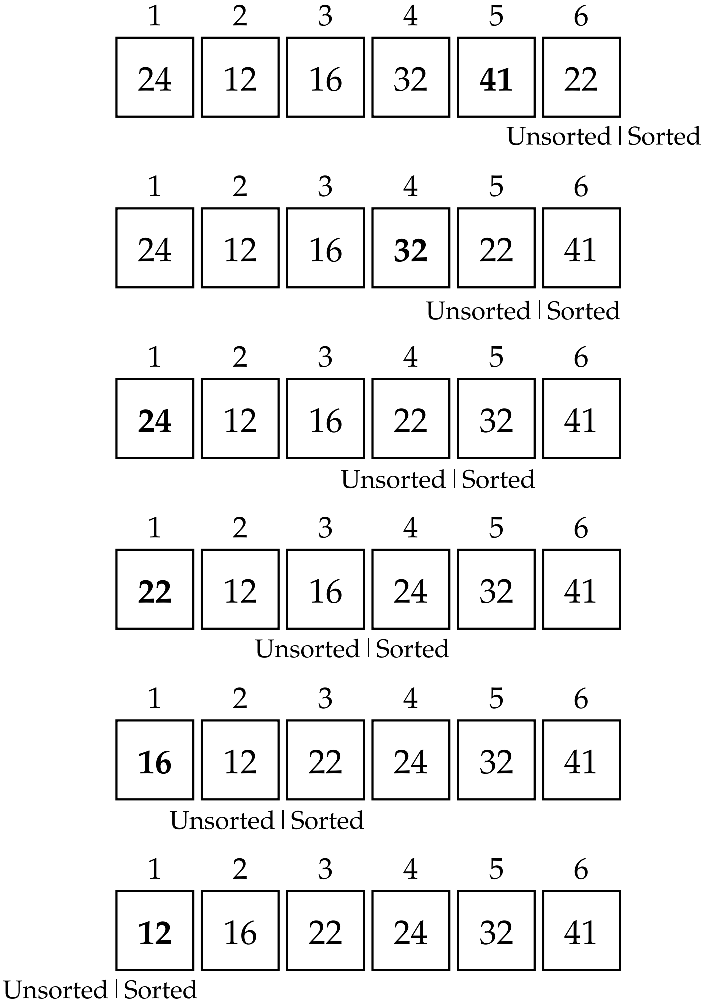
```
BEGIN SUBPROGRAM Swap (Position1, Position2)
    set Temp to data value at Position1
    set data at Position1 to data at Position2
    set data at Position2 to Temp
END SUBPROGRAM Swap
```

Selection Sort

In this algorithm a set of data is sorted into either ascending order or descending order as determined when the algorithm is written. In this case the order chosen is ascending order.

General Idea of the Algorithm

The general idea behind the algorithm is to divide the array into two parts — the unsorted part and the sorted part. Each pass through the unsorted part finds the largest number and places it at the start of the sorted part. The array originally has an 'empty' sorted part and a 'full' unsorted part. So the largest number in the unsorted part is found and swapped with the last element in the unsorted part. The length of the sorted part is then increased by one and the length of the unsorted part is decreased by one.



1	2	3	4	5	6
24	12	16	32	**41**	22

Unsorted | Sorted

1	2	3	4	5	6
24	12	16	**32**	22	41

Unsorted | Sorted

1	2	3	4	5	6
24	12	16	22	32	41

Unsorted | Sorted

1	2	3	4	5	6
22	12	16	24	32	41

Unsorted | Sorted

1	2	3	4	5	6
16	12	22	24	32	41

Unsorted | Sorted

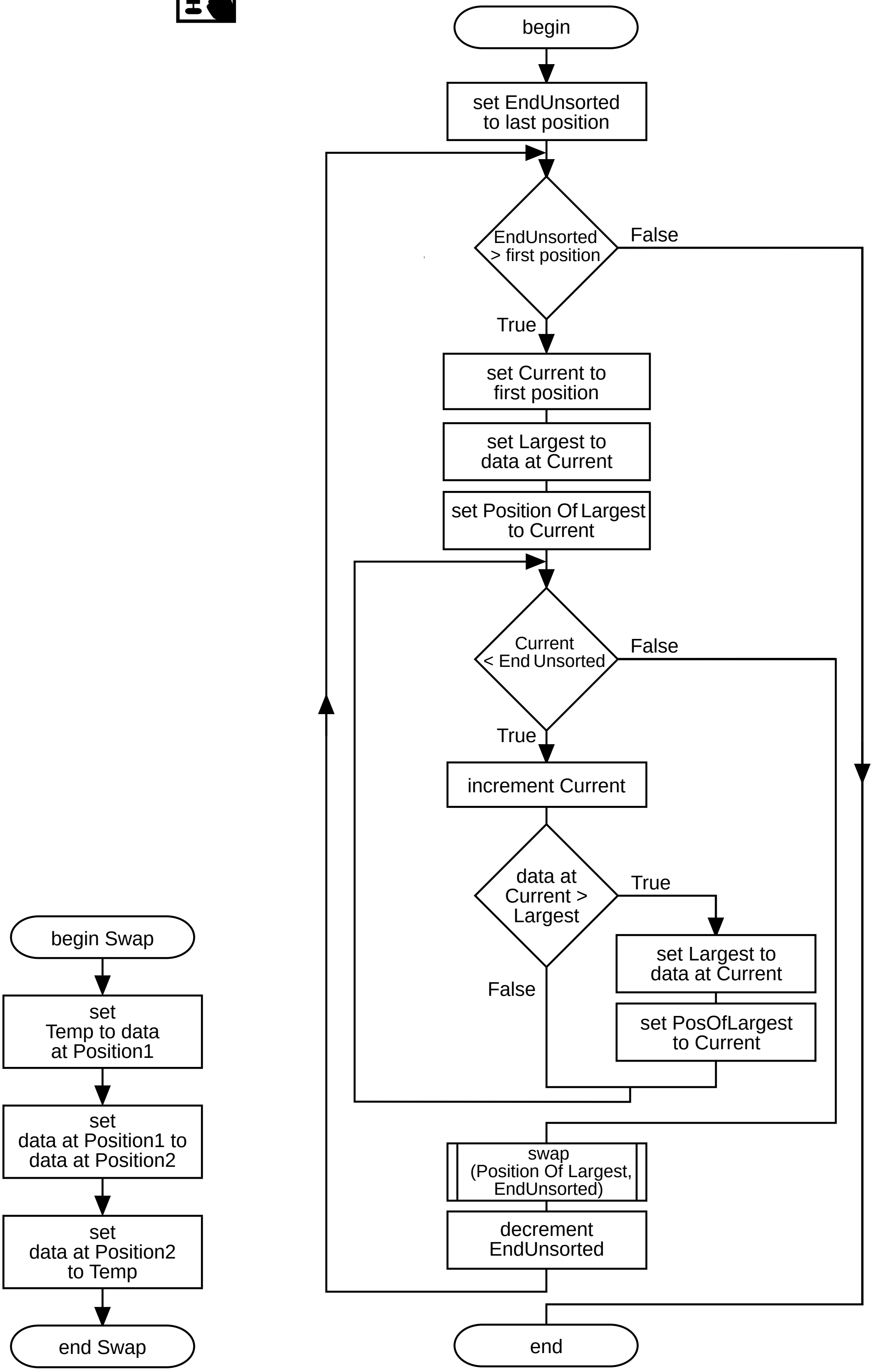
1	2	3	4	5	6
12	16	22	24	32	41

Unsorted | Sorted

Pseudocode

```
BEGIN MAINPROGRAM

INITIALISATION
set EndUnsorted to last position
END INITIALISATION

    WHILE EndUnsorted > first position
        set Current to first position
        set Largest to data at Current
        set PositionOfLargest to Current

        WHILE Current < EndUnsorted
            increment Current

            IF data at Current > Largest THEN
                set Largest to data at Current
                set PositionOfLargest to Current
            ENDIF

        ENDWHILE

        Swap (PositionOfLargest, EndUnsorted)
        decrement EndUnsorted
    ENDWHILE

END MAINPROGRAM


BEGIN SUBPROGRAM Swap (Position1, Position2)
set Temp to data value at Position1
set data at Position1 to data at Position2
set data at Position2 to Temp
END SUBPROGRAM Swap
```

Flowchart


begin
set EndUnsorted to last position
EndUnsorted > first position
False
True
set Current to first position
set Largest to data at Current
set Position Of Largest to Current
Current < End Unsorted
False
True
increment Current
data at Current > Largest
True
False
set Largest to data at Current
set PosOfLargest to Current
swap (Position Of Largest, EndUnsorted)
decrement EndUnsorted
end
begin Swap
set Temp to data at Position1
set data at Position1 to data at Position2
set data at Position2 to Temp
end Swap

Insertion Sort

In this algorithm a set of data is sorted into either ascending order or descending order as determined when the algorithm is written. In this case the order chosen is ascending order.

General Idea of the Algorithm

This is the method used by many card players to put their cards in order. The general idea of the algorithm is to divide the array into two parts — the unsorted part and the sorted part. To begin with, the sorted part contains only the right hand element. Each pass takes the last element from the unsorted part and then finds where it should be inserted in the sorted part. To find the proper place to insert the element a sequential (linear) search is used. As each element in the sorted part is checked, it is moved, if necessary, one place to the left to make room for the new element. At each pass the length of the sorted part increases by one and the length of the unsorted part decreases by one until its length is 0.

1	2	3	4	5	6
24	12	16	32	**41**	22

Unsorted | Sorted

1	2	3	4	5	6
24	12	16	**32**	22	41

Unsorted | Sorted

1	2	3	4	5	6
24	12	**16**	22	32	41

Unsorted | Sorted

1	2	3	4	5	6
24	**12**	16	22	32	41

Unsorted | Sorted

1	2	3	4	5	6
24	12	16	22	32	41

Unsorted | Sorted

1	2	3	4	5	6
12	16	22	24	32	41

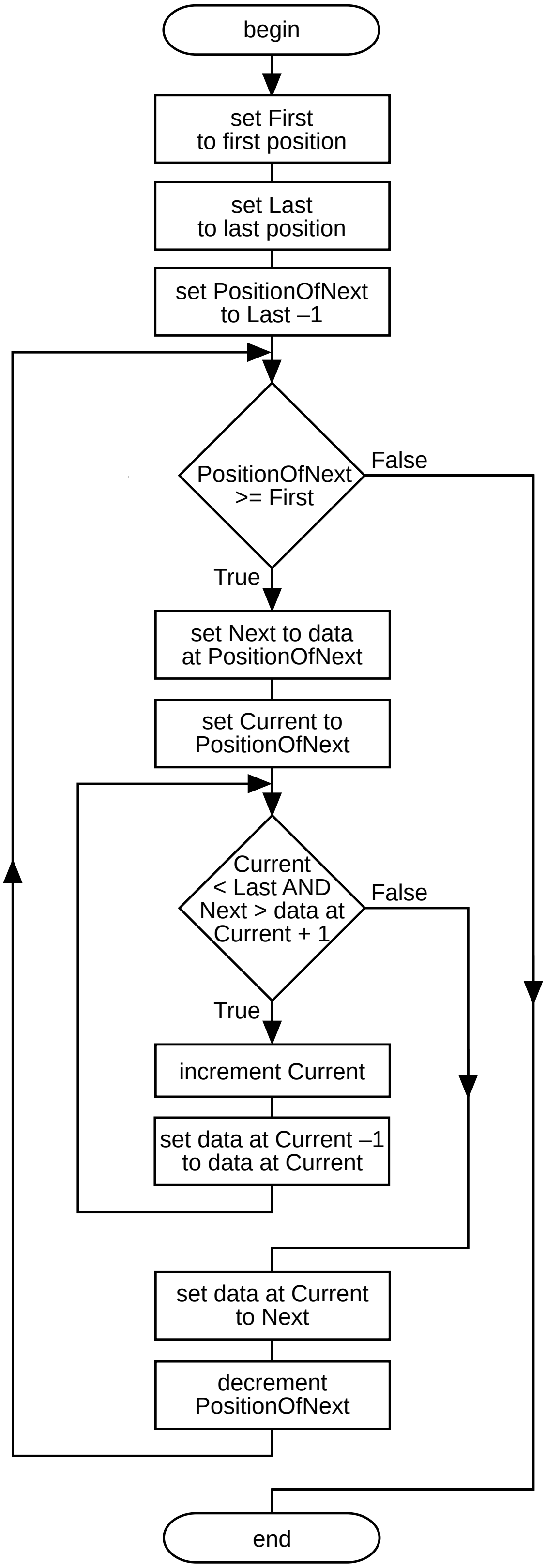
Unsorted | Sorted

Pseudocode

```
BEGIN MAINPROGRAM
INITIALISATION
set First to first position
set Last to last position
set PositionOfNext to Last – 1
ENDINITIALISATION
    WHILE PositionOfNext >= First
        set Next to data at PositionOfNext
        set Current to PositionOfNext
        WHILE (Current < Last ) AND (Next > data at (Current + 1))
            increment Current
            set data at (Current – 1) to data at Current
        ENDWHILE
        set data at Current to Next
        decrement PositionOfNext
    ENDWHILE
END MAINPROGRAM
```

Note: Variations of the algorithm are possible. In some versions, the task of finding the correct place to insert is separated from the task of moving the elements to make room. By doing this, the task of finding the correct place to insert can be speeded up by using a **binary search** rather than a **linear search**.

Flowchart


begin
set First to first position
set Last to last position
set PositionOfNext to Last –1
PositionOfNext >= First
False
True
set Next to data at PositionOfNext
set Current to PositionOfNext
Current < Last AND Next > data at Current + 1
False
True
increment Current
set data at Current –1 to data at Current
set data at Current to Next
decrement PositionOfNext
end

A COLLECTION OF PROBLEMS WITH NO SOLUTIONS GIVEN

Use these problems to test your skills at using methods of algorithm description.

1. Refine the 'Lift Problem' (on page 27) to establish a more 'realistic' problem and solution. Consider the problem of sending the lift to specific floors. Determine when the lift doors should be opened and closed.

2. Refine the 'Telephone Dialler Problem' to cater for these suggested extensions.

   (a) Modify the dialler so that it rejects numbers beginning with 0 (for STD call bar).

   (b) As for (a), but allow access to Austpac 01922, 01923, 01924.

   (c) Restrict as in (a), but allow 008 numbers.

3. A one-lane bridge only allows traffic to travel in one direction at a time. A set of traffic lights controls the flow of traffic. It takes a slow vehicle 45 seconds at most to cross the bridge. Write an algorithm to specify the control of the traffic lights.

   Extension:

   Consider a 'rush' period in which traffic travelling north is three times as heavy as traffic travelling south.

4. Road work is being undertaken on a country road and traffic is being controlled by a player of mechanical 'stop/slow' paddle turners. Write an algorithm to describe the control of the paddle turners to safely direct traffic around the road works.

5. A program accepts as input dates in the form dd/mm/yy (eg 13/11/85) and later uses them in expanded form (eg 13 November 1985). Write an algorithm that could be used to do this conversion. Assume that there are no incorrect dates, and that all dates are in the 20th century.

6. Write an algorithm that will take today's date and someone's birth date as input and use the data to calculate the person's age in years and full months.

7. A community group has decided to install an automatic sprinkler system in the local park. The sprinkler should come on when the ground moisture reduces to 20% of saturation level which is measured by a sensor. It should be turned off when the moisture reaches 55% of saturation level. Write an algorithm that could be used to control the sprinkler system.

8. A tourist bus has 53 seats. When tickets are booked, the next available seats are allocated according to number (ignoring where they are). Write an algorithm to decide what is the next seat available and to store the name of the person booking each seat.

   Extension 1

   The seats are arranged so that numbers 1 and 2 are together, 3 and 4 are across the aisle and so on up to 48. Seats 49 to 53 are across the back of the bus. Write an algorithm that can choose the seat wanted from what is available, then store the name of the person booked with the seat number.

   Extension 2

   Write an algorithm to print out the names of people booked on the bus in the order of the seats.

9. A subprogram of a grammar checking program checks for the use of apostrophes for the possessive case. Search a line of text for the symbol ʹ. If it follows an *s* and is also followed by an *s*, remove the second *s*.