A-LEVEL COMPUTER SCIENCE • EXERCISE SHEET

9.2.2 Drawing program flowcharts, and converting between pseudocode and a chart

Name: _____ Class: _____ Date: _____ **Total: 31 marks**

KEY WORDS algorithm 算法 • pseudocode 伪代码 • flowchart 流程图 • sequence 顺序 • identifier 标识符

Objective

Build the skill that sheets 9.2 and 9.2.1 between them ask for exactly once: **drawing a program flowchart** 流程图. Those sheets write pseudocode, complete an identifier table, use stepwise refinement and **read** a flowchart; the syllabus makes *drawing* one its own statement, in both directions, and a drawing question is usually worth five marks.

You must be able to:

- use the standard flowchart symbols, and use each one for its own purpose only
- draw a flowchart from a **structured English** 结构化英语 description and from **pseudocode** 伪代码
- write pseudocode from a given flowchart
- draw the right loop: a **pre-condition** loop (`WHILE`) and a **post-condition** loop (`REPEAT`), and tell them apart by where the decision box sits

1 Worked examples

Study these first. Each one shows a **method** that a question later on this sheet needs.

■ The symbols, and the rules that go with them

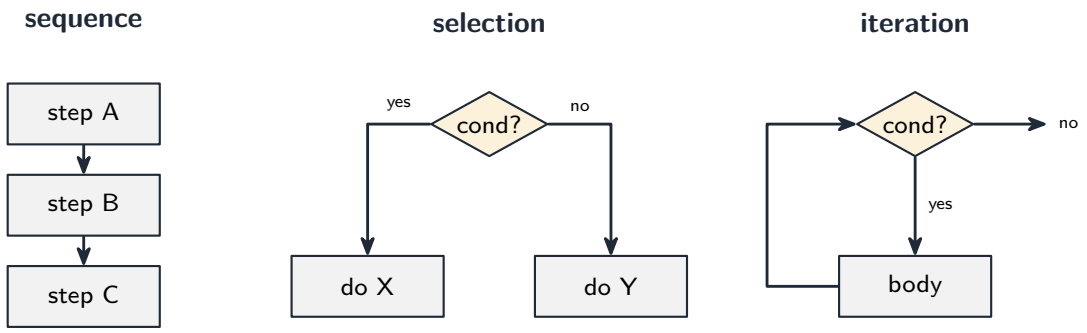
Symbol	Shape	Used for
terminator	rounded box	`Start` and `Stop` – one of each, and nothing else
process	rectangle	a calculation or an assignment
input/output	parallelogram	`INPUT` and `OUTPUT` only
decision	diamond	a question with a yes/no answer
flow line	arrow	the order the steps run in

Four rules the mark scheme applies:

1. Every symbol except the decision has **one** arrow in and **one** arrow out.

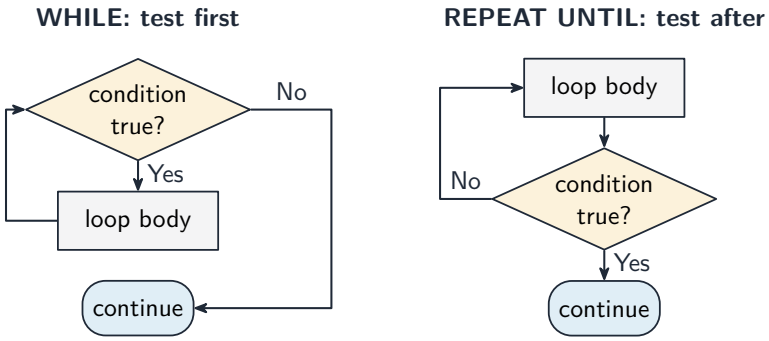
2. A **decision** has exactly **two** exits, and both must be **labelled** – `Yes`/`No` or `True`/`False`. An unlabelled diamond loses the mark.
3. Every path must end at `Stop`. A path that runs off the page or stops at a box is an error.
4. An assignment is a **process**, not an input. `Total <- 0` goes in a rectangle; only `INPUT` and `OUTPUT` go in a parallelogram.

The three constructs as shapes



- **Sequence** is boxes stacked in order, one arrow between each pair.
- **Selection** is a diamond with two labelled exits that **rejoin** below. If there is no `ELSE`, the `No` branch simply goes straight down to the rejoining point.
- **Iteration** is a diamond whose exit **loops back** upwards to an earlier point.

Where the diamond goes tells you which loop it is



This is the single most useful thing to know when converting in either direction.

- **`WHILE` is a pre-condition loop**: the diamond sits **above** the body, so the body may run **zero** times. Draw the test first, and take the `No` exit out of the loop.
- **`REPEAT ... UNTIL` is a post-condition loop**: the body sits **above** the diamond, so the body always runs **at least once**. Draw the body first, and take one exit back up to the top of the body.

So when you are given a flowchart and asked for pseudocode, find the diamond. **Above the body means `WHILE`; below the body means `REPEAT`.**

- One more sign-flip to watch: `WHILE` continues while its condition is **true**, but `REPEAT` stops when its condition becomes true. A diamond reading `count < n?` whose `Yes` loops back becomes `UNTIL count >= n` – the **negation**.

A worked conversion, pseudocode to flowchart

Draw the flowchart for:

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

1. `Start` in a rounded box.
2. `INPUT Mark` in a parallelogram.
3. A diamond reading `Mark >= 50?`.
4. From its `Yes` exit, a parallelogram `OUTPUT "Pass"`; from its `No` exit, a parallelogram `OUTPUT "Fail"`.
5. Both arrows **rejoin** and go to `Stop`.

Five boxes, six arrows, two of them labelled. Counting the marks against the symbols like this is what stops a step being dropped.

2 Practice

Now use the methods above.

2.1 Name the flowchart symbol used for each of these. [4]

(a) `Start`

(b) `Total <- Total + Mark`

(c) `INPUT Name`

(d) `Is Count = 10?`

2.2 State how many exits a **decision** box has, and state what must be written on them. [2]

2.3 State where the decision box is drawn for a `WHILE` loop and for a `REPEAT` loop, and state what follows from the difference. [3]

2.4 A student's flowchart has a **process** box with two arrows leaving it. State why this is wrong. [1]

3 Exam-style questions

3.1 An algorithm is described in structured English:

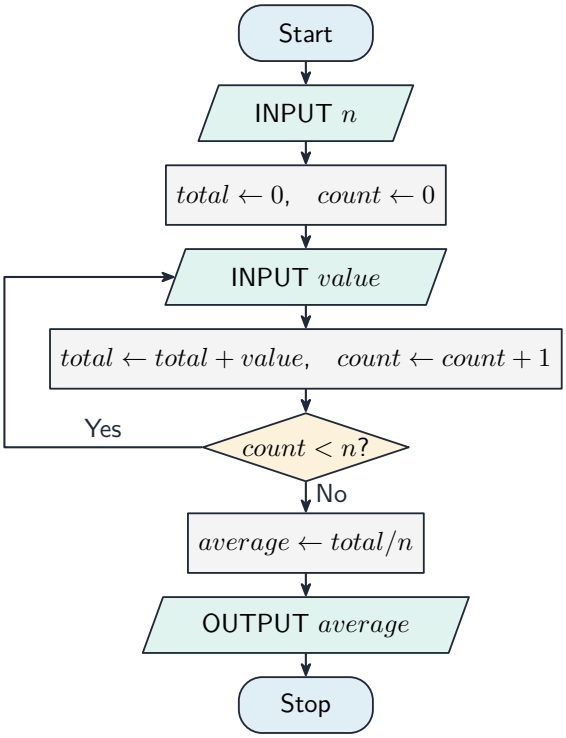
1. Input a temperature.
2. If the temperature is above 30, output `"Hot"`; otherwise output `"Not hot"`.
3. Stop.

Draw a program flowchart for this algorithm. [5]

3.2 Draw a program flowchart for this pseudocode. [5]

```
Total <- 0
FOR Count <- 1 TO 5
    INPUT Number
    Total <- Total + Number
NEXT Count
OUTPUT Total
```

3.3 The flowchart shows an algorithm that averages a list of numbers.



Write the pseudocode for this algorithm. Declare your variables. [5]

3.4 A student draws a flowchart in which:

- the condition is written inside a rectangle,
- the two arrows leaving it carry no labels,
- one of the two paths ends at an output box with no arrow leaving it.

State what is wrong in each case. [3]

3.5 Explain when an algorithm should use a `REPEAT ... UNTIL` loop rather than a `WHILE` loop, and give an example of such a task. [3]

Solutions

Each answer shows the steps, then the **result**.

2.1

(a) a **terminator** – a rounded box

(b) a **process** – a rectangle

(c) an **input/output** symbol – a parallelogram

(d) a **decision** – a diamond

2.2

- **two** exits
- each must be **labelled**, `Yes` and `No` (or `True` and `False`)

2.3

- for a `WHILE` loop the diamond is drawn **above** the body, so the condition is tested **before** the body runs
- for a `REPEAT` loop the diamond is drawn **below** the body, so the condition is tested **after** the body runs
- so a `WHILE` body may run **zero** times, while a `REPEAT` body always runs **at least once**

2.4

- only a **decision** box may have two exits; a process box does exactly one thing and has one arrow in and one arrow out

3.1

- `Start` and `Stop` in rounded boxes
- `INPUT Temperature` in a parallelogram
- a diamond reading `Temperature > 30?`
- `OUTPUT "Hot"` on the `Yes` branch and `OUTPUT "Not hot"` on the `No` branch, both in parallelograms
- both exits **labelled**, and the two branches rejoining before `Stop`

3.2

- `Start`, `Stop`, and `Total <- 0` in a process box
- `Count <- 1` initialised in a process box before the loop
- `INPUT Number` in a parallelogram and `Total <- Total + Number` in a process box
- `Count <- Count + 1` and a diamond testing `Count <= 5?`, whose `Yes` exit loops **back** to `INPUT Number`
- `OUTPUT Total` in a parallelogram on the `No` exit, before `Stop`
- a `FOR` loop counts a fixed number of times, so drawn as a flowchart it becomes an initialised counter, an increment and a test – the three parts the `FOR` line hides

3.3

- the declarations, and `INPUT n`
- `total <- 0` and `count <- 0`
- a **post-condition** loop, because the diamond is drawn **below** the body
- the loop body: `INPUT value`, `total <- total + value`, `count <- count + 1`
- `UNTIL count >= n`, then `average <- total / n` and `OUTPUT average`

```
DECLARE n, count, value, total : INTEGER
DECLARE average : REAL
INPUT n
total <- 0
count <- 0
REPEAT
    INPUT value
    total <- total + value
    count <- count + 1
UNTIL count >= n
average <- total / n
OUTPUT average
```

- the diamond reads `count < n?` and its `Yes` loops back, so the `UNTIL` condition is the **negation**, `count >= n`
- a `WHILE` version scores nothing for the loop mark: the chart tests **after** the body, so the body must always run once

3.4

- a condition must be drawn in a **diamond**, not a rectangle: a rectangle is a process and may not have two exits
- the two arrows leaving a decision must be **labelled** `Yes` and `No`, or the reader cannot tell which path is which
- every path must reach `Stop`: a box with no arrow leaving it leaves the algorithm unfinished

3.5

- use `REPEAT ... UNTIL` when the body must run **at least once** whatever happens, because the condition cannot be tested until the body has run
- the value the condition depends on does not exist before the first pass
- example: asking the user for a password, or for a value in a valid range – you must ask once before you can check what was entered; a `WHILE` would have to test a variable that has not been given a value yet