

## 5.2 Flowcharts, tracing and test data

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

**Total: 23 marks**

**KEY WORDS** flowchart • sequence • selection • iteration  
• trace table • pseudocode • boundary

### Objective

Build the skills to answer exam questions on **flowcharts, tracing and testing** – flowchart symbols, sequence, selection and iteration, trace tables and test data.

**You must be able to:**

- name and use the standard **flowchart** symbols
- identify **sequence**, **selection** and **iteration** in an algorithm
- complete a **trace table** for a flowchart or **pseudocode**
- choose normal, **boundary** and invalid test data from a specification

### 1 Key knowledge and worked examples

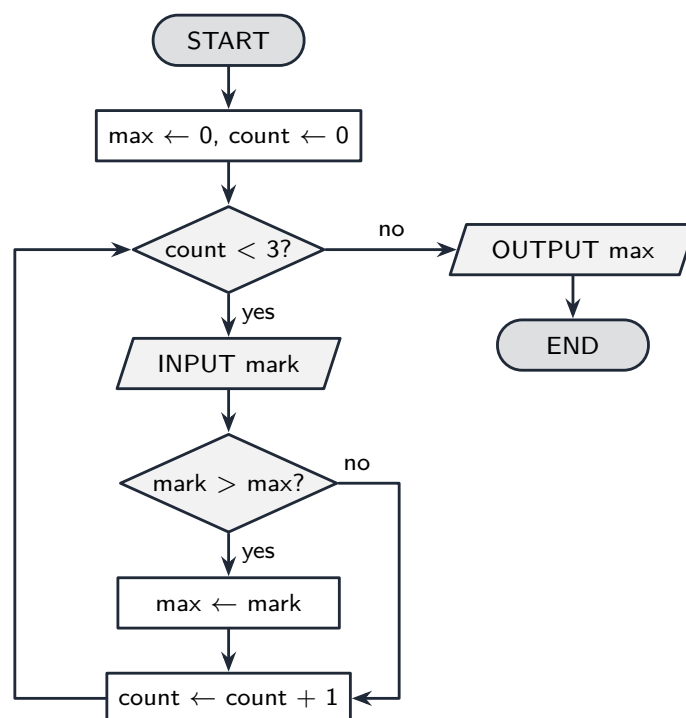
Study these first. Each one shows the method for a question type used later.

#### ■ Key knowledge: flowchart symbols

| Symbol            | Use                                                 |
|-------------------|-----------------------------------------------------|
| rounded rectangle | START, END                                          |
| parallelogram     | INPUT, OUTPUT                                       |
| rectangle         | process: $\text{total} \leftarrow \text{total} + x$ |
| diamond           | decision with yes and no exits                      |

$x \leftarrow 5$  is assignment: store 5 in  $x$ .

## ■ Worked example: tracing a flowchart



Inputs 62, 85, 71.

| count | mark | mark > max? | max | Output |
|-------|------|-------------|-----|--------|
| 0     |      |             | 0   |        |
| 0     | 62   | yes         | 62  |        |
| 1     | 85   | yes         | 85  |        |
| 2     | 71   | no          | 85  |        |
| 3     |      |             |     | 85     |

1. The diamond `count < 3?` with the arrow back is **iteration**; `mark > max?` is **selection**.
2. Output **85**. With inputs -5, -8, -2 it outputs 0, which is wrong: `max` should start at the first mark.

## ■ Worked example: test data

A quiz accepts a score from 0 to 50.

| Type                    | Values          | Expected |
|-------------------------|-----------------|----------|
| normal                  | 23, 41          | accepted |
| boundary                | 0, 50           | accepted |
| boundary (just outside) | -1, 51          | rejected |
| invalid                 | -30, 200, "abc" | rejected |

## 2 Practice

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**2.1** Name the flowchart symbol for: (i) `OUTPUT total`; (ii) `IF age >= 18`; (iii) `count ← count + 1`. [3]

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**2.2** Trace the flowchart above for the inputs 30, 75, 75, and state the output. [3]

**2.3** A password must be 8 to 16 characters long. Give **one** normal, **two** boundary and **one** invalid length. [2]

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## 3 Exam-style questions

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**3.1** Which construct does a diamond whose “yes” arrow loops back to an earlier step show? [1]

- ☐ **A** sequence  
**B** selection only  
**C** iteration  
**D** abstraction

**3.2** What is the output of this pseudocode?

[1]

```
x ← 1
loop while x < 30
    x ← x * 2
end loop
output x
```

- ☐ A 16  
☐ B 30  
☐ C 32  
☐ D 64

**3.3** Which value is boundary data for an age from 11 to 18 inclusive?

[1]

- ☐ A 14  
☐ B 18  
☐ C 25  
☐ D “eleven”

**3.4** An algorithm counts how many of the numbers entered are even. It stops when -1 is entered.

```
count ← 0
input N
loop while N ≠ -1
    if N mod 2 = 0 then
        count ← count + 1
    end if
    input N
end loop
output count
```

(a) Complete a trace table for the inputs 4, 7, 10, 0, -1, with columns N,  $N \bmod 2 = 0$ ? and count. State the output. [4]

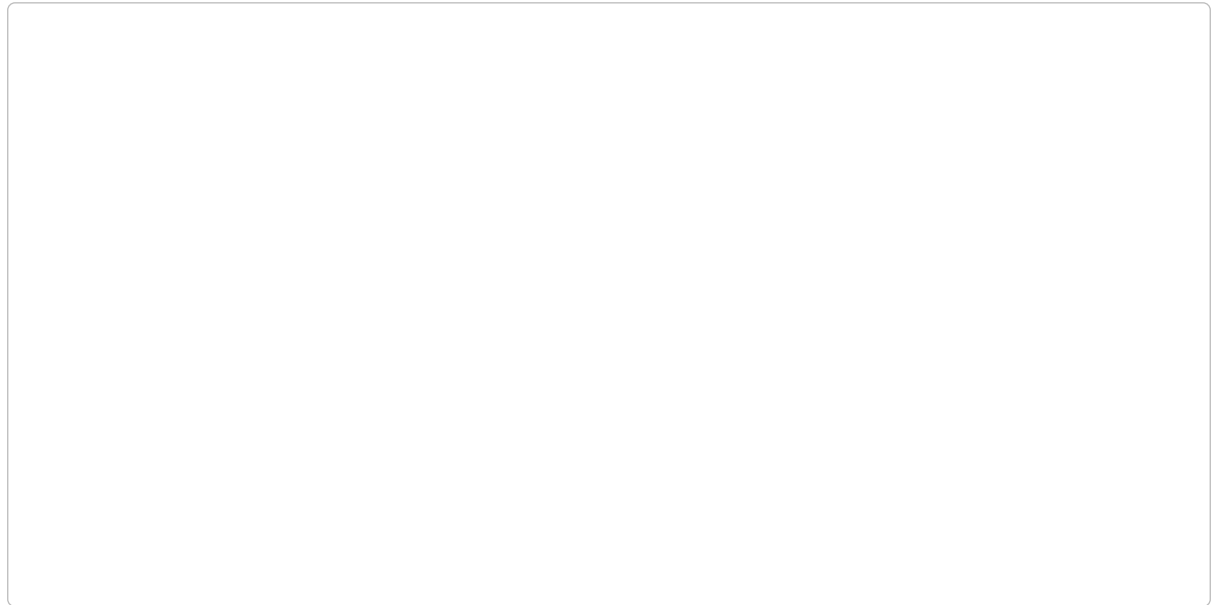
| N  | $N \bmod 2 = 0$ ? | count |
|----|-------------------|-------|
| 4  |                   |       |
| 7  |                   |       |
| 10 |                   |       |
| 0  |                   |       |
| -1 |                   |       |

(b) Identify **one** example of selection and **one** of iteration in the algorithm. [2]

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(c) Draw a flowchart for the algorithm. [4]



(d) State the output if the first number entered is -1, and whether this is correct. [2]

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## Solutions

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

### 2.1

- (i) **parallelogram**
- (ii) **diamond**
- (iii) **rectangle**

### 2.2

- $30 > 0$ : **max** 30
- $75 > 30$ : **max** 75; the second 75 is not greater, so **max** stays 75
- output **75**

### 2.3

- normal: e.g. 12
- boundary: 8 and 16 (or 7 and 17 just outside); invalid: e.g. 3 or 40

### 3.1 C

- a loop back is iteration

### 3.2 C

- 1, 2, 4, 8, 16, 32: the loop stops at 32

### 3.3 B

- 18 is the top edge of the range

### 3.4

(a)

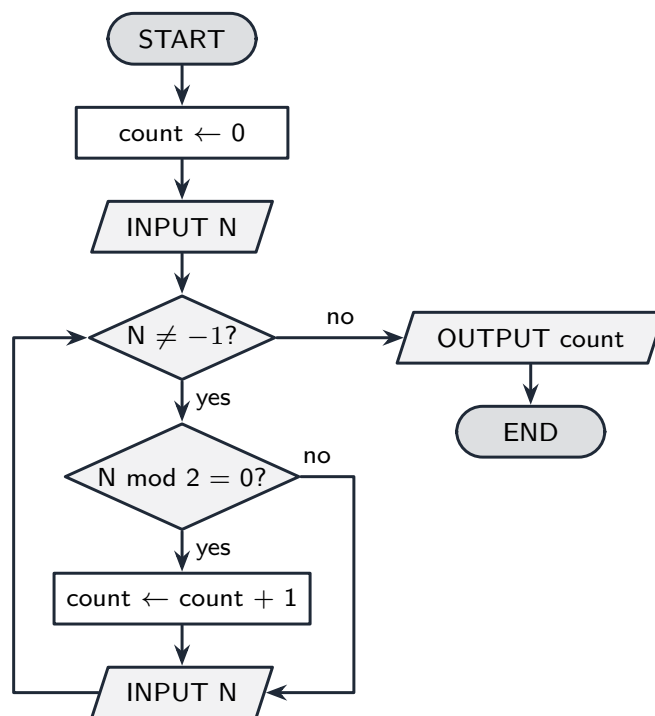
| N  | $N \bmod 2 = 0?$ | count |
|----|------------------|-------|
|    |                  | 0     |
| 4  | yes              | 1     |
| 7  | no               | 1     |
| 10 | yes              | 2     |
| 0  | yes              | 3     |
| -1 |                  |       |

- 4 and 7 correct
- 10 and 0 correct: 0 is even
- loop ends at -1 without testing it
- output **3**

(b)

- selection: if  $N \bmod 2 = 0$
- iteration: loop while  $N \neq -1$

(c)



- START,  $\text{count} \leftarrow 0$  and INPUT N in sequence
- decision  $N \neq -1?$ , with no leading to OUTPUT count and END
- decision  $N \bmod 2 = 0?$ , yes leading to  $\text{count} \leftarrow \text{count} + 1$
- INPUT N then an arrow back to the first decision

(d)

- the loop never runs: output **0**
- correct: no numbers were entered, so none are even