

Exercise walk-through

9.2.1

Logic statements and decisions in an algorithm

A-Level Computer Science

9.2.1 Logic statements and decisions in an algorithm

Name: _____ Class: _____ Date: _____ **Total: 51 marks**

KEY WORDS logic statements • decision • selection • pseudocode
• identifier

Objective

Learn to write the **logic statements** that an algorithm uses to make a **decision**. Sheet 9.2 wrote algorithms that run straight through; here the algorithm must choose. You write conditions with comparison operators and with **AND**, **OR** and **NOT**, work out whether they are **TRUE** or **FALSE**, and use one in a simple **IF**. The full rules for **IF** and **CASE** are on sheets 11.2 and 11.2.1.

You must be able to:

- write a logic statement for a condition that is given in words
- use the comparison operators, and join comparisons with **AND**, **OR** and **NOT**
- write the condition for a value **inside** a range and **outside** a range

- work out whether a logic statement is TRUE or FALSE for given values
- use a logic statement to define a decision in an algorithm

1 Worked examples

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

■ Comparisons

- A **logic statement** is a condition that is either **TRUE** or **FALSE**.
- The simplest one **compares** two values:

operator	meaning	with Age = 16
=	equal to	Age = 16 is TRUE
<>	not equal to	Age <> 16 is FALSE
<	less than	Age < 16 is FALSE
>	greater than	Age > 12 is TRUE
<=	less than or equal to ("at most")	Age <= 16 is TRUE
>=	greater than or equal to ("at least")	Age >= 18 is FALSE

"Over 18" is `Age > 18`. "18 or over" and "at least 18" are `Age >= 18`.

■ Joining comparisons: AND, OR, NOT

operator	the statement is TRUE when ...	example
AND	both parts are TRUE	<code>Age >= 13 AND Age <= 19</code>
OR	at least one part is TRUE	<code>Day = "Sat" OR Day = "Sun"</code>
NOT	the part is FALSE (reverses it)	<code>NOT Paid</code>

Every comparison needs **both sides**. Write `Temp >= 18 AND Temp <= 24`. Never write `Temp >= 18 AND <= 24`, and never write `18 <= Temp <= 24`.

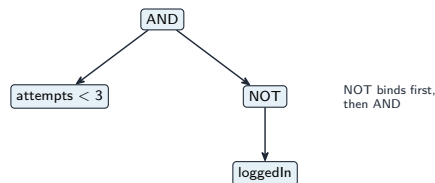
■ Inside a range, outside a range

- **Inside** a range: the value must pass **both** tests, so use **AND**: `Mark >= 0 AND Mark <= 100`.
- **Outside** a range: the value fails at **one** end, so use **OR**: `Mark < 0 OR Mark > 100`.

Test it with one value. Is 150 outside? `150 < 0` is FALSE, `150 > 100` is TRUE, and FALSE OR TRUE is **TRUE**: correct. With AND it is FALSE for every number: no number is below 0 **and** above 100.

■ Working out a logic statement

Work in this order: **brackets**, then NOT, then AND, then OR.



Worked example: `Age >= 18 AND (HasTicket OR IsStaff)` with `Age = 20`, `HasTicket = FALSE`, `IsStaff = TRUE`.

1. Replace each part with its value: `TRUE AND (FALSE OR TRUE)`.
2. Brackets first: `FALSE OR TRUE` is TRUE, so the statement is `TRUE AND TRUE`.
3. The result is **TRUE**.

■ A decision in an algorithm

When an algorithm must choose, the logic statement becomes the **condition** of an IF.

Worked example: `delivery is free for an order of more than 50.00, or for a member.`

Otherwise it costs 4.99.

In structured English:

1. If the order total is more than 50.00, or the customer is a member, set the delivery charge to 0.
2. Otherwise set the delivery charge to 4.99.

In pseudocode:

```
IF OrderTotal > 50.00 OR Member = TRUE THEN
    Delivery ← 0
ELSE
    Delivery ← 4.99
ENDIF
```

- The statements between THEN and ELSE run when the condition is TRUE. The statements between ELSE and ENDIF run when it is FALSE.
- Member is a BOOLEAN, so Member = TRUE can also be written as Member.

Past-paper practice: complete sheets 9.2.1, 11.2 and 11.2.1 before attempting past-paper set 11.2.1.

Exercise 2.1 (a)

2.1 Write the comparison operator for each phrase.

[4]

(a) is not equal to

Exercise 2.1 (a)

2.1 Write the comparison operator for each phrase.

[4]

(a) is not equal to

(a) <>

Exercise 2.1 (b)

2.1 Write the comparison operator for each phrase.

[4]

(b) is at least

Exercise 2.1 (b)

2.1 Write the comparison operator for each phrase.

[4]

(b) is at least

(b) "at least" includes the value itself $\rightarrow \geq$

Exercise 2.1 (c)

2.1 Write the comparison operator for each phrase.

[4]

(c) is less than

Exercise 2.1 (c)

2.1 Write the comparison operator for each phrase.

[4]

(c) is less than

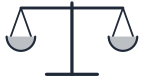
(c) <

Exercise 2.1 (d)

2.1 Write the comparison operator for each phrase.

[4]

(d) is at most

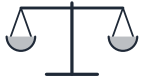


Exercise 2.1 (d)

2.1 Write the comparison operator for each phrase.

[4]

(d) is at most



(d) "at most" includes the value itself $\rightarrow \leq$

Exercise 2.2 (a)

2.2 The variable **X** holds the value 7. State whether each logic statement is TRUE or FALSE. [5]

(a) $X > 7$

Exercise 2.2 (a)

2.2 The variable **X** holds the value 7. State whether each logic statement is TRUE or FALSE. [5]

(a) **X** > 7

(a) 7 is not greater than 7 $\rightarrow$ **FALSE**

Exercise 2.2 (b)

2.2 The variable **x** holds the value 7. State whether each logic statement is TRUE or FALSE. [5]

(b) $x \geq 7$

Exercise 2.2 (b)

2.2 The variable **x** holds the value 7. State whether each logic statement is **TRUE** or **FALSE**. [5]

(b) **x** >= 7

(b) 7 is equal to 7 → **TRUE**

Exercise 2.2 (c)

2.2 The variable **X** holds the value 7. State whether each logic statement is TRUE or FALSE. [5]

(c) $X \neq 7$

Exercise 2.2 (c)

2.2 The variable **X** holds the value 7. State whether each logic statement is **TRUE** or **FALSE**. [5]

(c) $X \neq 7$

(c) 7 is equal to 7, so “not equal” $\rightarrow$ **FALSE**

Exercise 2.2 (d)

2.2 The variable **X** holds the value 7. State whether each logic statement is TRUE or FALSE. [5]

(d) $X < 10 \text{ AND } X > 5$

Exercise 2.2 (d)

2.2 The variable **X** holds the value 7. State whether each logic statement is **TRUE** or **FALSE**. [5]

(d) **X** < 10 AND **X** > 5

(d) **TRUE** AND **TRUE** $\rightarrow$ **TRUE**

Exercise 2.2 (e)

2.2 The variable X holds the value 7. State whether each logic statement is TRUE or FALSE. [5]

(e) $X < 5$ OR $X = 7$

X

Exercise 2.2 (e)

2.2 The variable X holds the value 7. State whether each logic statement is TRUE or FALSE. [5]

(e) $X < 5$ OR $X = 7$

X

(e) FALSE OR TRUE $\rightarrow$ **TRUE**

Exercise 2.3 (a)

2.3 Write a logic statement for each condition.

(a) Age is from 13 to 19.

[1]

Age UserName

Exercise 2.3 (a)

2.3 Write a logic statement for each condition.

(a) **Age** is from 13 to 19.

[1]

Age UserName

(a) inside a range, so AND: `Age >= 13 AND Age <= 19`

Exercise 2.3 (b)

2.3 Write a logic statement for each condition.

(b) `UserName` is not an empty string and has at most 12 characters. The function `LENGTH()` returns the number of characters in a string. [1]

Exercise 2.3 (b)

2.3 Write a logic statement for each condition.

(b) `UserName` is not an empty string and has at most 12 characters. The function `LENGTH()` returns the number of characters in a string. [1]

(b) `UserName <> "" AND LENGTH(UserName) <= 12`

Exercise 2.3 (c)

2.3 Write a logic statement for each condition.

(c) A ticket is free when **Age** is under 5 or is 80 or more.

[1]

Exercise 2.3 (c)

2.3 Write a logic statement for each condition.

(c) A ticket is free when **Age** is under 5 or is 80 or more.

[1]

(c) two separate groups, so OR: $\text{Age} < 5 \text{ OR } \text{Age} \geq 80$

Exercise 2.4 (a)

2.4 Each logic statement contains an error. Write the correct statement.

[4]

(a) `Mark >= 0 AND <= 100` should be TRUE for a mark from 0 to 100.

Exercise 2.4 (a)

2.4 Each logic statement contains an error. Write the correct statement.

[4]

(a) `Mark >= 0 AND <= 100` should be TRUE for a mark from 0 to 100.

(a) the second comparison has only one side

- `Mark >= 0 AND Mark <= 100`

Exercise 2.4 (b)

2.4 Each logic statement contains an error. Write the correct statement. [4]

(b) `Speed < 30 AND Speed > 120` should be TRUE for a speed that is **outside** the range 30 to 120.

Exercise 2.4 (b)

2.4 Each logic statement contains an error. Write the correct statement. [4]

(b) `Speed < 30 AND Speed > 120` should be TRUE for a speed that is **outside** the range 30 to 120.

(b) no speed is below 30 **and** above 120 at the same time, so the statement is never TRUE; outside a range needs OR

- `Speed < 30 OR Speed > 120`

Exercise 2.5 (a)

2.5 Score is 45, Paid is TRUE and Banned is FALSE. Work out whether each logic statement is TRUE or FALSE. Show your working. [4]

(a) $\text{Score} \geq 50 \text{ OR Paid}$

Score Paid Banned

Exercise 2.5 (a)

2.5 Score is 45, Paid is TRUE and Banned is FALSE. Work out whether each logic statement is TRUE or FALSE. Show your working. [4]

(a) `Score >= 50 OR Paid`

Score Paid Banned

(a) `45 >= 50` is FALSE, and Paid is TRUE: FALSE OR TRUE

- **TRUE**

Exercise 2.5 (b)

2.5 Score is 45, Paid is TRUE and Banned is FALSE. Work out whether each logic statement is TRUE or FALSE. Show your working. [4]

(b) Paid AND NOT Banned AND Score > 45

Exercise 2.5 (b)

2.5 Score is 45, Paid is TRUE and Banned is FALSE. Work out whether each logic statement is TRUE or FALSE. Show your working. [4]

(b) Paid AND NOT Banned AND Score > 45

(b) NOT Banned is TRUE, but $45 > 45$ is FALSE: TRUE AND TRUE AND FALSE

- **FALSE**

Exercise 2.6

2.6 A shop gives a discount of 10% when a customer buys more than 5 items. Complete the pseudocode. [3]

```
IF ..... THEN
    Discount ← .....
ELSE
    Discount ← .....
ENDIF
```



Exercise 2.6

2.6 A shop gives a discount of 10% when a customer buys more than 5 items. Complete the pseudocode. [3]

```
IF ..... THEN
    Discount ← .....
ELSE
    Discount ← .....
ENDIF
```



2.6

- the condition: `Items > 5` (any sensible identifier)
- the TRUE branch: `Discount ← 0.1` (or 10)
- the FALSE branch: `Discount ← 0`

Exercise 3.1 (a)

3.1 A cinema has three rules.

- Rule 1: a customer pays the child price if they are under 12.
- Rule 2: a customer pays the student price if they are from 12 to 17 **and** have a student card.
- Rule 3: a film marked “18” can be watched only by a customer who is 18 or over.

The variables are **Age** (an integer) and **HasCard** (a Boolean).

(a) Write a logic statement for **each** rule.

[3]

  
under 12 student card film

Exercise 3.1 (a)

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- Rule 1: a customer pays the child price if they are under 12.
- Rule 2: a customer pays the student price if they are from 12 to 17 **and** have a student card.
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The variables are **Age** (an integer) and **HasCard** (a Boolean).

(a) Write a logic statement for **each** rule.

[3]





 under 12 student card film

(a) rule 1: `Age < 12`

- rule 2: `Age >= 12 AND Age <= 17 AND HasCard (or HasCard = TRUE)`
- rule 3: `Age >= 18`

Exercise 3.1 (b)

3.1 A cinema has three rules.

- Rule 1: a customer pays the child price if they are under 12.
- Rule 2: a customer pays the student price if they are from 12 to 17 **and** have a student card.
- Rule 3: a film marked “18” can be watched only by a customer who is 18 or over.

The variables are **Age** (an integer) and **HasCard** (a Boolean).

(b) A customer is 17 and has no student card. State which of your three logic statements are TRUE for this customer. [2]

Exercise 3.1 (b)

3.1 A cinema has three rules.

- Rule 1: a customer pays the child price if they are under 12.
- Rule 2: a customer pays the student price if they are from 12 to 17 **and** have a student card.
- Rule 3: a film marked “18” can be watched only by a customer who is 18 or over.

The variables are **Age** (an integer) and **HasCard** (a Boolean).

(b) A customer is 17 and has no student card. State which of your three logic statements are TRUE for this customer. [2]

(b) rule 1: $17 < 12$ is FALSE; rule 3: $17 \geq 18$ is FALSE

- rule 2: the age is in the range, but **HasCard** is FALSE, so the AND is FALSE: **none** of the three statements is TRUE

Exercise 3.2 (a)

3.2 A new password is **valid** if it has at least 8 characters **and** it is different from the user name. The function `LENGTH()` returns the number of characters in a string.

(a) Write a logic statement that is TRUE when the password is **valid**. Use the variables `Password` and `UserName`. [2]

UserName

Password

Exercise 3.2 (a)

3.2 A new password is **valid** if it has at least 8 characters **and** it is different from the user name. The function `LENGTH()` returns the number of characters in a string.

(a) Write a logic statement that is TRUE when the password is **valid**. Use the variables `Password` and `UserName`. [2]

UserName
Password

(a) `LENGTH>Password) >= 8`

- `AND Password <> UserName`

Exercise 3.2 (b)

3.2 A new password is **valid** if it has at least 8 characters **and** it is different from the user name. The function `LENGTH()` returns the number of characters in a string.

(b) Write a logic statement that is TRUE when the password is **not valid**. Do **not** use NOT. [2]

Exercise 3.2 (b)

3.2 A new password is **valid** if it has at least 8 characters **and** it is different from the user name. The function `LENGTH()` returns the number of characters in a string.

(b) Write a logic statement that is TRUE when the password is **not valid**. Do **not** use NOT. [2]

(b) the password is not valid when **either** rule is broken, so the operator becomes OR

- `LENGTH>Password) < 8 OR Password = UserName`

Exercise 3.3

3.3 An algorithm is described in structured English:

1. Input the total of an order.
2. Input whether the customer is a member (TRUE or FALSE).
3. If the total is more than 50.00, or the customer is a member, the delivery charge is 0. Otherwise the delivery charge is 4.99.
4. Add the delivery charge to the total.
5. Output the total.

Write pseudocode for this algorithm. Declare your variables.

[6]



member

Exercise 3.3

3.3 An algorithm is described in structured English:

1. Input the total of an order.
2. Input whether the customer is a member (TRUE or FALSE).
3. If the total is more than 50.00, or the customer is a member, the delivery charge is 0. Otherwise the delivery charge is 4.99.
4. Add the delivery charge to the total.
5. Output the total.

Write pseudocode for this algorithm. Declare your variables.

[6]



3.3

- the variables declared with suitable types, including a **BOOLEAN** for the member
- the two inputs

Full solution on next slide

Full solution 3.3 (1/2)

3.3

- the variables declared with suitable types, including a `BOOLEAN` for the member
- the two inputs
- an `IF` with the condition `Total > 50.00 OR Member = TRUE`
- the delivery charge set to 0 in one branch and to 4.99 in the other, with `ELSE` and `ENDIF`
- the delivery charge added to the total **after** the `IF`
- the total is output

Full solution 3.3 (2/2)

```
DECLARE Total : REAL
DECLARE Delivery : REAL
DECLARE Member : BOOLEAN
INPUT Total
INPUT Member
IF Total > 50.00 OR Member = TRUE THEN
    Delivery ← 0
ELSE
    Delivery ← 4.99
ENDIF
Total ← Total + Delivery
OUTPUT Total
```

Exercise 3.4 (a)

3.4 A theme park has a fast ride. A child may go on the ride only if the child is at least 1.20 m tall. A child who is under 10 years old must **also** be with an adult.

(a) Complete the identifier table for this problem.

[3]

identifier	data type	description
		the child's height in metres
		the child's age in years
		whether the child is with an adult

Exercise 3.4 (a)

3.4 A theme park has a fast ride. A child may go on the ride only if the child is at least 1.20 m tall. A child who is under 10 years old must **also** be with an adult.

(a) Complete the identifier table for this problem. [3]

identifier	data type	description
		the child's height in metres
		the child's age in years
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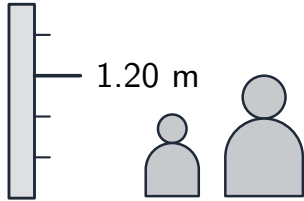
(a) one mark for each row with a meaningful name **and** the correct type, for example:

identifier	data type	description
Height	REAL	the child's height in metres
Age	INTEGER	the child's age in years
WithAdult	BOOLEAN	whether the child is with an adult

Exercise 3.4 (b)

3.4 A theme park has a fast ride. A child may go on the ride only if the child is at least 1.20 m tall. A child who is under 10 years old must **also** be with an adult.

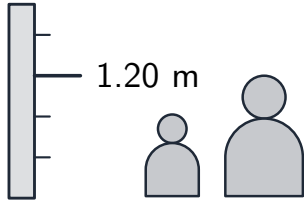
(b) Write a logic statement that is TRUE when the child **may** go on the ride. [3]



Exercise 3.4 (b)

3.4 A theme park has a fast ride. A child may go on the ride only if the child is at least 1.20 m tall. A child who is under 10 years old must **also** be with an adult.

(b) Write a logic statement that is TRUE when the child **may** go on the ride. [3]



(b) the height test: `Height >= 1.20`

- the age rule: the child is 10 or over, **or** is with an adult: `(Age >= 10 OR WithAdult)`
- the two parts joined with AND, with the brackets: `Height >= 1.20 AND (Age >= 10 OR WithAdult)`

Exercise 3.4 (c)

3.4 A theme park has a fast ride. A child may go on the ride only if the child is at least 1.20 m tall. A child who is under 10 years old must **also** be with an adult.

(c) Write pseudocode that inputs the three values and outputs "Enjoy the ride" or "Sorry, not today". Declare your variables. [5]

Exercise 3.4 (c)

3.4 A theme park has a fast ride. A child may go on the ride only if the child is at least 1.20 m tall. A child who is under 10 years old must **also** be with an adult.

(c) Write pseudocode that inputs the three values and outputs "Enjoy the ride" or "Sorry, not today". Declare your variables. [5]

(c) the three variables declared

- the three inputs
- an IF that uses the logic statement from part (b)
- the two outputs, in the correct branches
- ELSE and ENDIF used correctly

```
DECLARE Height : REAL
DECLARE Age : INTEGER
DECLARE WithAdult : BOOLEAN
INPUT Height
INPUT Age
INPUT WithAdult
IF Height >= 1.20 AND (Age >= 10 OR WithAdult) THEN
    OUTPUT "Enjoy the ride"
ELSE
    OUTPUT "Sorry, not today"
ENDIF
```

Exercise 3.4 (d)

3.4 A theme park has a fast ride. A child may go on the ride only if the child is at least 1.20 m tall. A child who is under 10 years old must **also** be with an adult.

(d) State what is output for each child.

[2]

- Child 1: height 1.35 m, age 8, not with an adult
- Child 2: height 1.25 m, age 11, not with an adult

Exercise 3.4 (d)

3.4 A theme park has a fast ride. A child may go on the ride only if the child is at least 1.20 m tall. A child who is under 10 years old must **also** be with an adult.

(d) State what is output for each child.

[2]

- Child 1: height 1.35 m, age 8, not with an adult
- Child 2: height 1.25 m, age 11, not with an adult

(d) child 1: the height test is TRUE, but $8 \geq 10$ is FALSE and `WithAdult` is FALSE, so the bracket is FALSE → **"Sorry, not today"**

- child 2: the height test is TRUE and $11 \geq 10$ is TRUE → **"Enjoy the ride"**