A-LEVEL COMPUTER SCIENCE • EXERCISE SHEET

6.2 Data Integrity

Name: _____ Class: _____ Date: _____ **Total: 34 marks**

KEY WORDS verification 核对 • validation 验证 • check digit 校验位 • data integrity 完整性 • checksum 校验和

Objective

Build the skills to answer exam questions on **data integrity** 完整性 — how **validation** and **verification** protect it, and the methods used for each.

You must be able to:

- explain how **validation** 验证 and **verification** 核对 protect data integrity
- describe and use methods of **validation**
- describe and use methods of **verification** during data entry and data transfer

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

Validation vs verification

- **Validation** asks *"is this data sensible?"* — automatic checks before storing.
- **Verification** asks *"was this data copied/entered correctly?"* — confirms it was not changed.

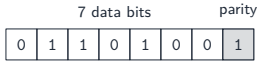
Use both: validation catches nonsense; verification catches copying errors. Neither proves the data is *factually* correct (a sensible, correctly-typed value can still be wrong).

Validation methods

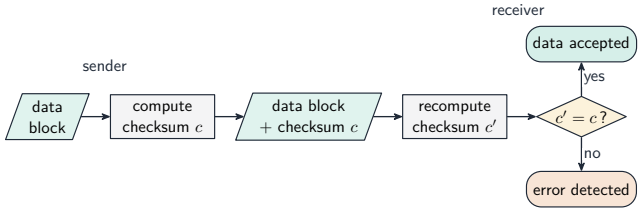
Check	Rejects...	Example
range	values outside limits	a month not in 1–12
length	wrong number of characters	a 5-digit phone number
type / character	wrong kind of data	a letter in an age field
format	wrong pattern	an email with no `@`
presence	empty required fields	a blank surname
check digit	mistyped long numbers	a wrong ISBN / card number

Verification methods

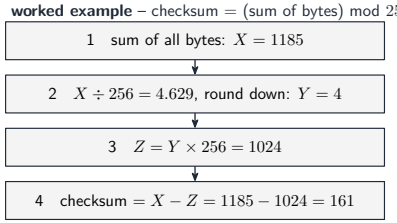
- **On entry: double entry** (type it twice and compare, like a new password) or a visual check.
- **On transfer** (bits can flip): a **parity check** adds a bit so the number of 1s is even (or odd); the receiver re-counts.



data has three 1s; for **even parity** the parity bit is **1** (four 1s in total)



worked example – checksum = (sum of bytes) mod 256



A checksum is the other main data-integrity check

A **checksum** sends a summary value the receiver recomputes and compares.

Check digit

A **check digit** is an extra digit added to the end of a long number (ISBN, barcode, card number) so that a mistyped digit can be spotted.

Worked example (modulo 11). For the digits `4 2 1 3`, multiply each by a weight (here 5, 4, 3, 2) and add: $4{\times}5 + 2{\times}4 + 1{\times}3 + 3{\times}2 = 37$. The check digit is chosen so the grand total — with the check digit itself weighted 1 — is a **multiple of 11**: $37 + c \equiv 0 \pmod{11}$, so $c = 7$. The full number is `42137`.

To **verify** a number, repeat the weighted sum including the check digit; if the total is a multiple of 11, the number is probably correct.

2 Practice

Now apply the methods above.

2.1 State the difference between **validation** and **verification**. [2]

2.2 Name the validation check for each: (a) a month must be 1–12 (b) an email must contain `@`. [2]

2.3 Describe how **double-entry** verification works. [1]

2.4 A byte uses **even parity**. The seven data bits are `1011001`. State the parity bit. [1]

3 Exam-style questions

3.1 Describe **three** validation checks, giving an example of each. [3]

3.2 Explain why validation **cannot guarantee** that stored data is correct. [2]

3.3 (a) Describe how a **parity check** detects an error during transmission. [2]

(b) State one limitation of a parity check. [1]

3.4 A new user sets a password by typing it into two boxes. State which technique this is and what it checks. [2]

3.5 A 4-digit code `5 1 3 2` uses a modulo-11 check digit. Each digit is multiplied by a weight (5, 4, 3, 2) and the check digit (weight 1) makes the total a multiple of 11. Calculate the **check digit**. Show your working. [3]

3.6 A membership number is a five-digit integer. When a number is typed in, the system checks it before use.

(a) **Draw one line** from each method to say whether it is used during **data entry** or during **data transfer**. [2]

method	used during
double entry	data entry
parity check	
visual check	data transfer
checksum	

(b) **State** the difference between **validation** and **verification**. [2]

(c) The number `41623` is typed as `14623` — the **first two digits** were transposed. **State** which single check would catch this, and **explain** why a **range check** would not. [3]

(d) A **check digit** is added to make a six-digit number. **Describe** how a check digit is calculated and used. [3]

(e) **Write** pseudocode for a function `Generate(Original)` that takes a five-digit integer and returns it with a check digit appended, where the check digit is the sum of the five digits modulo 10. [5]

Solutions

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

2.1

- validation checks the data is **sensible** (against rules) before storing
- verification checks the data was **entered/transferred correctly** (not changed)

2.2

(a) **range** check

(b) **format** check

2.3

- the data (e.g. password) is entered **twice** and the two copies are compared; if they differ, there was a typing error

2.4

- `1011001` has **four** 1s (already even), so the parity bit is `0`

3.1

- any three with examples, e.g. range (month 1–12); length (a 6-character code); type (digits only in a phone field); format (email contains `@`); presence (required field not blank)

3.2

- validation only checks the data is the right **format/range**
- a value can be sensible and correctly formatted yet **factually wrong** (e.g. "Bob" instead of "Bib"), which validation cannot detect

3.3

(a) a parity bit makes the number of 1s even (or odd) when sent; the receiver re-counts the 1s

- if the count no longer matches, a bit was flipped — an error is detected

(b) it misses an **even number** of flipped bits (e.g. two), which leave the parity unchanged

3.4

- **double-entry** verification
- it checks the two typed copies match, catching a typing error before the password is saved

3.5

- weighted sum of the digits

$$5 \times 5 + 1 \times 4 + 3 \times 3 + 2 \times 2 = 25 + 4 + 9 + 4 = 42$$

- remainder modulo 11, then 11 minus that remainder

$$42 \bmod 11 = 9 \Rightarrow \text{check digit} = 11 - 9 = \mathbf{2}$$

- check: $42 + 2 = 44 = 4 \times 11$

3.6

(a) **data entry**: double entry and visual check

- **data transfer**: parity check and checksum

(b) **validation** is an automatic check that data is **reasonable** — the right type, in range, the right format

- **verification** checks that data has been **copied or transmitted accurately**, that it matches the source

(c) a **check digit**

- transposing two digits changes the weighted sum and so changes the digit that should follow
- a range check passes both values: 14623 and 41623 are each five-digit numbers within the allowed range

(d) the check digit is calculated from the other digits by a fixed rule — often a weighted sum reduced modulo a number

- it is appended to them
- whenever the number is entered or received, the rule is applied again to the leading digits and compared with the carried digit; a mismatch means an error

(e)

```
FUNCTION Generate(Original : INTEGER) RETURNS INTEGER
    DECLARE Total, Temp, CheckDigit : INTEGER
    Total ← 0
    Temp ← Original
    WHILE Temp > 0
        Total ← Total + (Temp MOD 10)
        Temp ← Temp DIV 10
    ENDWHILE
    CheckDigit ← Total MOD 10
    RETURN Original * 10 + CheckDigit
ENDFUNCTION
```

- header with parameter and return type
- digit-extraction loop using `MOD 10` and `DIV 10`
- running total
- `CheckDigit ← Total MOD 10`
- appending it with `* 10 +`