Data

AP Computer Science Principles ▪ Unit 2

AP Computer Science Principles

1	0	1	1

What we will cover

1. Binary numbers
2. Data compression
3. Extracting information
4. Using programs with data

0	1	1	0	1

bits

1 Binary

Everything is bits

A **bit** 位 is a single 0 or 1. **Binary** 二进制 (base 2) uses place values that are **powers of two** 2 的幂.

128	64	32	16	8	4	2	1	
0	0	1	0	1	1	0	1	$= 45$

$32 + 8 + 4 + 1 = 45$. Read binary → decimal by adding the place values where a bit is 1.

place value	128	64	32	16	8	4	2	1
bits	**1**	0	0	**1**	0	**1**	**1**	0

$150 = 128 + 16 + 4 + 2 \Rightarrow$ 10010110

Fixed bits, overflow & sampling

Convert & overflow

1011_2: place values $8, 4, 2, 1$; bits at $8, 2, 1$ give $8 + 2 + 1 = 11$.

With n bits you can make 2^n values, 0 to $2^n - 1$. Exceeding it is an **overflow error** 溢出错误 (4 bits max 15; $15 + 1$ overflows).

Analog 模拟 signals become **digital** 数字 by **sampling** 采样 – many quick measurements. Eight bits group into one **byte** 字节.

A finite number of bits has two consequences

the cause	a computer has a finite number of bits, so it can represent only a limited range of values
overflow error 溢出错误	a number too large for the available bits cannot be stored correctly
round-off error 舍入错误	numbers with decimals can only be approximated, because infinitely many real values must map onto finitely many bit patterns
why it matters	$0.1 + 0.2$ does not print as 0.3 in most languages – and that is not a bug in the language

Both are consequences of the same fact. Say "finite bits" first and the explanation writes itself.

Where a number loses precision

Overflow	A value too large for the bits allotted wraps around or errors – the count that goes negative.
Round-off error	**Round-off (rounding) error** 舍入误差: a real number stored in finite bits is stored *approximately*, so $0.1 + 0.2 \neq 0.3$ exactly.
Accumulation	Round the same way a million times and the error compounds – which is why money is stored in integer cents, not floats.
The shared cause	Both are the same limit: a fixed number of bits cannot represent unlimited values.

An answer that names the limit – "only 2^{32} distinct values exist" – explains both errors at once.

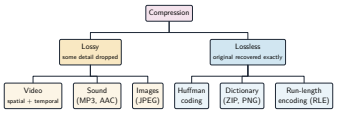
2 Compression

Data compression

Compression 压缩 stores the same data in **fewer bits** – less space, faster transmission.

Lossless 无损
every bit restored exactly (text, code)

Lossy 有损
discards unnoticed data; much smaller (photos, music)



Lossy trades **size** 大小 against **quality** 质量. Many methods remove **redundancy** 冗余 – e.g. "100 white pixels" → "white, 100 times".

Two kinds of compression, and when each is right

compression 压缩	reducing the number of bits needed to store or send data
lossless compression 无损压缩	the original is perfectly recoverable – PNG, ZIP, FLAC. Use it for text, code and anything where a changed bit matters
lossy compression 有损压缩	discards data judged unnoticeable, and it cannot be recovered – JPEG, MP3, MP4
the trade	lossy achieves far smaller files; lossless guarantees fidelity
the rule	never use lossy on a program's source, a spreadsheet, or a medical scan

The exam asks which is appropriate, not which is better. Match the choice to whether losing detail is acceptable.

3 Extracting information

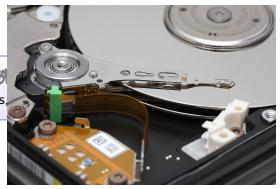
Extracting information from data

Programs turn raw **data sets** 数据集 into **information** 信息, finding **patterns** 模式 and **trends** 趋势.

Filtering 筛选
keep the rows you want

Cleaning 清洗
fix duplicates, blanks,

Beware: a **correlation** 相关 never proves **causation** 因果, and **bias** 偏差 in how data was collected can mislead. **Metadata** 元数据 & **visualization** 可视化 help.



Hard-disk platters and head: data compressed and stored as magnetic patterns

From data to information

data 数据 into information 信息	data becomes useful when patterns, trends and answers are extracted from it
filtering 过滤	keeping only the rows that meet a condition
cleaning 清洗	removing errors, duplicates and incomplete records before analysing
visualizing 可视化	a chart makes a pattern visible that a table hides
the caution	large data sets reveal correlation, which is not causation – and they raise **privacy** 隐私 questions about the people in them

> Programs process data at scales no human can. That is the benefit *and* the reason the privacy question is on this paper.

4 Using programs

Using programs with data

A program **processes** 处理 data: records in, new information out.

Iterate to summarise

A loop uses **iteration** 迭代 to visit each **element** 元素: summing $70, 85, 90, 60, 95$ gives 400; $\div 5 = 80$ (the average).

A **filter** 过滤器 keeps a **subset** 子集 that meets a condition; programs also **combine** 合并 sources, **transform** 转换 values, and **clean** 清洗 first – dirty data gives a wrong answer.

Worked example – choosing a compression

Which compression for a source-code file? For a holiday photo?

Code → lossless. Every bit matters – a single changed character breaks the program. Restoring the exact original is non-negotiable. **Photo** → lossy. A small quality loss is invisible, and the file gets much smaller.

> The trade is size against fidelity. Lossy loss is permanent – you can never get the discarded data back.

Key points

Binary place values are powers of two; watch **overflow**

Lossless keeps every bit; **lossy** trades quality for size

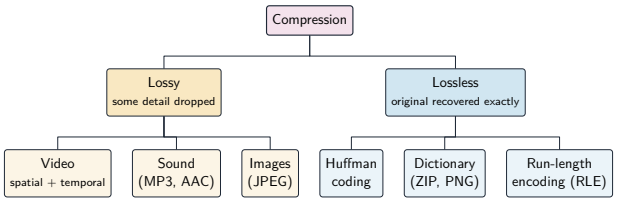
Correlation is not **causation**; clean data first

Programs **iterate**, **filter** & transform data

Binary Numbers

> Binary digits on a display – all digital data is ultimately stored as 0s and 1s

Check yourself, in detail



Compression methods: lossless versus lossy, with common examples

Exam tips

- Convert confidently between **binary, decimal**, and (where asked) hexadecimal – practise until it is quick.
- Remember a bit is one binary digit and a byte is 8 bits; n bits represent 2^n values.
- Explain that all data – numbers, text, images, sound – is stored as binary, and that finite bits cause **overflow** and **round-off**.
- Distinguish **lossless** from **lossy** compression and when each is appropriate.
- Show the analog-to-digital idea: **sampling** turns a continuous signal into discrete values.

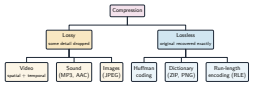
5 Recap

Unit 2 – key takeaways

1. **Bases**
   binary, decimal, hex – until it is quick
2. **Bits**
   n bits $\Rightarrow 2^n$ values; byte $= 8$ bits
3. **Limits**
   overflow and round-off from finite bits
4. **Compression**
   lossless vs lossy; sampling analog to digital

Check yourself

1. Convert 1011_2 to decimal.
2. How many values can n bits represent?
3. Lossless or lossy for a program file – and why?
4. Does a correlation in the data prove causation?



Answers **1.** 11 **2.** 2^n (from 0 to $2^n - 1$) **3.** lossless – every bit must be restored exactly **4.** no