Units and capacity

1.2.3 · Computer systems (Paper 1) · revision notes

Why computers store data in binary, the units of data from bit to petabyte, converting between units, and calculating how much storage is needed, including file sizes for text, images and sound. Both J277 papers are non-calculator, so the numbers are chosen to be worked out by hand.

Key facts

- 1 nibble = 4 bits; 1 byte = 8 bits
- 1 KB = 1000 bytes; 1 MB = 1000 KB; 1 GB = 1000 MB; 1 TB = 1000 GB; 1 PB = 1000 TB (1024 also accepted)
- Order: bit, nibble, byte, KB, MB, GB, TB, PB
- To a smaller unit → multiply; to a larger unit → divide
- Text (bits) = bits per character × number of characters
- Image (bits) = colour depth × width × height
- Sound (bits) = sample rate × bit depth × seconds
- Bits ÷ 8 = bytes

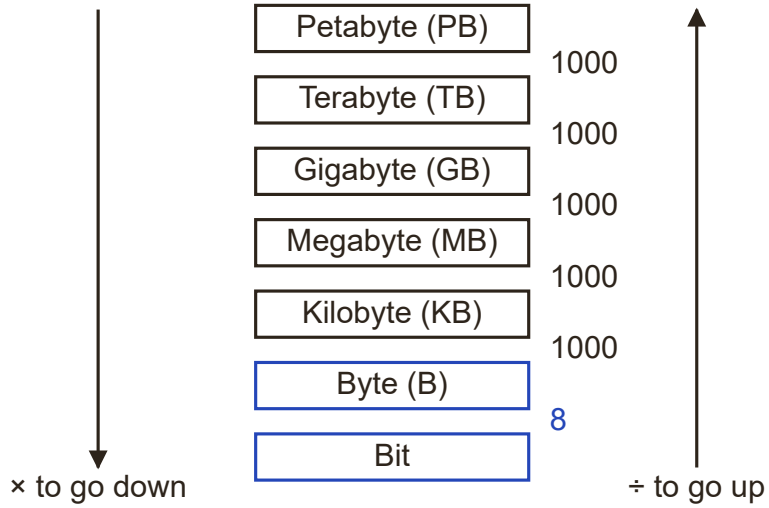
Notes

Why binary

- A computer's processor and memory are made of billions of tiny switches (transistors) that are either on or off.
- These two states are represented by 1 and 0, so all data (numbers, text, images, sound and program instructions) must be converted into **binary** before a computer can store or process it.

Units of data

- **Bit**: a single binary digit, 0 or 1. The smallest unit.
- **Nibble** = 4 bits. **Byte** = 8 bits.
- **Kilobyte** (KB) = 1000 bytes; **megabyte** (MB) = 1000 KB; **gigabyte** (GB) = 1000 MB; **terabyte** (TB) = 1000 GB; **petabyte** (PB) = 1000 TB.



Each step is 1000 (8 between bytes and bits): multiply going down, divide going up

- The specification also accepts 1024 at each step. Use whichever the question tells you; 1000 is much easier without a calculator.
- With 1024, 1 MB = 1024 × 1024 = 1,048,576 bytes. The same number of bytes gives a slightly smaller number of KB, MB or GB than with 1000; the amount of data is unchanged. Grade 8+ only

Converting

- To a smaller unit, multiply: 3 GB = 3 × 1000 = 3000 MB.
- To a larger unit, divide: 4500 KB = 4500 ÷ 1000 = 4.5 MB.
- Between bits and bytes, use 8: bytes = bits ÷ 8, and bits = bytes × 8.
- Several steps: 2 GB = 2 × 1000 × 1000 × 1000 = 2,000,000,000 bytes.

Calculating storage requirements

- Add the sizes of all the files in the **same unit**, then compare the total with the device's capacity.
- Text file size (bits) = bits per character × number of characters. E.g. 500 characters at 8 bits each = 4000 bits = 500 bytes.
- Image file size (bits) = colour depth × image width × image height (in pixels).
- Sound file size (bits) = sample rate × bit depth × duration (in seconds).
- These formulas give bits: divide by 8 for bytes, then by 1000 for KB. Real files are a little larger because they also store metadata.
- When working out how many files fit, round **down**: part of a file cannot be stored.

How to answer each type of question

Convert between units

1 to 2 marks | Grade 4

1. Decide whether you are going to a smaller unit (multiply) or a larger unit (divide).
2. Use 1000 between KB, MB, GB, TB and PB (or 1024 if the question says so), and 8 between bits and bytes.
3. Sense check: a smaller unit gives a bigger number.

Example. (a) Convert 3.5 GB into megabytes. Use 1 GB = 1000 MB. [1]
(b) Convert 48 bits into bytes. [1]

Model answer.

(a) 3.5 × 1000 = 3500 MB (1)

(b) 48 ÷ 8 = 6 bytes (1)

Calculate the size of a text file

2 to 3 marks | Grade 6

1. Multiply the bits per character by the number of characters.
2. Divide by 8 to get bytes.
3. Divide by 1000 to get kilobytes if asked.

Example. A document contains 2500 characters. Each character is stored using 16 bits. Calculate the file size in kilobytes. Use 1 KB = 1000 bytes. Show your working. [3]

Model answer.

2500 × 16 = 40,000 bits (1)

40,000 ÷ 8 = 5000 bytes (1)

5000 ÷ 1000 = 5 KB (1)

Calculate the total storage needed and choose a device

3 to 4 marks | Grade 6

1. Multiply file size by number of files for each type of file.
2. Convert everything into the same unit and add.
3. Compare with each capacity and choose the smallest device that is big enough.
4. Show every step: method marks are available even if you make a slip.

Example. A student wants to store 200 photos of 3 MB each and 40 videos of 250 MB each. Memory cards are available in 8 GB, 16 GB and 32 GB sizes. Use 1 GB = 1000 MB.
Calculate the total storage needed and identify the smallest card that is big enough. Show your working. [3]

Model answer.

Photos: 200 × 3 = 600 MB and videos: 40 × 250 = 10,000 MB	(1)
Total = 10,600 MB = 10.6 GB	(1)
The 16 GB card (8 GB is too small)	(1)

Work out how many files fit

2 to 3 marks | Grade 7

1. Find the space available (capacity minus space already used).
2. Convert it into the same unit as the file size.
3. Divide, then round DOWN to a whole number of files.

Example. A 64 GB USB flash drive already has 16 GB of data on it. Songs are 9 MB each. Calculate how many songs can be stored in the remaining space. Use 1 GB = 1000 MB. Show your working. [3]

Model answer.

Free space: 64 − 16 = 48 GB	(1)
48 × 1000 = 48,000 MB and 48,000 ÷ 9 = 5333.3…	(1)
5333 songs, rounded down because there is not enough space for another whole song	(1)

Don’t lose marks

- Dividing when you should multiply, or the other way round.
- Forgetting to divide by 8 to change bits into bytes, or dividing by 8 twice.
- Adding sizes in different units, e.g. MB and GB, without converting first.
- Rounding up the number of files that fit. Always round down.
- Using minutes instead of seconds in sound file calculations.

More tips

Memory tricks

- Unit ladder: 4 bits = 1 nibble, 2 nibbles = 1 byte, then 1000 of each unit makes the next: KB, MB, GB, TB, PB.
- 'Kind Men Give Tiny Presents' = KB, MB, GB, TB, PB.
- Sense check: changing to a smaller unit should give a bigger number.
- In file size formulas, multiply everything to get bits first, then divide by 8 and by 1000 at the end.

Exam technique

- Show your working step by step with a unit at each step: method marks are given even if the final answer is wrong.
- Use whichever of 1000 or 1024 the question states. If it doesn't say, either is accepted, but 1000 is easier by hand.
- Write large numbers with commas (48,000) so you don't lose a zero.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Explain why data is stored in binary**
Computers are made of switches (transistors) with two states, on and off, represented by 1 and 0.

Grade 3 — **Put the units in order**
Bit, nibble, byte, kilobyte, megabyte, gigabyte, terabyte, petabyte.

Grade 4 — **Convert between units of data**
Multiply by 1000 to change to a smaller unit and divide by 1000 to change to a larger one (use 8 between bits and bytes).

Grade 5 — **Calculate the storage needed for several files**
Convert every file size to the same unit, add them up and compare the total with a device's capacity.

Grade 6 — **Calculate the size of a text file**
Bits per character × number of characters, then divide by 8 for bytes.

Grade 7 — **Solve multi-step capacity problems**
E.g. find how many files fit in the space left on a device, rounding down to a whole number of files.

Grade 8 — **Work with 1000 and 1024 conventions**
Know that 1 KB can be taken as 1000 or 1024 bytes and use whichever the question states.

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