Units and file size calculations

2.3.1 · Data · revision notes

The units used to measure data storage (bit, nibble, byte, kibibyte, mebibyte, gibibyte and tebibyte), converting between them, and constructing expressions for file sizes and storage requirements. Paper 1 is taken without a calculator, so many questions ask you to construct an expression rather than work out the answer.

Key facts

- 1 nibble = 4 bits; 1 byte = 8 bits
- 1 KiB = 1024 bytes
- 1 MiB = 1024 KiB
- 1 GiB = 1024 MiB
- 1 TiB = 1024 GiB
- Smaller to larger unit: ÷ (8 or 1024); larger to smaller: × (8 or 1024)
- Order: bit, nibble, byte, KiB, MiB, GiB, TiB
- Number of files that fit = capacity ÷ file size, rounded down

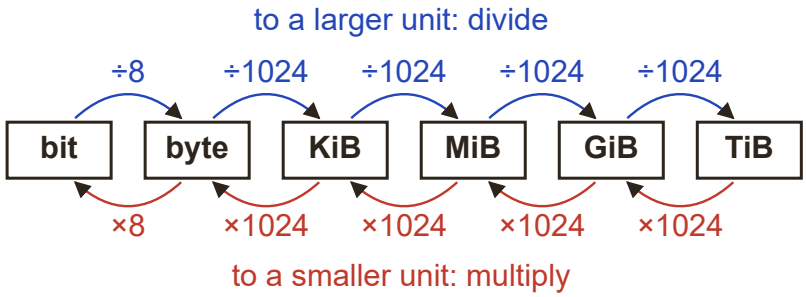
Notes

The units

- **Bit**: a single binary digit, 0 or 1. The smallest unit of data.
- **Nibble** = 4 bits. **Byte** = 8 bits.
- **Kibibyte (KiB)** = 1024 bytes. **Mebibyte (MiB)** = 1024 KiB. **Gibibyte (GiB)** = 1024 MiB. **Tebibyte (TiB)** = 1024 GiB.
- These are **binary multiples**: 1024 = 2^{10}. Computers work in binary, so storage is measured in powers of 2.
- Drive makers often use decimal units (1 TB = 1,000,000,000,000 bytes). A tebibyte is bigger than a terabyte, so a computer that measures in TiB shows a smaller number for the same drive. Grade 7+ only

Converting

- To a larger unit, divide: bits ÷ 8 = bytes; bytes ÷ 1024 = KiB; KiB ÷ 1024 = MiB; MiB ÷ 1024 = GiB; GiB ÷ 1024 = TiB.
- To a smaller unit, multiply: e.g. 3 GiB = 3 × 1024 = 3072 MiB.



8 bits = 1 byte; after that each unit is 1024 times the one before. (A nibble is 4 bits, half a byte.)

- Several steps: 2 MiB in bits = 2 × 1024 × 1024 × 8.

File sizes and capacity

- Text: number of characters × bits per character.
- Image: width × height × colour depth (bits).
- Sound: sample rate × bit depth × seconds (bits).
- Then convert: ÷ 8 for bytes, ÷ 1024 for KiB, ÷ 1024 again for MiB.
- **Construct an expression** means write the calculation with the right numbers and operations. You do not have to work it out.
- To find how many files fit on a device, divide the capacity by the size of one file (both in the same unit) and round down to a whole number.

How to answer each type of question

Convert between units 1 to 2 marks **Grade 5**

1. Decide whether the unit is getting bigger (divide) or smaller (multiply).
2. Use 8 between bits and bytes, and 1024 for every other step.
3. Count the steps: bytes to MiB is two steps, so ÷ 1024 ÷ 1024.

Example. (a) State the number of bits in 5 bytes.
(b) Construct an expression to calculate the number of bytes in 6 GiB.

Model answer.

(a) 40 (1)
(b) 6 × 1024 × 1024 × 1024 (1)

Calculate the total storage needed

3 marks | Grade 7

1. Work out the size of each group of files.
2. Convert everything to the unit the question asks for.
3. Add, and give the unit.

Example. A student has 40 photos of 3 MiB each and a video of 1.5 GiB.
Calculate the total storage needed, in MiB. Show your working.

Model answer.

Photos: 40 × 3 = 120 MiB (1)
Video: 1.5 × 1024 = 1536 MiB (1)
Total: 120 + 1536 = 1656 MiB (1)

Construct an expression for a storage requirement

3 to 4 marks | Grade 8

1. Write the size of one file in bits.
2. Multiply by the number of files.
3. Divide by 8, then by 1024 once for each step up to the unit asked for.

Example. An online album stores 500 images. Each image is 1600 × 1200 pixels with a colour depth of 24 bits.
Construct an expression to calculate the storage needed for all the images, in GiB. You do not need to do the calculation.

Model answer. 1600 × 1200 × 24 (bits for one image) (1) × 500 (1) ÷ 8 (1) ÷ 1024 ÷ 1024 ÷ 1024 (1)

Calculate how many files will fit

2 marks | Grade 8

1. Convert the capacity and the file size to the same unit.
2. Divide the capacity by the size of one file.
3. Round down: only complete files count.

Example. A memory card has 2 GiB of free space. Each recording is 96 MiB.
Calculate the number of complete recordings that can be stored. Show your working.

Model answer.

2 × 1024 = 2048 MiB (1)
2048 ÷ 96 = 21.3, so 21 complete recordings (1)

Don’t lose marks

- ✕ Using 1000 instead of 1024 for storage units.
- ✕ Forgetting to divide by 8 to change bits into bytes (the image and sound formulas give bits).

- Adding sizes that are in different units without converting them first.
- Rounding up the number of files that fit: 21.3 means 21 complete files, not 22.
- Multiplying when you should divide: going to a bigger unit makes the number smaller.

More tips

Memory tricks

- Order of units: 'Big Nosy Bears Kick Muddy Green Tyres' (bit, nibble, byte, KiB, MiB, GiB, TiB).
- Every step up is ÷ 1024, except bits to bytes, which is ÷ 8.
- Handy facts: 0.5 MiB = 512 KiB, 0.25 GiB = 256 MiB, 1 KiB = 8192 bits.
- Sense check: a larger unit always gives a smaller number.

Exam technique

- In 'construct an expression' questions, keep each stage visible (e.g. × 8, ÷ 1024 ÷ 1024) so each stage can earn its mark.
- Write the unit next to every number in your working so you can see when you need to convert.
- Without a calculator, choose methods that keep the numbers simple, e.g. divide by 8 early.

What each grade needs

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

Grade 3 — **Put the units of storage in order**
bit, nibble, byte, kibibyte, mebibyte, gibibyte, tebibyte.

Grade 4 — **Recall the size of each unit**
4 bits = 1 nibble, 8 bits = 1 byte, 1024 bytes = 1 KiB, and each larger unit is 1024 of the one before.

Grade 5 — **Convert between units**
Divide by 1024 to go to a larger unit and multiply to go to a smaller one (use 8 between bits and bytes).

Grade 6 — **Explain why storage uses multiples of 1024**
$1024 = 2^{10}$, a power of 2, which suits binary computers.

Grade 6 — **Construct an expression for a file size**
Build it stage by stage: size in bits, then ÷ 8, then ÷ 1024 for each unit.

Grade 7 — **Calculate the total storage for several files**
Convert every size to the same unit before adding or multiplying.

Grade 8 — **Solve multi-step storage capacity problems**
Number of files that fit = capacity ÷ size of one file, in the same unit, rounded down.

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