CPU performance

1.1.2 · Computer systems (Paper 1) · revision notes

How three characteristics of a CPU affect its performance: clock speed, cache size and number of cores. Expect 'explain how … improves performance' questions and comparisons of CPUs from a table, where you choose one for a given use and justify your choice.

Key facts

- Three factors: clock speed, cache size, number of cores
- Clock speed = fetch–execute cycles per second
- 1 GHz = 1,000,000,000 cycles per second; 1 GHz = 1000 MHz
- Higher clock speed → more instructions per second (but more heat)
- Larger cache → fewer slow fetches from RAM
- More cores → more instructions processed at the same time
- More cores only help if the software or workload can be split between them

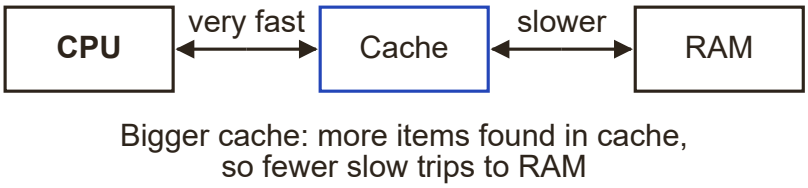
Notes

Clock speed

- The **clock speed** is the number of fetch–execute cycles the CPU can carry out each second. It is measured in hertz (Hz): 1 GHz = 1 billion cycles per second.
- A CPU with a clock speed of 3.2 GHz can carry out 3.2 billion cycles per second.
- Higher clock speed → more instructions executed per second → programs run faster.
- A higher clock speed also makes the CPU produce more heat and use more power, so it needs better cooling.

Cache size

- Cache is very fast memory in or next to the CPU that holds frequently used instructions and data.
- A larger cache can hold more of them, so the CPU finds what it needs in cache more often and has to fetch from the slower RAM less often. Less waiting means better performance.



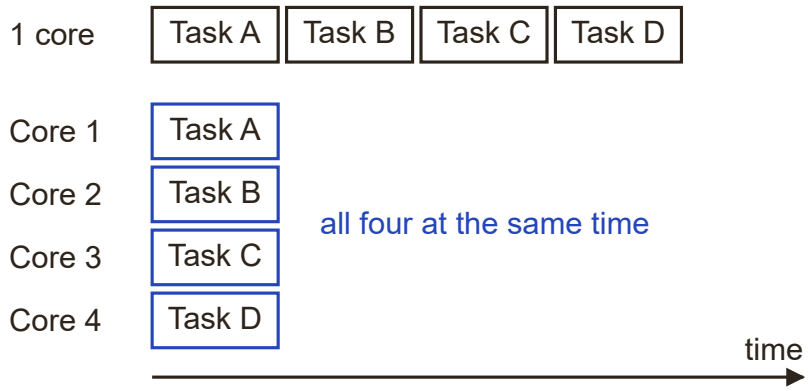
Bigger cache: more items found in cache,
so fewer slow trips to RAM

The CPU checks the fast cache first and only goes to slower RAM if the item is not there

- Cache is expensive and takes up space on the chip, so it is kept small. Beyond a certain size, extra cache gives less and less benefit.

Number of cores

- A **core** is a complete processing unit: it can fetch, decode and execute instructions on its own.
- More cores → more instructions can be processed at the same time (in parallel). A quad-core CPU can work on four streams of instructions at once.



More cores: separate tasks run in parallel, so they finish sooner (if the work can be split)

- This helps most when several programs are running at once (multitasking) or when software is written to use several cores, e.g. video editing.
- Doubling the cores does not double the performance: some programs are only written to use one core, some tasks cannot be split because each step needs the result of the one before, and the cores spend time coordinating with each other.

Putting it together Grade 7+ only

- No single characteristic decides performance. A 2-core CPU at 4.0 GHz may beat an 8-core CPU at 2.5 GHz on a program that uses only one core, but lose when many programs run at once.

How to answer each type of question

State the number of cycles per second from a clock speed

1 mark | Grade 4

1. Remember that G (giga) means billion: 1 GHz = 1,000,000,000 Hz.
2. Multiply the number by 1,000,000,000, or write it in words, e.g. '2.5 billion'.

Example. A CPU has a clock speed of 2.5 GHz. State how many cycles it can carry out each second. [1]

Model answer. 2,500,000,000 / 2.5 billion (1)

Explain how a characteristic affects performance

2 marks | Grade 5

1. Say what the characteristic does.
2. Link it to the effect: more instructions per second, or less time waiting for RAM.
3. Join the two ideas with 'so'.

Example. Explain how increasing the clock speed of a CPU can improve its performance. [2]

Model answer. More fetch–execute cycles are carried out each second (1), so more instructions are processed per second and programs run faster (1).

Explain why an upgrade did not improve performance as expected

2 marks | Grade 6

1. Identify what the upgrade changed.
2. Explain why the program cannot take advantage of it, or what else is limiting performance.

Example. Jamal replaces his 4-core CPU with an 8-core CPU that has the same clock speed and cache size. His favourite game runs no faster. Explain why. [2]

Model answer. The game may only be written to use one or a few cores (1), so the extra cores are not used / the game's tasks cannot be split up because each step depends on the one before (1).

Recommend a CPU from a table and justify

3 to 4 marks | **Grade 7**

1. Read the scenario: one program on one core, or many tasks at the same time?
2. Choose one CPU clearly.
3. Quote and compare the figures, e.g. '8 cores rather than 2'.
4. Link each figure to the task with 'so…'.

Example. A teacher edits videos using software that can use many cores. Two CPUs are available:

CPU	Clock speed	Number of cores	Cache size
X	3.8 GHz	2	4 MB
Y	3.0 GHz	8	16 MB

Recommend which CPU the teacher should choose. Justify your answer. [3]

Model answer. CPU Y (1). It has 8 cores rather than 2, so the software can process more instructions at the same time (1). It has a larger cache (16 MB rather than 4 MB), so it has to fetch from the slower RAM less often (1). The justification marks depend on choosing Y: X's higher clock speed matters less because the software can use many cores.

Don’t lose marks

- Defining clock speed as 'how fast the computer is'. Say it is the number of fetch–execute cycles per second.
- Saying that twice as many cores always makes a computer twice as fast.
- Confusing cache with RAM, or saying a bigger cache 'stores more files'.
- Choosing a CPU in a table question without using the figures. Quote and compare the numbers.
- Not linking to the scenario: 'it has more cores' is not a justification until you say why that suits the task.

More tips

Memory tricks

- Faster, bigger, more: a faster clock, a bigger cache and more cores all tend to improve performance.
- Picture a kitchen: clock speed is how fast each chef works, cores are the number of chefs, and cache is the worktop right next to them. RAM is the storeroom down the corridor.
- GHz means billions: 3.6 GHz = 3,600,000,000 cycles per second.

Exam technique

- In 'explain' questions give the change and its effect: 'more cores, so more instructions can be processed at the same time'.
- In comparison questions, commit to one choice. The justification marks usually depend on a sensible choice.
- Check units: 1 GHz = 1000 MHz, so 2 GHz is faster than 1800 MHz.
- Use the phrase 'fetch–execute cycles per second' when you define clock speed.

What each grade needs

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

Grade 3

Name the three characteristics affecting performance

Clock speed, cache size and number of cores.

Grade 4

State what clock speed measures

The number of fetch–execute cycles carried out per second, e.g. 3.5 GHz means 3.5 billion cycles per second.

Grade 5

Explain how each characteristic improves performance

Link each one to more instructions processed per second or less time waiting for RAM.

Grade 6

Explain why more cores don't always help

Some programs can only use one core, some tasks cannot be split up, and cores take time to coordinate.

Grade 7

Choose a CPU for a task and justify

Use the figures in a table and link each characteristic to the task, e.g. multitasking benefits from more cores.

Grade 8

Weigh up characteristics that point different ways

Decide, for example, whether a faster clock or more cores matters more, depending on whether the software can use several cores.

Free notes, Full packs, practice papers and mock exams at chhetriacademy.com. Written for this site; not taken from past papers. Stuck? 1-to-1 tutoring with a free 30-minute trial lesson.