4.1.1 Processor Performance & Pipelining

1 **(a)** A computer system contains a CPU .

(i) State **two** factors that affect the performance of a CPU.

[2 marks]

- **Clock speed.**
- **Number of cores.**
- **Amount of cache.**

Accept: Use of pipelining.

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2 The processors in the company's powerful computers have fast clock speeds and large amounts of cache memory. Describe how each of these improves the processor's performance:

(a) fast clock speed

[2 marks]

- **A higher clock speed means more clock cycles can occur per second.**
- **More instructions can be executed per second.**
- **So the program takes less time to run.**

Do not accept: 'data is processed quickly'.

(b) large cache memory

[2 marks]

- **More space for data/instructions in cache memory.**
- **This reduces the frequency with which RAM needs to be accessed.**
- **Accessing cache is quicker than accessing the RAM.**

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3 "The Megahertz Myth" is the name given to the argument that clock speed alone is an insufficient method to compare the performance of processors.

Discuss the extent to which you agree with this argument. You should include any other factors that might affect a processor's performance.

[9 marks]

- **Number of cores has an impact…**
- **Each core is a processing unit…**
- **Giving the potential for multiple instructions to be run simultaneously.**
- **A processor with multiple cores may outperform a processor with a higher clock speed when the workload can be effectively divided between the cores.**

- **The amount of cache (and levels) will benefit performance.**
- **Cache helps reduce the bottleneck caused by RAM being slow.**
- **No matter how fast the clock speed, the access time to RAM will always be a limiting factor.**

- **Contemporary processors have performance enhancing features such as pipelining and out of order execution.**
- **Harvard architecture processors benefit from having separate data and instruction memories.**

- **In conclusion one cannot judge performance solely on clock speed as…**
- **A processor without cache may be outperformed by a processor with a slower speed but access to cache.**
- **Processors will have other performance enhancements such as pipelining.**

Points above are for example only. Not all are needed for full marks nor do they represent all possible correct answers.

4 A CPU uses pipelining to improve efficiency.

(a) Explain what is meant by the term 'pipelining'.

[3 marks]

- **The concurrent processing of multiple instructions.**
- **One instruction is executed while the next is decoded…**
- **While the one after that is fetched.**
- **In the case of a branch instructions the pipeline is flushed.**
- **It increases the number of instructions that can be processed in a given period of time.**

(b) Explain **one** benefit of using a processor that allows pipelining.

[2 marks]

- **More instructions can be carried out in a set amount of time // less time to execute the same number of instructions.**
- **Increasing the speed/performance/efficiency of the computer/program // quicker for the program to complete.**

Do not allow 'each instruction is quicker to execute'.

5 A Little Man Computer (LMC) assembly language program is stored in memory as shown in Fig 1.

Fig 1

0	LDA &7
1	ADD #4
2	OUT
3	HALT
4	6
5	2
6	10
7	15
8	16
9	17

In this variant of LMC the symbols & and # are used to denote different modes of addressing.

Explain how pipelining would help a CPU execute the code in Fig 1 more quickly.

[3 marks]

- **Pipelining would allow one instruction to be fetched as the previous one is being decoded and the one before that is being executed.**
- **For example, OUT could be fetched, while ADD #4 is decoded, while LDA &7 is executed.**
- **As there are no jump/branch instructions it pipelines well (as there is no need to flush the pipeline.**