3.1 Computer architecture (question bank, public)

1. The central processing unit (CPU)

Question

A computer has a central processing unit (CPU).
State the role of the CPU.

[1]

- Perform FDE cycle
- Execute/process instructions

Question

A student has a computer that has a central processing unit (CPU).
Describe the role of the CPU in the computer.

[2]

- To process instructions and data
- That are input into the computer
- So that a result can be output

2a. Von Neumann Architecture and the CPU

Question

A computer has a central processing unit (CPU). Identify **three** components that are built into a CPU from the given list: accumulator (ACC), binary counter (BC), binary register (BR), binary unit (BU), current instruction register (CIR), instruction unit (IU), program counter (PC), read only memory (ROM).

[3]

- Accumulator // ACC
- Current instruction register // CIR
- Program counter // PC

Question

The computer has a Von Neumann architecture.
Identify **three** registers that are found in the Von Neumann architecture from the given list:
accumulator, arithmetic register, binary counter, binary register control register current data register, current instruction register, data counter, instruction counter, logical register, program counter, storage register

[3]

accumulator, current instruction register, program counter

Question

The memory address register (MAR) and the memory data register (MDR) are two registers built into the CPU. Give two other registers that are built into the CPU.

[2]

- Program counter // PC
- Current instruction register // CIR
- Accumulator // ACC

Question

A student has a computer that has a CPU.

(a) Give two units that are built into the CPU.

[2]

(b) Give three registers that are built into the CPU.

[3]

(c) One component in the CPU is the arithmetic logic unit (ALU).

Describe the purpose of the ALU.

[3]

(a) Two from:
- Arithmetic logic unit // ALU
- Control unit // CU

(b) Three from:
- Program counter // PC
- Memory address register // MAR
- Memory data register // MDR
- Current instruction register // CIR
- Accumulator // ACC

(c) Three from:
- To execute **instructions**
- To perform calculations // by example
- To perform logical operations // by example
- To store interim **results** of calculations
- Stores/reads/writes data to/from the accumulator

Question

A student has a computer that has a CPU.

State the role of:

- Control unit

- ALU
- Program counter
- MAR
- MDR
- CIR

[6]

- Control unit - sends signals to manage the flow of data through the CPU
- ALU - carries out all the arithmetic and logic operations in the CPU
- Program counter - stores the address of the next instruction to be fetched
- MAR - stores the address of the data/instruction that is about to be fetched from RAM
- MDR - stores the data/instruction that has been fetched from or is to be written to RAM
- CIR - stores the instruction currently being decoded/executed

Question

A student has a computer that has a CPU.

State the role of:

- Address bus
- Data bus
- Control bus
- Clock
- Cache
- Core

[6]

- Address bus - transmits addresses between RAM and CPU
- Data bus - transmits data between RAM and CPU
- Control bus - transmits control signals between components
- Clock - controls the number of FDE cycles performed per second
- Cache - stores frequently used instructions/data for quick access
- Core - a processing unit within the CPU that can fetch, decode and execute instructions

Question

The control unit is part of a computer system.

Describe the function of the control unit.

[3]

- Controls the operation of the memory, processor and input/output devices
- Interprets instructions
- Sends control signals to other components telling them “what to do”

Question

A CPU contains registers and buses.

(a) Describe the role of a register in the CPU.

[2]

(b) Identify one bus that can be found in the CPU and explain its purpose in the fetch-decode-execute cycle.

[3]

(a)

- To store / holds data / address / instruction
- … temporarily

(b) One mark for correct name of bus. Two marks for matching description.
Address bus
Transmit / carries addresses …
… between **components** in the CPU

Data bus
Transmit / carries data …
… between **components** in the CPU

Control bus
Transmits control signals …
… from the control unit to other components in the CPU

Question

A CPU contains registers and buses.

(a) Describe the role of the address bus.

[2]

(b) Describe the role of the address bus.

[2]

(c) Describe the role of the control bus.

[2]

(a)
Transmit / carries addresses …
… between **components** in the CPU

(b)
Transmit / carries data …
… between **components** in the CPU

(c)
Transmits control signals …
… from the control unit to other components in the CPU

2b. Fetch-decode-execute (FDE) cycle

Question

Instructions are processed by a central processing unit (CPU) in a computer.

Complete the paragraph about fetching an instruction into the CPU to be processed.
Use the terms from the list.

Some of the terms in the list will not be used. You should only use a term once.
address, arithmetic logic unit (ALU), binary, control unit (CU), current instruction register (CIR), data, denary, driver, fetch, interrupt, memory address register (MAR), memory data register (MDR), random access memory (RAM), read only memory (ROM), secondary storage, signal

The program counter contains the …… of the next instruction to be processed; this is then sent to the …… using the address bus. The address is then sent to the …… .

Once the address is received, the instruction stored at the location is sent to the ……, using the …… bus. The instruction is then sent to the …… that is built into the …… .

[7]

- address
- memory address register // MAR
- random access memory // RAM
- memory data register // MDR
- data
- current instruction register // CIR
- control unit // CU

Question

The processor performs the fetch-decode-execute (FDE) cycle.
(a) The first register used in the FDE cycle stores the location in random access memory (RAM) of the next instruction. Identify the name of this register.

[1]

(b) Explain the actions that take place in the decode stage of the FDE cycle.

[4]

(c) Give the name of one component that is used in the execute stage of the FDE cycle.

[1]

(a)
- Program counter // PC

(b) Four from:
- **CIR/CU** receives the instruction from the **MDR** // Instruction sent from **MDR** to **CIR/CU**
- … using the data bus
- Instruction is **separated** into opcode and operand
- Control unit decodes the **instruction**
- … using an instruction set

(c) One from:
- Arithmetic logic unit // ALU
- Accumulator // ACC
- Control unit // CU
- (Data/address/control) bus
- Memory data register // MDR

Question

A central processing unit (CPU) performs the fetch-decode-execute (FDE) cycle.

(a) Give the name of two registers that are used in the fetch stage of the cycle.

[2]

(b) State the purpose of the decode stage of the FDE cycle.

[1]

(c) Give one register in the CPU that is used in the execute stage of the cycle.

[1]

(d) Buses are used in the CPU to transmit data and signals. Name three buses found in the CPU.

[3]

(a) Two from:
- Program counter // PC
- Memory address register // MAR
- Memory data register // MDR

(b)
- To interpret/translate the instruction (into commands/signals the CPU can understand)

(c) One from:
- Accumulator // ACC
- ALU

- CU
- MDR
- MAR
- PC

(d)

- Address bus
- Data bus
- Control bus

Question

A value is fetched from random access memory (RAM) to the CPU. Explain how the MAR and MDR are used in this process.

[3]

Three from:

- The MAR stores/holds the address/location for the value/data that is to be fetched in RAM
- The address is sent from the MAR to RAM via the address bus
- The value/data at that address is fetched from RAM
- The MDR stores/holds the value/data that has been fetched

Question

Identify **three** registers that are used in the fetch stage of the fetch-decode-execute (FDE) cycle.

[3]

- Program counter // PC
- Memory address register // MAR
- Memory data register // MDR
- Current instruction register // CIR

Question

A CPU contains registers including the memory data register (MDR) and memory address register (MAR).

(a) Describe the role of the MDR in the fetch-decode-execute cycle.

[2]

(b) Describe the role of the MAR in the fetch-decode-execute cycle.

[2]

(a)

- **Stores** data …

- … that has been fetched/to be written to memory

(b)

- **Stores** addresses …
- … of next instruction/data to be fetched // where data is to be written to

Question

A computer has a central processing unit (CPU).

The CPU includes the registers:

- Program counter (PC)
- Memory address register (MAR)
- Memory data register (MDR)
- Accumulator (ACC)
- Current instruction register (CIR).

Below are **five** statements about the role of registers in the fetch-decode-execute cycle of a CPU.

A. PC stores the address of the next instruction to be accessed
B. MAR stores the instructions of the program that is running
C. MDR stores the data passed to it from the PC
D. ACC stores the result of each calculation
E. CIR stores the instruction currently being executed

Two of the statements are not correct.
Identify the letter of each incorrect statement.
Suggest a corrected statement for each.

[4]

- Statement B …
- …MAR stores addresses and not instructions
- Statement C …
- …Data is from bus not PC // Data is from address in MAR not PC

Question

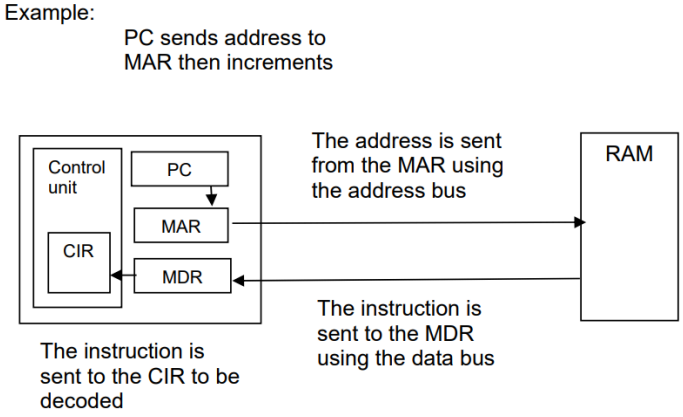
The computer processes instructions using the fetch-decode-execute (FDE) cycle. Draw and annotate a diagram to show the process of the **fetch** stage of the FDE cycle.

[5]

- The registers MAR, MDR and PC
- **Address** sent from PC to MAR

- …using address bus (award anywhere for correct use of address bus)
- …PC is incremented
- **Address** sent from MAR to RAM
- **Data/instruction** sent from RAM to MDR
- …using data bus (award anywhere for correct use of data bus)
- **Data/instruction** sent from MDR to CIR/CU
- Control unit sending control signal for any part of the process
- … using control bus (award anywhere for correct use of control bus)

Example:



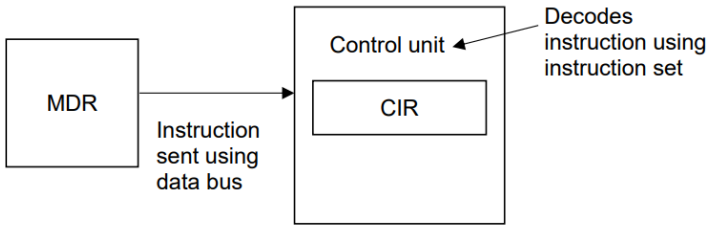
Question

The computer processes instructions using the fetch-decode-execute (FDE) cycle. Draw and annotate a diagram to show how the data is decoded once it has been fetched into the MDR.

[5]

- Data/Instruction sent from the MDR to the CIR/CU
- … using the data bus
- … the CIR that is built into the CU
- Data/instruction separated into operand and op code
- Control unit/CU decodes instruction
- … using an instruction set

For example:



3. Core, cache and clock

Question

The CPU has a clock speed of 3 GHz. Describe what is meant by a 3 GHz clock speed.

[2]

Two from:
- 3 billion (cycles per second)
- ...is the (maximum) number of instructions / FDE cycles / clock cycles processed **per second**

Question
Explain the advantages of having a quad-core processor instead of a dual-core processor.

[2]

Two from:
- It can execute more instructions/FDE cycles **simultaneously** // four instructions can be executed simultaneously rather than two
- It can execute more instructions/FDE cycles **per second**
- ...as it has double the number of cores // It has twice as many cores

Question
Explain how the clock speed can affect the performance of a CPU.

[3]

- On each clock pulse, an FDE cycle is performed.
- The clock speed is the number of FDE cycle performed in a second // The clock speed is the number of times the clock pulses per second/per unit of time.
- If clock speed is increased more FDE cycles can be performed in a second // If clock speed is decreased fewer FDE cycles can be performed in a second.
- If clock speed is increased, it can improve the performance of the CPU // If clock speed is decreases it decreases the performance of the CPU.

Question
A user changes their CPU from one with a dual core and a clock speed of 2.4 GHz to one with a dual core and a clock speed of 3.5 GHz. Explain the effect this change will have on the performance of the CPU.

[3]

Three from:
- More FDE/FE/clock cycles per second
- More instructions can be processed per second
- ...as the clock speed is higher // the clock speed has increased from 2.4 to 3.5 GHz
- The computer will perform/run faster

Question
A computer has a central processing unit (CPU), memory and secondary storage.

Computer A has a 2.1GHz quad-core processor.
Computer B has a 2.5GHz dual-core processor.
Computer C has a 5.2GHz single-core processor.

(a) Identify which computer is most likely to execute more instructions simultaneously. Justify your answer.

[3]

(b) Explain why Computer C can execute more instructions per second than Computer B.

[2]

(a)
1 mark for Computer A
Any two for justification:

- It has **4** cores/processors
- …**each core** will execute one instruction **at a time**
- **4** instructions can be executed **simultaneously** (others can only execute 1 or 2)

(b)

- C has a higher clock speed // B has max 5 GHz
- C can run **5.2 billion instructions**/FDE cycles **per second**
- B can only run **5 billion instructions**/FDE cycles **per second**
- Single core has less latency

Question
The student wants to replace the CPU to increase the performance of the computer. State **three** reasons why a different CPU might increase the performance.

[3]

- More cores
- Faster clock speed
- Larger cache

Question
The student wants to replace the CPU to increase the performance of the computer. Explain why a different CPU can increase the performance.

[4]

- More cores

- …so more instructions can be processed simultaneously
- Faster clock speed
- …so more FDE cycles per second
- Larger cache
- …so more frequently used data/instructions can be stored closer to the CPU for quicker access

4. Instruction set

Question

The CPU uses an instruction set to decode the instruction. State what is meant by an instruction set.

[1]

a list of the (machine code) commands that can be processed by a CPU

5. Embedded systems

Question

State what is meant by an embedded system.

[1]

- A computer system that is built into a larger device/system to perform a dedicated/specific function

Question

The computer is an example of a general purpose computer and not an embedded system. Explain why the computer is **not** an embedded system.

[2]

Two from:

- An embedded system is designed to perform a dedicated/limited/single function // a computer can be used to perform many different functions
- An embedded system has **dedicated** hardware // a computer has hardware that can be used by other devices
- An embedded system has software that is not easily updated/reprogrammed // software can easily be updated on the computer
- An embedded system has a microprocessor // a computer has a CPU
- An embedded system can be built into a larger device // a computer is normally standalone

Question

A smart speaker is an example of an embedded system. Give two features of the smart speaker that make it an embedded system.

[2]

Two from:
- It has a dedicated/limited function
- It has dedicated hardware
- It has software/firmware that is not easily changed
- It has a microprocessor (not a full CPU)
- It is part of/built into a larger system

Question

A washing machine is an example of an embedded system.

(a) Give **three** characteristics of an embedded system.

[3]

(b) Circle three other examples of an embedded system.

freezer laptop personal computer (PC) security light system smartphone vending machine web server

[3]

(a)
- Performs a single/limited/dedicated function/task
- It has a microprocessor
- It has **dedicated** hardware
- Uses firmware
- It is normally built into a larger device/system
- User normally cannot reprogram
- It does not require much power
- It is cheap to **manufacture**
- Works automatically // works without human intervention
- It is small (in size)
- It is a real-time system

(b)
- security light system
- freezer
- vending machine

Question

An automated teller machine (ATM) is a device where a person inserts their bank card and can request to withdraw money. The ATM also allows the person to check how much money they have in their bank account.

Describe the features of the ATM that identify it as an embedded system.

[3]

- Dedicated function // special purpose device // not general purpose
- device
- **Dedicated** hardware // by description, for example hardware is only used for ATM functions
- Cannot be (easily) reprogrammed
- Uses firmware
- Contains microprocessor // does not have CPU