Higher National Unit Specification

General information

Unit title: Computer Architecture (SCQF level 7)

Unit code: J0J8 34

Superclass: CC

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Unit purpose

The purpose of this unit is to introduce learners to the principles of computer architecture and explore how these principles are implemented in contemporary computer systems. This is a **specialist** unit intended for learners with a vocational interest in computing or STEM, but any learner may benefit from an improved understanding of how computers work.

Learners will gain an understanding of the **basic** operating principles of computers and how these principles are applied to create working computer systems. The focus of the unit is computer organisation, rather than low level aspects of computer architecture, but learners will gain an appreciation of the inner workings of contemporary computer systems. Topics covered include: types of computer, how a computer works, internal and external components, and contemporary developments in computing. Learners will also understand number systems and how these are used in computing.

On completion of this unit, learners may progress to *Computer Architecture* at SCQF level 8, which explores lower level aspects of the inner workings of a computer.

Outcomes

On successful completion of the unit, the learner will be able to:

1 Manipulate data representations.
2 Explain the functions of the hardware components of digital computers.
3 Explain the functions of the software components of digital computers.
4 Describe computer architecture designs.

Higher National Unit Specification: General information (cont)

Unit title: Computer Architecture (SCQF level 7)

Credit points and level

1 Higher National unit credit at SCQF level 7: (8 SCQF credit points at SCQF level 7)

Recommended entry to the unit

No previous knowledge or experience is required. However, it would be beneficial if learners possessed some basic knowledge of computer hardware and possess some numeracy skills. This may be evidenced by possession of the Core Skill component *Numeracy*: Using Number at SCQF level 5.

Core Skills

Achievement of this Unit gives automatic certification of the following Core Skills component:

Complete Core Skill None

Core Skill component Critical Thinking at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

Context for delivery

This unit may be offered standalone or as part of a group award. If it is delivered as part of a group award, it is recommended that it should be taught and assessed within the subject area of the group award to which it contributes.

If offered as part of a group award, there may be opportunities to combine and integrate teaching and learning across units.

The Assessment Support Pack (ASP) for this unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website **(http://www.sqa.org.uk/sqa/46233.2769.html)**.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

Higher National Unit specification: Statement of standards

Unit title: Computer Architecture (SCQF level 7)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Where evidence for outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Manipulate data representations.

Knowledge and/or skills

- Number systems including binary and hexadecimal
- Conversions between number systems
- Arithmetic operations
- Character encoding standards including ASCII
- Internal representation of data including Two's compliment
- Boolean logic and Boolean algebra

Outcome 2

Explain the functions of the hardware components of digital computers.

Knowledge and/or skills

- Types of computer
- Motherboards
- Central Processing Units
- Graphics Processing Units
- Memory
- Storage devices
- Units of measurement for storage and performance
- Interfaces
- Communication devices, standards and protocols including ODD and EVEN parity
- Interaction and communication between components
- Factors affecting performance
- Historical trends in component capacity and performance

Higher National Unit specification: Statement of standards (cont)

Unit title: Computer Architecture (SCQF level 7)

Outcome 3

Explain the functions of the software components of digital computers.

Knowledge and/or skills

- Systems software including operating systems
- File systems and file types
- BIOS
- Virtual machines

Outcome 4

Describe computer architecture designs.

Knowledge and/or skills

- Stored program concept
- Von Neumann architecture
- Harvard architecture
- Contemporary developments in computer architecture
- Machine code instruction sets

Evidence requirements for this unit

Learners will need to provide evidence to demonstrate the knowledge and/or skills across all outcomes.

The evidence requirements for this unit will consist of one type of evidence: **knowledge evidence**.

The knowledge evidence will relate to all outcomes. Knowledge evidence is required for all knowledge and/or skills statements. The evidence may be produced over an extended period of time in lightly controlled conditions. The amount of evidence may be the **minimum** required to infer competence. For example, a small number of conversions between number systems would be sufficient (Outcome 1); a few simple arithmetic operations on numbers in two or three bases would be adequate (Outcome 1); the main historical trends in component capacity and performance is sufficient (Outcome 2).

The evidence for this unit may be written or oral or a combination of these. Evidence may be captured, stored and presented in a range of media (including audio and video) and formats (analogue and digital). Particular consideration should be given to digital formats and the use of multimedia.

The knowledge evidence may be sampled when testing is used. In this case, the evidence must be produced under controlled conditions in terms of location (supervised), timing (limited) and access to reference materials (not permitted). The sampling frame must cover all outcomes but not all knowledge/skills statements; however, the majority of the knowledge/skills should be sampled in every test. The sampling frame must always include the following:

Higher National Unit specification: Statement of standards (cont)

Unit title: Computer Architecture (SCQF level 7)

- Conversions (**at least** four)
- Arithmetic operations (**at least** four)
- Boolean algebra (**at least** four examples)
- Internal representation of data
- **At least** three different types of computers
- The functions of the main hardware components which make up modern computers (**at least** four components)
- Measurements for storage and performance (**at least** two examples)
- **At least** two factors that affect overall performance of a computer
- **At least** two factors which can affect and cause bottlenecks in performance
- **At least** one historical trend in component capacity and performance
- System software including operating systems (**at least** two examples)
- Popular file systems and file types (**at least** two examples of each)
- The function of the BIOS and where it is stored
- **At least** one use of virtual machines
- The principals of stored program concept
- Machine code instruction sets (**at least** two examples)
- Contrast Von Neumann architecture with Harvard architecture
- At least one contemporary development in computer systems

The SCQF level of this unit (level 7) provides additional context on the nature of the required evidence and the associated standards. Appropriate level descriptors should be used when making judgements about the evidence.

When evidence is produced in loosely controlled conditions it must be authenticated. The Guide to Assessment provides further advice on methods of authentication.

The support notes section of this specification provides specific examples of instruments of assessment that will generate the required evidence.

Higher National Unit Support Notes

Unit title: Computer Architecture (SCQF level 7)

Unit support notes are offered as guidance and are not mandatory.

While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this unit

This unit has been developed to introduce learners to the principles of computer architecture and explore how these principles are implemented in contemporary computer systems. It is suitable for learners who are proposing to follow a career path in cyber security, technical support or networking. It is also suitable for learners with a vocational interest in computing or STEM, but any learner may benefit from an improved understanding of how computers work.

On completion of this unit, learners may progress to *Computer Architecture* at SCQF level 8, which explores lower level aspects of the inner workings of a computer.

Learners will gain an understanding of the **basic** operating principles of computers and how these principles are applied to create working computer systems. The focus of the unit is computer organisation, rather than low level aspects of computer architecture, but learners will gain an appreciation of the inner workings of contemporary computer systems. Topics covered include: types of computer, how a computer works, internal and external components, and contemporary developments in computing. Learners will also understand number systems and how these are used in computing.

Outcome 1

Topic 1 — Numbering systems

Learners should be taught how to convert between different number bases using integer numbers. These should include denary to hexadecimal, hexadecimal to denary, denary to binary, binary to denary, binary to hexadecimal and hexadecimal to binary. Learners should cover how to calculate the two's complement of binary and denary numbers.

Topic 2 — Arithmetic operations in different number bases

Learners should be taught how to perform arithmetic operations in different number bases. These should include addition and subtraction in binary, as well as addition and subtraction in hexadecimal.

Topic 3 — Boolean logic operations

Learners should be taught how to perform Boolean logic operations. These should include Boolean AND, OR, NOT and XOR operations on binary inputs of not less than eight bits.

Higher National Unit Support Notes (cont)

Unit title: Computer Architecture (SCQF level 7)

Topic 4 — Character encoding standards

Learners should learn about different character encoding standards, and how these are represented in computer storage. American Standard Code for Information Interchange (ASCII) and Unicode should be covered. This should include teaching them how to read ASCII and Unicode look up tables. How ODD and EVEN parity is applied at the binary level to ASCII should also be covered.

Outcome 2

Learners should gain an understanding of the functions of the main hardware components which make up modern computers and how they interact with each other, including:

- Motherboards
- Common Interfaces (SATA, USB, HDMI, DisplayPort, CPU socket types, PCI-Express, DIMM slots, etc)
- Central Processing Units (CPUs)
- Graphics Processing Units (GPUs)
- Memory (RAM, ROM, EEPROM, Cache)
- Types of RAM (DDR3, DDR4, GDDR5 etc)
- Storage devices
  - Optical drives (CD, DVD, Blu-Ray)
  - Internal and External Hard Drives (including Hard Disk Drives, Solid State Drives, Embedded MultiMediaCard, Network Attached Storage)
  - USB flash drives
- Communication devices (Ethernet adapters, Wi-Fi adapters and Bluetooth adapters)

As part of learning about the components listed above, learners should learn how to describe storage capacity and performance of the components above using measurements such as Megabytes, Gigabytes, Terabytes, Megabits per second, Gigahertz, MIPS, etc. Learners should also be able to explain factors that affect overall performance of a computer, including potential bottlenecks, with reference to the components listed above and using the measurements of capacity and performance mentioned. Learners should also examine historical trends in components capacity and performance.

Learners should become familiar with different types of computers including personal computers, workstations, minicomputers, mainframes and supercomputers. They should also be familiar with various types of personal computers, such as laptops, desktops, tablets, phablets, smart phones, etc.

Outcome 3

Leaners should gain an understanding of system software including operating systems (Windows, macOS, Linux, iOS, Android, etc). They should also learn about popular file systems (FAT32, NTFS, APFS, etc) and file types (.jpg, .txt, .docx, .png, .mp4, .exe, .bat, etc) that are used within those operating systems. Leaners should research the relative advantages of different file systems and file types. They should become knowledgeable in the function of the BIOS and where it is stored. Lastly, they should study the purpose and uses of virtual machines.

Outcome 4

Leaners should gain an understanding of the principles of stored program concept, which will then lead them onto learning about Von Neumann (who proposed stored program concept) architecture and Harvard architecture. They should also learn about machine code instruction sets (from popular processor families) and gain an understanding of some of the common instructions from these sets.

They should also research at least one contemporary development in computer systems, which they will be required to write about later in the unit for assessment purposes.

Guidance on approaches to delivery of this unit

A suggested distribution of time, across the outcomes, is:

Outcome 1: 12 hours

Topic 1 — Numbering systems — 3.5 hours

Learners should be set several exercises in which they must carry out all of the conversions mentioned above.

Topic 2 — Arithmetic operations in different number bases — 3.5 hours

Learners should be set several exercises in which they must carry out all of the arithmetic operations mentioned above.

Topic 3 — Boolean logic operations — 3 hours

Learners should be set several exercises in which they must carry out all of the logic operations mentioned above.

Topic 4 — Character encoding standards — 2 hours

Learners should be set the task of converting a character from ASCII into binary and binary into ASCII, taking account of ODD or EVEN parity at the same time.

Outcome 2: 10 hours

Learners should learn about computers, hardware components (listed above) and measurements of capacity and performance via various methods, which could include: Lectures, online tutorials/videos and hands-on practical exercises with real hardware components. Providing learners with some real components to examine and better still allowing them to open a desktop PC and see the components inside a computer, would be highly recommended.

Outcome 3: 9 hours

Learners should learn about system software (including BIOS and Operating Systems), file types, file systems and virtual machines, via a variety of methods, such as lectures, online tutorials/videos and hands-on practical exercises. Practical exercises which could include using various operating systems, formatting drives and using a variety of file systems and file types, is recommended.

Higher National Unit Support Notes (cont)

Unit title: Computer Architecture (SCQF level 7)

Outcome 4: 9 hours

Learners should learn about the principles of stored program concept, which will then lead them onto learning about Von Neumann (who proposed stored program concept) architecture and Harvard architecture. They should also learn about machine code instruction sets (from popular processor families) and gain an understanding of some of the common instructions from these sets. Learners should also look at contemporary developments in computer systems. It is recommended that a mixture of delivery approaches be taken for this outcome, such as lectures, online tutorials/videos and hands-on practical exercises. However, for this outcome, learners should also do some personal research into some of the topics, particularly the contemporary developments, rather than all the learning being led by the assessor.

Summative assessment may be carried out at any time. However, when testing is used (see evidence requirements) it is recommended that this is carried out towards the end of the unit (but with sufficient time for remediation and re-assessment). When continuous assessment is used (eg, with the use of a web log), this could commence early in the life of the unit and be carried out throughout the duration of the unit.

There are opportunities to carry out formative assessment at various stages in the unit. For example, formative assessment could be carried out on the completion of each outcome to ensure that learners have grasped the knowledge contained within it. This would provide assessors with an opportunity to diagnose misconceptions and intervene to remedy them before progressing to the next outcome.

Guidance on approaches to assessment of this unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

Assessment evidence is required at all stages and for all outcomes. It must be documented and recorded electronically or in written/printed form. However, centres are encouraged to look at alternate approaches such as web blog, video blog, pod casts and even social media. Alternate approaches making use of modern technology is encouraged.

Higher National Unit Support Notes (cont)

Unit title: Computer Architecture (SCQF level 7)

The **knowledge** evidence is required to demonstrate that the learner can:

Outcome 1

- Perform addition between two 8-digit binary numbers
- Perform subtraction between two 8-digit binary numbers
- Perform addition between two 4-digit hexadecimal numbers
- Perform subtraction between two 4-digit hexadecimal numbers
- Convert a 4-digit base ten (denary) number to base sixteen (hexadecimal)
- Convert a 4-digit base sixteen (hexadecimal) number base ten (denary)
- Convert an 8-digit base two (binary) number to base ten (denary)
- Convert a 4-digit base ten (denary) number to base two (binary)
- Convert an 8-digit base two (binary) number to base sixteen (hexadecimal)
- Convert a 4-digit base sixteen (hexadecimal) number to base two (binary)
- Apply a Boolean AND operation with binary inputs of not less than eight bits
- Apply a Boolean OR operation with binary inputs of not less than eight bits
- Apply a Boolean NOT operation with binary inputs of not less than eight bits
- Apply a Boolean XOR operation with binary inputs of not less than eight bits
- Describe at least one, character encoding standard
- Convert a 7-bit ASCII character to an 8-bit binary value applying ODD or EVEN parity to it
- Convert a binary value to a 7-bit ASCII character
- Calculate the two's complement of an 8-digit base two (binary) number
- Calculate the two's complement of a 3-digit base ten (denary) number

Outcome 1 may take the form of a single test (multiple-choice would be acceptable), consisting of 20 questions with a pass mark of 60%, which should cover all the topics listed above and be carried out under supervised, timed, closed-book conditions. Use of a calculator will not be allowed. It could be carried out *via* an online assessment or a paper-based one. In the case of an online assessment, learners should be able to use paper to write out their workings.

If a centre is presenting the assessment for Outcome 1 online, the following assessment methods, where appropriate, may be selected:

- Multiple-choice
- Drag and drop
- Multiple response
- Mix and match
- A combination of the above

Higher National Unit Support Notes (cont)

Unit title: Computer Architecture (SCQF level 7)

Outcome 2

- Describe at least three different types of computers
- Explain the functions of the main hardware components which make up modern computers and how they interact and communicate with each other, including:
  - Motherboards
  - Common Interfaces (SATA, USB, HDMI, DisplayPort, CPU socket types, PCI-Express, DIMM slots, etc)
  - Central Processing Units (CPUs)
  - Graphics Processing Units (GPUs)
  - Memory (RAM, ROM, EEPROM, Cache)
  - Types of RAM (DDR3, DDR4, GDDR5, etc)
  - Storage devices
    - Optical drives (CD, DVD, Blu-Ray)
    - Internal and External Hard Drives (including Hard Disk Drives, Solid State Drives, Embedded MultiMediaCard, Network Attached Storage)
    - USB flash drives
  - Communication devices (Ethernet adapters, Wi-Fi adapters and Bluetooth adapters)
- Demonstrate an understanding of measurements for storage and performance (transfer speed, bandwidth, calculations per second) by comparison of components with different capacities and speeds. This should include measurements such as Megabytes, Gigabytes, Terabytes, Megabits per second, Gigahertz, MIPS, etc
- Describe at least two factors that affect overall performance of a computer. This should include mention of transfer speeds, calculations per second, bandwidth, communication standards and protocols
- Describe at least two factors which can affect and cause bottlenecks in performance
- Describe at least one historical trend in component capacity and performance

Outcome 2 may take the form of a single test, consisting of 20 questions with a pass mark of 60%, which would cover all the topics listed above, carried out under supervised, timed, closed-book conditions. It can be carried out via an online assessment or a paper-based one. A mixture of multiple-choice and short answer questions would be an acceptable approach.

If a centre is presenting the assessment for Outcome 2 online, the following assessment methods, where appropriate, may be selected:

- Multiple-choice
- Drag and drop
- Multiple response
- Mix and match
- Short answer questions
- A combination of the above

Higher National Unit Support Notes (cont)

Unit title: Computer Architecture (SCQF level 7)

Outcome 3

- Describe system software including operating systems. Learners must describe the main functions of an operating system and give at least two examples of operating systems for different platforms
- Describe popular file systems and file types
- Describe the function of the BIOS and where it is stored
- Describe the purpose and uses of virtual machines

Outcome 4

- Describe the principals of stored program concept
- Describe what a machine code instruction set is and give some examples of common instructions from an instruction set from a popular processor
- Describe and contrast Von Neumann architecture with Harvard architecture
- Describe at least one contemporary development in computer systems

Outcomes 3 and 4 may be assessed by a single assessment instrument consisting of short answer questions that cover all the topics listed above, carried out under supervised, open-book conditions over an extended period of time. It could be carried out *via* an online assessment or a paper-based one.

Formative assessment could be used to assess learners' knowledge at various stages throughout the life of the unit. An ideal time to gauge their knowledge would be at the end of each outcome. This assessment could be delivered through an item bank of selected response questions, providing diagnostic feedback to learners (when appropriate).

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the evidence requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

There are opportunities to develop the Core Skill of *Numeracy*: Using Number at SCQF level 5 in this unit, although there is no automatic certification of Core Skills or Core Skills components.

Learners could meet the *Numeracy*: Using Number component by performing conversions between different number bases and by performing arithmetic on hexadecimal and binary numbers, as required in Outcome 1.

Higher National Unit Support Notes (cont)

Unit title: Computer Architecture (SCQF level 7)

This Unit has the Critical Thinking component of Problem Solving embedded in it. This means that when learners achieve the Unit, their Core Skills profile will also be updated to show they have achieved Critical Thinking at SCQF level 6.

History of changes to unit

Version	Description of change	Date
03	Update to Outcome 1 in the Unit Support Notes	16/09/21
02	Core Skills Component Critical Thinking at SCQF level 6 embedded.	31/08/18

General information for learners

Unit title: Computer Architecture (SCQF level 7)

This section will help you decide whether this is the unit for you by explaining what the unit is about, what you should know or be able to do before you start, what you will need to do during the unit and opportunities for further learning and employment.

The purpose of this unit is to introduce you to the principles of computer architecture and explore how these principles are implemented in contemporary computer systems. This is a **specialist** unit suitable for you if you have a vocational interest in Computing or STEM, but if not, you will still benefit from an improved understanding of how computers work.

You will gain an understanding of the **basic** operating principles of computers and how these principles are applied to create working computer systems. The focus of the unit is computer organisation, rather than low level aspects of computer architecture, but you will gain an appreciation of the inner workings of contemporary computer systems. Topics covered include: types of computer, how a computer works, internal and external components, and contemporary developments in computing. You will also gain an understanding of number systems and how these are used in computing.

The unit comprises four outcomes and sits within the optional units of the HNC in Cyber Security, although it may be delivered as a standalone unit. It is worth one Higher National unit credit at SCQF level 7 (8 SCQF credit points at SCQF level 7).

In **Outcome 1** you will learn how to manipulate data representations, including converting numbers between different numbering systems, arithmetic operations on binary and hexadecimal, character encoding standards, internal representation of data, Boolean logic and Boolean algebra.

In **Outcome 2** you will learn about the functions of the main hardware components of digital computers and the distinct types of computers that exist. This will include understanding how components like Central Processing Units, memory and storage devices interact and communicate with each other. It will also cover how those computers components are measured in terms of capacity and performance. You will also look at historical trends in component capacity and performance.

In **Outcome 3** you will learn about the functions of the software components of digital computers, including system software such as operating systems and BIOS. You will also learn about the various file systems and file types that are commonly used. Lastly you will learn about the purpose and uses of virtual machines in modern computing.

In **Outcome 4** you will examine computer architecture designs, including stored program concept, Von Neumann architecture and Harvard architecture. You will also research contemporary developments in computer architecture. Lastly, you will learn about machine code instruction sets for popular processor families.

On completion of this unit, you may progress to *Computer Architecture* at SCQF level 8, which explores lower level aspects of the inner workings of a computer.

The Critical Thinking component of *Problem Solving* at SCQF level 6 is embedded in this unit. When you achieve this unit, your Core Skills profile will be updated to include this component.