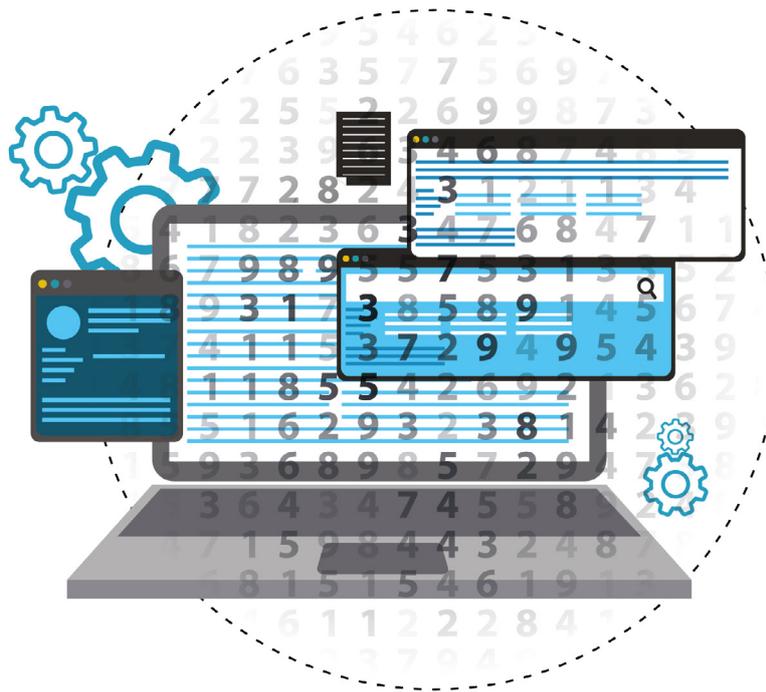




Syllabus

Cambridge International AS & A Level Computer Science 9608

For examination in June and November 2021.



Changes to the syllabus for 2021

The latest syllabus is version 1, published September 2018.

Technical updates will not be available for this syllabus in 2021.

Availability by examination series

This is Cambridge International AS & A Level Computer Science (9608). The last examination for this syllabus will be 2021.

The table below shows the last examination for this syllabus and the first examination series for the new AS & A Level Computer Science (9618).

	Code	Paper	June 19	Nov 19	June 20	Nov 20	June 21	Nov 21	June 22	Nov 22	June 23	Nov 23
	9608	AS	✓	✓	✓	✓	✓	✓				
		AL	✓	✓	✓	✓	✓	✓				
New	9618	AS					✓	✓	✓	✓	✓	✓
		AL					✓	✓	✓	✓	✓	✓

Please note that candidates can resit Cambridge International AS and A Level Computer Science (9608) in 2021 only. This syllabus will **not** be available for examination after 2021.

Making entries

When making your examination entries, you **must** use the code of the syllabus you have taught. If you have taught the new AS & A Level Computer Science (9618) syllabus, you **must** enter candidates for that examination.

Combining syllabuses

Please note: candidates may **not** take Cambridge International AS Level Computer Science (9608) and complete the A Level with components from the new syllabus Cambridge International AS and A Level Computer Science (9618).

There are no significant changes which affect teaching.

Any textbooks endorsed to support the syllabus for examination from 2017 are still suitable for use with this syllabus.

Cambridge Assessment International Education is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which itself is a department of the University of Cambridge.

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Contents

Introduction	2
Why choose Cambridge International?	
Why choose Cambridge International AS & A Levels?	
Why Cambridge International AS & A Level Computer Science?	
Supporting teachers	
1 Syllabus content at a glance	8
2 Assessment at a glance	12
3 Syllabus aims and assessment objectives	14
3.1 Syllabus aims	
3.2 Assessment objectives	
3.3 Relationship between assessment objectives and components	
4 Syllabus content	16
Section 1 Theory Fundamentals	
Section 2 Fundamental Problem-solving and Programming Skills	
Section 3 Advanced Theory	
Section 4 Further Problem-solving and Programming Skills	
5 Description of components	43
5.1 Scheme of assessment	
5.2 Paper 2 and Paper 4 Problem-solving and Programming Skills pre-release material	
6 Notes for the guidance of teachers	44
7 Other information	45
Equality and inclusion	
Language	
Making entries	
Exam administration	
Retakes	
Grading and reporting	
How students, teachers and higher education can use the grades	

Why choose Cambridge International?

Cambridge Assessment International Education prepares school students for life, helping them develop an informed curiosity and a lasting passion for learning. We are part of the University of Cambridge.

Our Cambridge Pathway gives students a clear path for educational success from age 5 to 19. Schools can shape the curriculum around how they want students to learn – with a wide range of subjects and flexible ways to offer them. It helps students discover new abilities and a wider world, and gives them the skills they need for life, so they can achieve at school, university and work.

Our programmes and qualifications set the global standard for international education. They are created by subject experts, rooted in academic rigour and reflect the latest educational research. They provide a strong platform for students to progress from one stage to the next, and are well supported by teaching and learning resources.

We review all our syllabuses regularly, so they reflect the latest research evidence and professional teaching practice – and take account of the different national contexts in which they are taught.

We consult with teachers to help us design each syllabus around the needs of their learners. Consulting with leading universities has helped us make sure our syllabuses encourage students to master the key concepts in the subject and develop the skills necessary for success in higher education.

Our mission is to provide educational benefit through provision of international programmes and qualifications for school education and to be the world leader in this field. Together with schools, we develop Cambridge learners who are confident, responsible, reflective, innovative and engaged – equipped for success in the modern world.

Every year, nearly a million Cambridge students from 10 000 schools in 160 countries prepare for their future with the Cambridge Pathway.

“ We think the Cambridge curriculum is superb preparation for university. ”

Christoph Guttentag, Dean of Undergraduate Admissions, Duke University, USA

“ Cambridge students develop a deep understanding of subjects and independent thinking skills. ”

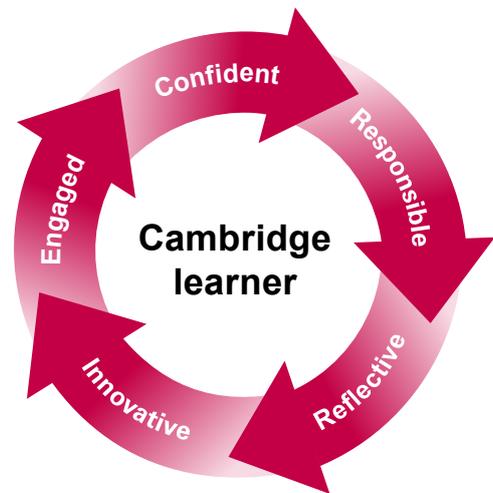
Tony Hines, Principal, Rockledge High School, USA

Why choose Cambridge International AS & A Levels?

The best motivation for a student is a real passion for the subject they're learning. By offering students a variety of Cambridge International AS & A Levels, you can give them the greatest chance of finding the path of education they most want to follow. With over 50 subjects to choose from, students can select the ones they love and that they're best at, which helps motivate them throughout their studies.

Following a Cambridge International AS & A Level programme helps students develop abilities which universities value highly, including:

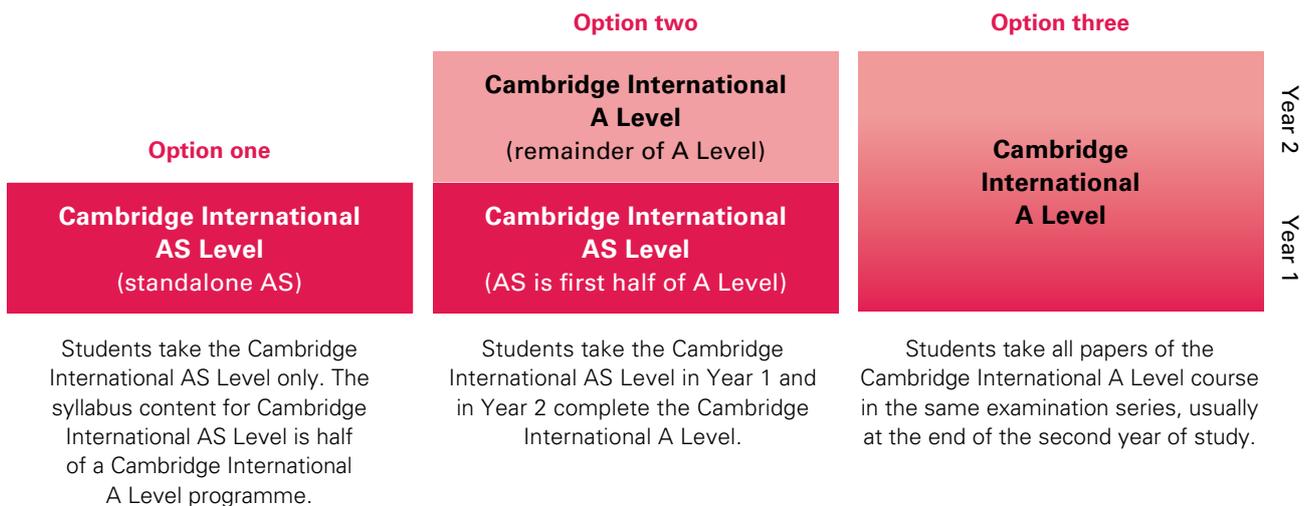
- a deep understanding of their subjects
- higher order thinking skills – analysis, critical thinking, problem solving
- presenting ordered and coherent arguments
- independent learning and research.



Our approach in Cambridge International AS & A Level encourages learners to be:

- **confident** in working with information and ideas – their own and those of others
- **responsible** for themselves, responsive to and respectful of others
- **reflective** as learners, developing their ability to learn
- **innovative** and equipped for new and future challenges
- **engaged** intellectually and socially, ready to make a difference.

Cambridge International AS & A Level offers a choice of assessment routes with staged assessment available in many subjects: Cambridge International AS Level can be offered as a standalone qualification or as part of a progression to Cambridge International A Level:



Recognition

Our expertise in curriculum, teaching and learning, and assessment is the basis for the recognition of our programmes and qualifications around the world. Every year thousands of students with Cambridge International AS & A Levels gain places at leading universities worldwide. They are valued by top universities around the world including those in the UK, US (including Ivy League universities), Europe, Australia, Canada and New Zealand.

UK NARIC, the national agency in the UK for the recognition and comparison of international qualifications and skills, has carried out an independent benchmarking study of Cambridge International AS & A Level and found it to be comparable to the standard of AS & A Level in the UK. This means students can be confident that their Cambridge International AS & A Level qualifications are accepted as equivalent, grade for grade, to UK AS & A Levels by leading universities worldwide.

Learn more

For more details go to www.cambridgeinternational.org/recognition

Quality management

Cambridge International is committed to providing exceptional quality. In line with this commitment, our quality management system for the provision of international qualifications and education programmes for students aged 5 to 19 is independently certified as meeting the internationally recognised standard, ISO 9001:2015. Learn more at www.cambridgeinternational.org/ISO9001

“ The depth of knowledge displayed by the best A Level students makes them prime targets for America’s Ivy League universities ”

Yale University, USA

Why Cambridge International AS & A Level Computer Science?

About the syllabus

Cambridge International AS Level and A Level Computer Science are accepted by universities and employers as proof of essential knowledge and ability.

This syllabus is designed to give greater flexibility both to teachers and to learners. It is envisaged that learners will use the skills and knowledge of computer science acquired through this course in one of three ways:

- to provide a general understanding and perspective of the development of computer technology and systems, which will inform their decisions and support their participation in an increasingly technologically dependent society
- to provide the necessary skills and knowledge to seek employment in areas that use computer science
- to develop their knowledge and understanding of computer science through entry to higher education, where this qualification will provide a useful foundation for further study of computer science or more specialist aspects of computer science.

Guided learning hours

Guided learning hours give an indication of the amount of contact time teachers need to have with learners to deliver a particular course. Our syllabuses are designed around 180 guided learning hours for Cambridge International AS Level, and around 360 guided learning hours for Cambridge International A Level.

These figures are for guidance only. The number of hours needed to gain the qualification may vary depending on local practice and the learners' previous experience of the subject.

Prior learning

Candidates beginning this course are not expected to have studied computer science or ICT previously.

Progression

Cambridge International A Level Computer Science provides a suitable foundation for the study of computer science or related courses in higher education. Equally, it is suitable for candidates intending to pursue careers or further study in computer science or ICT, or as part of a course of general education.

Cambridge International AS Level Computer Science constitutes the first half of the Cambridge International A Level course in computer science and provides a suitable foundation for the study of computer science at Cambridge International A Level and then for related courses in higher education. Depending on local university entrance requirements, it may permit or assist progression directly to university courses in Computer Science or some other subjects. It is also suitable for candidates intending to pursue careers or further study in computer science or ICT, or as part of a course of general education.

We recommend learners check the Cambridge recognitions database and the university websites to find the most up-to-date entry requirements for courses they wish to study.

How can I find out more?

If you are already a Cambridge school

You can make entries for this qualification through your usual channels. If you have any questions, please contact us at info@cambridgeinternational.org

If you are not yet a Cambridge school

Learn more about the benefits of becoming a Cambridge school from our website at www.cambridgeinternational.org/startcambridge

Email us at info@cambridgeinternational.org to find out how your organisation can register to become a Cambridge school.

Cambridge AICE

Cambridge AICE (Advanced International Certificate of Education) Diploma is the group award of the Cambridge International AS & A Level. It gives schools the opportunity to benefit from offering a broad and balanced curriculum by recognising the achievements of candidates who pass examinations from different curriculum groups.

Learn more

For more details go to www.cambridgeinternational.org/aice

“ Our research has shown that students who came to the university with a Cambridge AICE background performed better than anyone else that came to the university. That really wasn't surprising considering the emphasis they have on critical research and analysis, and that's what we require at university. ”

John Barnhill, Assistant Vice President for Enrollment Management, Florida State University, USA

Supporting teachers

We provide a wide range of practical resources, detailed guidance, and innovative training and professional development so that you can give your learners the best possible preparation for Cambridge International AS & A Level.

Teaching resources

- School Support Hub
www.cambridgeinternational.org/support
- Syllabuses
- Schemes of work
- Learner guides
- Discussion forums
- Endorsed resources

Exam preparation resources

- Question papers
- Mark schemes
- Example candidate responses to understand what examiners are looking for at key grades
- Examiner reports to improve future teaching

Support
for Cambridge
International
AS & A Level

Training

- Introductory – face-to-face or online
 - Extension – face-to-face or online
 - Enrichment – face-to-face or online
 - Coursework – online
 - Cambridge Professional Development Qualifications
- Find out more at
www.cambridgeinternational.org/profdev

Community

You can find useful information, as well as share your ideas and experiences with other teachers, on our social media channels and community forums.

Find out more at
www.cambridgeinternational.org/social-media

“ Cambridge International AS & A Levels prepare students well for university because they’ve learnt to go into a subject in considerable depth. There’s that ability to really understand the depth and richness and the detail of a subject. It’s a wonderful preparation for what they are going to face at university. ”

US Higher Education Advisory Council

1 Syllabus content at a glance

Section	Topics
Section 1 Theory Fundamentals	<ul style="list-style-type: none">1.1 Information representation<ul style="list-style-type: none">1.1.1 Number representation1.1.2 Images1.1.3 Sound1.1.4 Video1.1.5 Compression techniques1.2 Communication and Internet technologies<ul style="list-style-type: none">1.2.1 Networks1.2.2 IP addressing1.2.3 Client- and server-side scripting1.3 Hardware<ul style="list-style-type: none">1.3.1 Input, output and storage devices1.3.2 Main memory1.3.3 Logic gates and logic circuits1.4 Processor fundamentals<ul style="list-style-type: none">1.4.1 CPU architecture1.4.2 The fetch-execute cycle1.4.3 The processor's instruction set1.4.4 Assembly language1.5 System software<ul style="list-style-type: none">1.5.1 Operating system1.5.2 Utility programs1.5.3 Library programs1.5.4 Language translators1.6 Security, privacy and data integrity<ul style="list-style-type: none">1.6.1 Data security1.6.2 Data integrity1.7 Ethics and ownership<ul style="list-style-type: none">1.7.1 Ethics1.7.2 Ownership1.8 Database and data modelling<ul style="list-style-type: none">1.8.1 Database Management Systems (DBMS)1.8.2 Relational database modelling1.8.3 Data Definition Language (DDL) and Data Manipulation Language (DML)

Section	Topics
Section 2 Fundamental Problem-solving and Programming	<ul style="list-style-type: none">2.1 Algorithm design and problem-solving<ul style="list-style-type: none">2.1.1 Algorithms2.1.2 Structure chart2.1.3 Corrective maintenance2.1.4 Adaptive maintenance2.2 Data representation<ul style="list-style-type: none">2.2.1 Data types2.2.2 Arrays2.2.3 Files2.3 Programming<ul style="list-style-type: none">2.3.1 Programming basics2.3.2 Transferable skills2.3.3 Selection2.3.4 Iteration2.3.5 Built-in functions2.3.6 Structured programming2.4 Software development<ul style="list-style-type: none">2.4.1 Programming2.4.2 Program testing2.4.3 Testing strategies

Section	Topics
Section 3 Advanced Theory	<ul style="list-style-type: none">3.1 Data representation<ul style="list-style-type: none">3.1.1 User-defined data types3.1.2 File organisation and access3.1.3 Real numbers and normalised floating-point representation3.2 Communication and Internet technologies<ul style="list-style-type: none">3.2.1 Protocols3.2.2 Circuit switching, packet switching and routers3.2.3 Local Area Networks (LAN)3.3 Hardware<ul style="list-style-type: none">3.3.1 Logic gates and circuit design3.3.2 Boolean algebra3.3.3 Karnaugh Maps3.3.4 Flip-flops3.3.5 RISC processors3.3.6 Parallel processing3.4 System software<ul style="list-style-type: none">3.4.1 Purposes of an operating system (OS)3.4.2 Virtual machine3.4.3 Translation software3.5 Security<ul style="list-style-type: none">3.5.1 Asymmetric keys and encryption methods3.5.2 Digital signatures and digital certificates3.5.3 Encryption protocols3.5.4 Malware3.6 Monitoring and control systems<ul style="list-style-type: none">3.6.1 Overview of monitoring and control systems3.6.2 Bit manipulation to monitor and control devices

Section	Topics
Section 4 Further Problem-solving and Programming Skills	<ul style="list-style-type: none">4.1 Computational thinking and problem-solving<ul style="list-style-type: none">4.1.1 Abstraction4.1.2 Algorithms4.1.3 Abstract Data Types (ADT)4.1.4 Recursion4.2 Algorithm design methods<ul style="list-style-type: none">4.2.1 Decision tables4.2.2 Jackson Structured Programming (JSP)4.2.3 State-transition diagrams4.3 Further programming<ul style="list-style-type: none">4.3.1 Programming paradigms<ul style="list-style-type: none">Low-level programmingImperative programmingObject-oriented programmingDeclarative programming4.3.2 File processing4.3.3 Exception handling4.3.4 Use of development tools / programming environments4.4 Software development<ul style="list-style-type: none">4.4.1 Stages of software development4.4.2 Testing4.4.3 Project management

2 Assessment at a glance

For Cambridge International AS and A Level Computer Science, candidates may choose:

- to take Papers 1, 2, 3 and 4 in the same examination series, leading to the full Cambridge International A Level
- to follow a **staged** assessment route by taking Papers 1 and 2 (for the AS Level qualification) in one series, then Papers 3 and 4 (for the full Cambridge International A Level) in a later series
- to take Papers 1 and 2 only (for the AS Level qualification).

Please see the inside front cover for more information about when this syllabus is available.

Components	Weighting (%)	
	AS	A
<p>Paper 1 Theory Fundamentals</p> <p>This written paper contains short-answer and structured questions. There is no choice of questions. 75 marks Externally assessed</p> <p style="text-align: right;">1 hour 30 minutes</p>	50	25
<p>Paper 2 Fundamental Problem-solving and Programming Skills</p> <p>This written paper contains short-answer and structured questions. There is no choice of questions. Topics will include those given in the pre-release material.¹ 75 marks Externally assessed</p> <p style="text-align: right;">2 hours</p>	50	25
<p>Paper 3 Advanced Theory</p> <p>This written paper contains short-answer and structured questions. There is no choice of questions. 75 marks Externally assessed</p> <p style="text-align: right;">1 hour 30 minutes</p>	–	25
<p>Paper 4 Further Problem-solving and Programming Skills</p> <p>This written paper contains short-answer and structured questions. There is no choice of questions. Topics will include those given in the pre-release material.¹ 75 marks Externally assessed</p> <p style="text-align: right;">2 hours</p>	–	25

Advanced Subsidiary (AS) forms 50% of the assessment weighting of the full Advanced (A) Level.

¹ On receipt of estimated entry forms by the required date stated in the Administrative Guide, the pre-release material for Paper 2 and Paper 4 will be made available to centres the January before the June examination, and the July before the November examination. The material will be sent in hard-copy form. When the material has been received, it should be shared with the relevant teachers in the centre and issued to candidates immediately, as teachers and candidates need the material to prepare for the examinations. Candidates are not permitted to bring any prepared material into the examination.

Availability

This syllabus is examined in the June and November examination series.

The last examination for this syllabus will be 2021.

This syllabus is available to private candidates.

Detailed timetables are available from www.cambridgeinternational.org/timetables

Combining this with other syllabuses

Candidates can combine this syllabus in an examination series with any other Cambridge International syllabus, except:

- 9618 AS & A Level Computer Science
- 9626 AS & A Level Information Technology
- syllabuses with the same title at the same level.

3 Syllabus aims and assessment objectives

3.1 Syllabus aims

The aims of a course based on Cambridge International AS and AL Computer Science, whether leading to an AS or A Level qualification are:

- to develop computational thinking
- to develop an understanding of the main principles of solving problems using computers
- to develop an understanding that every computer system is made up of subsystems, which in turn consist of further subsystems
- to develop an understanding of the component parts of computer systems and how they interrelate, including software, data, hardware, communications and people
- to acquire the skills necessary to apply this understanding to develop computer-based solutions to problems.

Computer science is the study of the foundational principles and practices of computation and computational thinking and their application in the design and development of computer systems.

This syllabus aims to encourage the development of computational thinking, that is thinking about what can be computed and how by the use of abstraction and decomposition. It includes consideration of the data required. Learning computational thinking involves learning to program, by writing computer code, because this is the means by which computational thinking is expressed.

3.2 Assessment objectives

Cambridge International AS and A Level Computer Science has two assessment objectives:

AO1 Knowledge with understanding

- show understanding of the characteristics and methods of operation of component parts of computer systems (hardware, software, communication) and their subsystems
- describe, explain and use various different methods of representing data for use in computer systems
- comment critically on ethical issues arising from the use of computer solutions.

AO2 Skills

- apply knowledge with understanding to computational problems
- select, justify and apply appropriate techniques and principles to develop data structures and algorithms for the solutions of computational problems
- design, implement, document and evaluate an effective solution using appropriate hardware, software and programming languages.

3.3 Relationship between assessment objectives and components

The approximate weightings allocated to each of the assessment objectives (AOs) are summarised below.

Assessment objective	Paper 1 (%)	Paper 2 (%)	Paper 3 (%)	Paper 4 (%)	AS Level (%)	A Level (%)
AO1 Knowledge with understanding	20	5	20	5	50	50
AO2 Skills	5	20	5	20	50	50

4 Syllabus content

This syllabus is set out in the form of teaching sections. Each teaching section is assessed by its associated paper. The AS Level syllabus consists of teaching Sections 1 and 2 only, and the A Level syllabus consists of all four teaching sections.

The subject content for each section is shown below.

Syllabus content section	Paper	Section title
1	1	Theory Fundamentals
2	2	Fundamental Problem-solving and Programming Skills
3	3	Advanced Theory
4	4	Further Problem-solving and Programming Skills

Each section is presented as a set of sub-sections, each with details of content and associated learning outcomes.

Section 1 Theory Fundamentals

1.1 Information representation

Candidates should be able to:

1.1.1 Number representation

- show understanding of the basis of different number systems and use the binary, denary and hexadecimal number systems
- convert a number from one number system to another
- express a positive or negative integer in two's complement form
- show understanding of, and be able to represent, character data in its internal binary form depending on the character set used (Candidates will not be expected to memorise any particular character codes but must be familiar with ASCII and Unicode.)
- express a denary number in Binary Coded Decimal (BCD) and vice versa
- describe practical applications where BCD is used

1.1.2 Images

- show understanding of how data for a bitmapped image is encoded
- use the terminology associated with bitmaps: pixel, file header, image resolution, screen resolution
- perform calculations estimating the file size for bitmapped images of different resolutions
- show understanding of how data for a vector graphic is represented and encoded
- use the terminology associated with vector graphics: drawing object, property and drawing list
- show understanding of how typical features found in bitmapped and vector graphics software are used in practice
- justify where bitmapped graphics and/or vector graphics are appropriate for a given task

1.1.3 Sound

- show understanding of how sound is represented and encoded
- use the associated terminology: sampling, sampling rate, sampling resolution
- show understanding of how file sizes depend on sampling rate and sampling resolution
- show understanding of how typical features found in sound editing software are used in practice

1.1.4 Video

- Show understanding of the characteristics of video streams:
 - the frame rate (frames/second)
 - interlaced and progressive encoding
 - video interframe compression algorithms and spatial and temporal redundancy
 - multimedia container formats

1.1.5 Compression techniques

- show understanding of how digital data can be compressed, using either 'lossless' (including run-length encoding – RLE) or 'lossy' techniques

1.2 Communication and Internet technologies

Candidates should be able to:

1.2.1 Networks

- explain the client-server model of networked computers
- give examples of applications which use the client-server model
- describe what is meant by the World Wide Web (WWW) and the Internet
- explain how hardware is used to support the Internet: networks, routers, gateways, servers
- explain how communication systems are used to support the Internet: The Public Switched Telephone Network (PSTN), dedicated lines, cell phone network
- explain the benefits and drawbacks of using copper cable, fibre-optic cabling, radio waves, microwaves, satellites
- show understanding of bit streaming (both real-time and on-demand)
- show understanding of the importance of bit rates/broadband speed on bit streaming

1.2.2 IP addressing

- explain the format of an IP address and how an IP address is associated with a device on a network
- explain the difference between a public IP address and a private IP address and the implication for security
- explain how a Uniform Resource Locator (URL) is used to locate a resource on the World Wide Web (WWW) and the role of the Domain Name Service

1.2.3 Client- and server-side scripting

- describe the sequence of events executed by the client computer and web server when a web page consisting only of HTML tags is requested and displayed by a browser
 - Client-side
 - recognise and identify the purpose of some simple JavaScript code
 - describe the sequence of events executed by the client computer and web server when a web page with embedded client-side code is requested and displayed by a browser
 - show understanding of the typical use of client-side code in the design of an application
 - Server-side
 - recognise and identify the purpose of some simple PHP code
 - describe the sequence of events executed by the client computer and web server when a web page with embedded server-side code is requested and displayed by a browser
 - show understanding that an appropriately designed web application for accessing database data makes use of server-side scripting

1.3 Hardware

Candidates should be able to:

1.3.1 Input, output and storage devices

- identify hardware devices used for input, output, secondary storage
- show understanding of the basic internal operation of the following specific types of device:
 - keyboard
 - trackerball mouse
 - optical mouse
 - scanner
 - inkjet printer
 - laser printer
 - 3D printer
 - speakers
 - hard disk
 - solid state (flash) memory
 - optical discs
 - microphone
 - touchscreen
- show understanding of the need for secondary (including removable) storage

1.3.2 Main memory

- show understanding of the need for primary storage
 - explain the differences between RAM and ROM memory
 - explain the differences between Static RAM (SRAM) and Dynamic RAM (DRAM)

1.3.3 Logic gates and logic circuits

- use the following logic gate symbols:



NOT



AND



OR



NAND



NOR



XOR

- understand and define the functions of NOT, AND, OR, NAND, NOR and XOR (EOR) gates including the binary output produced from all the possible binary inputs (all gates, except the NOT gate, will have two inputs only)
- construct the truth table for each of the logic gates above
- construct a logic circuit from either:
 - a problem statement
 - a logic expression
- construct a truth table from either:
 - a logic circuit
 - a logic expression
- show understanding that some circuits can be constructed with fewer gates to produce the same outputs

1.4 Processor fundamentals

Candidates should be able to:

1.4.1 CPU architecture

- show understanding of the basic Von Neumann model for a computer system and the stored program concept
- show understanding of the roles carried out by registers, including the difference between general purpose and special purpose registers: Program Counter, Memory Data Register, Memory Address Register, Index Register, Current Instruction Register and Status Register
- show understanding of the roles carried out by the Arithmetic and Logic Unit (ALU), Control Unit and system clock
- show understanding of how data are transferred between various components of the computer system using the address bus, data bus and control bus
- show understanding of how the bus width and clock speed are factors that contribute to the performance of the computer system
- show understanding of the need for ports, for example Universal Serial Bus (USB), to provide the connection to peripheral devices

1.4.2 The fetch-execute cycle

- describe the stages of the fetch-execute cycle
- show understanding of 'register transfer' notation
- describe how interrupts are handled

1.4.3 The processor's instruction set

- show understanding that the set of instructions are grouped into instructions for:
 - data movement (register to main memory and vice versa)
 - input and output of data
 - arithmetic operations
 - unconditional and conditional jump instructions
 - compare instructions
 - modes of addressing: immediate, direct, indirect, indexed, relative
- (No particular instruction set will be expected but candidates should be familiar with the type of instructions given in the table on page 21.)

1.4.4 Assembly language

- show understanding of the relationship between assembly language and machine code, including symbolic and absolute addressing, directives and macros
- describe the different stages of the assembly process for a 'two-pass' assembler for a given simple assembly language program
- trace a given simple assembly language program

Instruction		Explanation
Op Code	Operand	
LDM	#n	Immediate addressing. Load the number n to ACC
LDD	<address>	Direct addressing. Load the contents of the location at the given address to ACC
LDI	<address>	Indirect addressing. The address to be used is at the given address. Load the contents of this second address to ACC
LDX	<address>	Indexed addressing. Form the address from <address> + the contents of the index register. Copy the contents of this calculated address to ACC
LDR	#n	Immediate addressing. Load the number n to IX
STO	<address>	Store the contents of ACC at the given address
ADD	<address>	Add the contents of the given address to the ACC
INC	<register>	Add 1 to the contents of the register (ACC or IX)
DEC	<register>	Subtract 1 from the contents of the register (ACC or IX)
JMP	<address>	Jump to the given address
CMP	<address>	Compare the contents of ACC with the contents of <address>
CMP	#n	Compare the contents of ACC with number n
JPE	<address>	Following a compare instruction, jump to <address> if the compare was True
JPN	<address>	Following a compare instruction, jump to <address> if the compare was False
IN		Key in a character and store its ASCII value in ACC
OUT		Output to the screen the character whose ASCII value is stored in ACC
END		Return control to the operating system

All questions will assume there is only one general purpose register available (Accumulator)

ACC denotes Accumulator

IX denotes Index Register

denotes immediate addressing

B denotes a binary number, e.g. B01001010

& denotes a hexadecimal number, e.g. &4A

1.5 System software

Candidates should be able to:

1.5.1 Operating system

- describe why a computer system requires an operating system
- explain the key management tasks carried out by the operating system

1.5.2 Utility programs

- show an understanding of the need for typical utility software used by a PC computer system:
 - disk formatter
 - virus checker
 - defragmenter software
 - disk contents analysis/disk repair software
 - file compression
 - backup software

1.5.3 Library programs

- show an understanding that software under development is often constructed using existing code from program libraries
- describe the benefits to the developer of software constructed using library files, including Dynamic Link Library (DLL) files
- draw on experience of the writing of programs which include library routines

1.5.4 Language translators

- show an understanding of the need for:
 - assembler software for the translation of an assembly language program
 - a compiler for the translation of a high-level language program
 - an interpreter for execution of a high-level language program
- explain the benefits and drawbacks of using either a compiler or interpreter
- show awareness that high-level language programs may be partially compiled and partially interpreted, such as Java

1.6 Security, privacy and data integrity

Candidates should be able to:

1.6.1 Data security

- explain the difference between the terms security, privacy and integrity of data
- show appreciation of the need for both the security of data and the security of the computer system
- describe security measures designed to protect computer systems, ranging from the stand-alone PC to a network of computers, including:
 - user accounts
 - firewalls
 - general authentication techniques, including the use of passwords and digital signatures
- describe security measures designed to protect the security of data, including:
 - data backup
 - a disk-mirroring strategy
 - encryption
 - access rights to data (authorisation)
- show awareness of what kind of errors can occur and what can be done about them

1.6.2 Data integrity

- describe error detection and correction measures designed to protect the integrity of data, including:
 - data validation
 - data verification for data entry
 - data verification during data transfer, including
 - parity check
 - checksum check

1.7 Ethics and ownership

Candidates should be able to:

1.7.1 Ethics and the computing professional

- show a basic understanding of ethics
- explain how ethics may impact on the job role of the computing professional
- show understanding of the eight principles listed in the ACM/IEEE Software Engineering Code of Ethics
- demonstrate the relevance of these principles to some typical software developer workplace scenarios
- show understanding of the need for a professional code of conduct for a computer system developer

1.7.2 Ownership of software and data

- show understanding of the concept of ownership and copyright
- describe the need for legislation to protect ownership, usage and copyright
- discuss measures to restrict access to data made available through the Internet and World Wide Web
- show understanding of the implications of different types of software licensing: Free Software Foundation, the Open Source Initiative, shareware and commercial software

1.8 Database and data modelling

Candidates should be able to:

1.8.1 Database Management Systems (DBMS)

- show understanding of the limitations of using a file-based approach for the storage and retrieval of data
- describe the features of a relational database which address the limitations of a file-based approach
- show understanding of the features provided by a DBMS to address the issues of:
 - data management, including maintaining a data dictionary
 - data modelling
 - logical schema
 - data integrity
 - data security, including backup procedures and the use of access rights to individuals/groups of users
- show understanding of how software tools found within a DBMS are used in practice:
 - developer interface
 - query processor
- show awareness that high-level languages provide accessing facilities for data stored in a database

1.8.2 Relational database modelling

- show understanding of, and use, the terminology associated with a relational database model: entity, table, tuple, attribute, primary key, candidate key, foreign key, relationship, referential integrity, secondary key and indexing
- produce a relational design from a given description of a system
- use an entity-relationship diagram to document a database design
- show understanding of the normalisation process: First (1NF), Second (2NF) and Third Normal Form (3NF)
- explain why a given set of database tables are, or are not, in 3NF
- make the changes to a given set of tables which are not in 3NF to produce a solution in 3NF, and justify the changes made

1.8.3 Data Definition Language (DDL) and Data Manipulation Language (DML)

- show understanding that DBMS software carries out:
 - all creation/modification of the database structure using its DDL
 - query and maintenance of data using its DML
- show understanding that the industry standard for both DDL and DML is Structured Query Language (SQL)
 - show understanding of a given SQL script
 - write simple SQL (DDL) commands using a sub-set of commands for:
 - creating a database (CREATE DATABASE)
 - creating a table definition (CREATE TABLE)
 - changing a table definition (ALTER TABLE)
 - adding a primary key or foreign key to a table (ADD PRIMARY KEY)
 - write a SQL script for querying or modifying data (DML) which are stored in (at most two) database tables
 - Queries:
 - SELECT, FROM, WHERE, ORDER BY, GROUP BY, INNER JOIN
 - Data maintenance:
 - INSERT INTO, DELETE FROM, UPDATE

Section 2 Fundamental Problem-solving and Programming Skills

2.1 Algorithm design and problem-solving

Candidates should be able to:

2.1.1 Algorithms

- show understanding that an algorithm is a solution to a problem expressed as a sequence of defined steps
- use suitable identifier names for the representation of data used by a problem
 - summarise identifier names using an identifier table
- show understanding that many algorithms are expressed using the four basic constructs of assignment, sequence, selection and repetition
- show understanding that simple algorithms consist of input, process, output at various stages
- document a simple algorithm using:
 - structured English
 - pseudocode (on the examination paper, any given pseudocode will be presented using the Courier New font)
 - program flowchart
- derive pseudocode or a program flowchart from a structured English description of a problem
- derive pseudocode from a given program flowchart or vice versa
- use the process of stepwise refinement to express an algorithm to a level of detail from which the task may be programmed
- decompose a problem into sub-tasks leading to the concept of a program module (procedure/function)
- show an appreciation of why logic statements are used to define parts of an algorithm solution
- use logic statements to define parts of an algorithm solution

2.1.2 Structure chart

- use a structure chart to express the parameters passed between the various modules/procedures/functions which are part of the algorithm design
- describe the purpose of a structure chart
- construct a structure chart for a given problem
- derive equivalent pseudocode from a structure chart

2.1.3 Corrective maintenance

- perform white-box testing by:
 - selecting suitable data
 - using a trace table
- identify any error(s) in the algorithm by using the completed trace table
- amend the algorithm if required

2.1.4 Adaptive maintenance

- make amendments to an algorithm and data structure in response to specification changes
- analyse an existing program and make amendments to enhance functionality

2.2 Data representation

Candidates should be able to:

2.2.1 Data types

- select appropriate data types for a problem solution
- use in practical programming the data types that are common to procedural high-level languages: integer, real, char, string, Boolean, date (pseudocode will use the following data types:
INTEGER, REAL, CHAR, STRING, BOOLEAN, DATE, ARRAY, FILE)
- show understanding of how character and string data are represented by software including the ASCII and Unicode character sets

2.2.2 Arrays

- use the technical terms associated with arrays including upper and lower bound
- select a suitable data structure (1D or 2D array) to use for a given task
- use pseudocode for 1D and 2D arrays (pseudocode will use square brackets to contain the array subscript, for example a 1D array as A[1:n] and a 2D array as C[1:m, 1:n])
- write program code using 1D and 2D arrays
- write algorithms/program code to process array data including:
 - sorting using a bubble sort
 - searching using a linear search
- given pseudocode will use the following structures:
DECLARE <identifier> : ARRAY[<lbound>:<ubound>] OF <datatype>
DECLARE <identifier> : ARRAY[<lbound1>:<ubound1>, [<lbound2>:<ubound2>]
OF <datatype>

2.2.3 Files

- show understanding of why files are needed
- use pseudocode for file handling:
OPENFILE <filename> FOR READ/WRITE/APPEND // Open file (understand the
difference between various file modes)
READFILE <filename>, <string> // Read a line of text from the file
WRITEFILE <filename>, <string> // Write a line of text to the file
CLOSEFILE <filename> // Close file
EOF(<filename>) // function to test for the end of the file
- write program code for simple file handling of a text file, consisting of several lines of text

2.3 Programming

Candidates should be able to:

2.3.1 Programming basics

- write a program in a high-level language (The nature of the language should be procedural and will be chosen by the centre from the following: Python, Visual Basic (console mode), Pascal/Delphi (console mode))
- implement and write a program from a given design presented as either a program flowchart or pseudocode
- write program statements for:
 - the declaration of variables and constants
 - the assignment of values to variables and constants
 - expressions involving any of the arithmetic or logical operators
 - input from the keyboard and output to the console

given pseudocode will use the following structures:

```
DECLARE <identifier> : <data type> // declaration
CONSTANT <identifier> = <value>
<identifier> ← <value> or <expression> // assignment
INPUT <identifier>
OUTPUT <string>
OUTPUT <identifier(s)>
```

2.3.2 Transferable skills

- recognise the basic control structures in a high-level language other than the one chosen to be studied in depth
- appreciate that program coding is a transferable skill

2.3.3 Selection

- use an 'IF' structure including the 'ELSE' clause and nested IF statements

- given pseudocode will use the following structure:

```
IF <condition>
  THEN
    <statement(s)>
  ENDIF
```

- or, including an 'else' clause:

```
IF <condition>
  THEN
    <statement(s)>
  ELSE
    <statement(s)>
  ENDIF
```

- use a 'CASE' structure

- given pseudocode will use the following structure:

```
CASE OF <identifier>
  <value 1>: <statement>
  <value 2>: <Statement>
  ...
ENDCASE
```

- alternatively:

```
CASE OF <identifier>
  <value 1>: <statement>
  <value 2>: <Statement>
  ...
  OTHERWISE <statement>
ENDCASE
```

2.3.4 Iteration

- use a 'count-controlled' loop:
 - given pseudocode will use the following structure:

```
FOR <identifier> ← <value1> TO <value2>
  <statement (s)>
ENDFOR
```
 - alternatively:

```
FOR <identifier> ← <value1> TO <value2> STEP <value3>
  <statement (s)>
ENDFOR
```
- use a 'post-condition' loop:
 - given pseudocode will use the following structure:

```
REPEAT
  <statement (s)>
UNTIL <condition>
```
- use a 'pre-condition' loop
 - given pseudocode will use the following structure:

```
WHILE <condition>
  <statement (s)>
ENDWHILE
```
- justify why one loop structure may be better suited to a problem than the others

2.3.5 Built-in functions

- use a subset of the built-in functions and library routines supported by the chosen programming language. This should include those used for:
 - string/character manipulation
 - formatting of numbers
 - random number generator
- use the information provided in technical documentation describing functions/procedures

2.3.6 Structured programming

- use a procedure
- explain where in the construction of an algorithm it would be appropriate to use a procedure
 - given pseudocode will use the following structure for procedure definitions:

```
PROCEDURE <identifier>
  <statement(s)>
ENDPROCEDURE
```

- a procedure may have none, one or more parameters
- a parameter can be passed by reference or by value
- show understanding of passing parameters by reference

```
PROCEDURE <identifier> (BYREF <identifier>: <datatype>)
  <statement(s)>
ENDPROCEDURE
```

- show understanding of passing parameters by value

```
PROCEDURE <identifier> (BYVALUE <identifier>: <datatype>)
  <statement(s)>
ENDPROCEDURE
```

- a call is made to the procedure using `CALL <identifier> ()`

- use a function
- explain where in the construction of an algorithm it is appropriate to use a function
- use the terminology associated with procedures and functions: procedure/function header, procedure/function interface, parameter, argument, return value
 - given pseudocode will use the following structure for function definitions:

```
FUNCTION <identifier> RETURNS <data type> // function has no
                                         parameters
  <statement(s)>
ENDFUNCTION
```

```
FUNCTION <identifier> (<identifier>: <data type>)
RETURNS <data type> // function has one or more parameters
  <statement(s)>
ENDFUNCTION
```

- a function is used in an expression, for example
 - `x ← SQRT(n)`
 - `WHILE NOT EOF(<filename>)`
- write programs containing several components and showing good use of resources

2.4 Software development

Candidates should be able to:

2.4.1 Programming

- show understanding of the design, coding and testing stages in the program development cycle
- show understanding of how to write, translate, test and run a high-level language program
- describe features found in a typical Integrated Development Environment (IDE):
 - for coding, including context-sensitive prompts
 - for initial error detection, including dynamic syntax checks
 - for presentation, including prettyprint, expand and collapse code blocks
 - for debugging, including: single stepping, breakpoints, variables/expressions report window

2.4.2 Program testing

- show understanding of ways of exposing faults in programs and ways of avoiding faults
- locate and identify the different types of errors:
 - syntax errors
 - logic errors
 - run-time errors
- correct identified errors

2.4.3 Testing strategies

- choose suitable data for black-box testing
- choose suitable data for white-box testing
- understand the need for stub testing

Section 3 Advanced Theory

3.1 Data representation

Candidates should be able to:

3.1.1 User-defined data types

- show understanding of why user-defined types are necessary
- define and use non-composite types: enumerated, pointer
- define and use composite data types: set, record and class/object
- choose and design an appropriate user-defined data type for a given problem

3.1.2 File organisation and access

- show understanding of methods of file organisation: serial, sequential (using a key field) and random (using a record key)
- show understanding of methods of file access:
 - sequential access for serial and sequential files
 - direct access for sequential and random files
- select an appropriate method of file organisation and file access for a given problem

3.1.3 Real numbers and normalised floating-point representation

- describe the format of binary floating-point real numbers
- convert binary floating-point real numbers into denary and vice versa
- normalise floating-point numbers
- show understanding of the reasons for normalisation
- show understanding of the effects of changing the allocation of bits to mantissa and exponent in a floating-point representation
- show understanding of how underflow and overflow can occur
- show understanding of the consequences of a binary representation only being an approximation to the real number it represents (in certain cases)
- show understanding that binary representations can give rise to rounding errors

3.2 Communication and Internet technologies

Candidates should be able to:

3.2.1 Protocols

- show understanding of why a protocol is essential for communication between computers
- show understanding of how protocol implementation can be viewed as a stack, where each layer has its own functionality
- show understanding of the function of each layer of the TCP/IP protocol suite
- show understanding of the application of the TCP/IP protocol suite when a message is sent from one host to another on the Internet
- show understanding of how the BitTorrent protocol provides peer-to-peer file sharing
- show an awareness of other protocols (HTTP, FTP, POP3, SMTP) and their purposes

3.2.2 Circuit switching, packet switching and routers

- show understanding of circuit switching and where it is applicable
- show understanding of packet switching
- show understanding of the function of a router in packet switching
- explain how packet switching is used to pass messages across a network, including the Internet

3.2.3 Local Area Networks (LAN)

- show understanding of a bus topology network and the implications of how packets are transmitted between two hosts
- show understanding of a star topology network and the implications of how packets are transmitted between two hosts
- show understanding of a wireless network
- explain how hardware is used to support a LAN: switch, router, servers, Network Interface Cards (NICs), wireless access points
- show understanding of Ethernet and how collision detection and avoidance (such as CSMA/CD) works

3.3 Hardware

Candidates should be able to:

3.3.1 Logic gates and circuit design

- produce truth tables for common logic circuits including half adders and full adders
- derive a truth table for a given logic circuit

3.3.2 Boolean algebra

- show understanding of Boolean algebra
- show understanding of De Morgan's Laws
- perform Boolean algebra using De Morgan's Laws
- simplify a logic circuit/expression using Boolean algebra

3.3.3 Karnaugh Maps

- show understanding of Karnaugh Maps
- show understanding of the benefits of using Karnaugh Maps
- solve logic problems using Karnaugh Maps

3.3.4 Flip-flops

- show understanding of how to construct a flip-flop (SR and JK)
- describe the role of flip-flops as data storage elements

3.3.5 RISC processors

- show understanding of the differences between RISC and CISC processors
- show understanding of the importance/use of pipelining and registers in RISC processors
- show understanding of interrupt handling on CISC and RISC processors

3.3.6 Parallel processing

- show awareness of the four basic computer architectures: SISD, SIMD, MISD, MIMD
- show awareness of the characteristics of massively parallel computers

3.4 System software

Candidates should be able to:

3.4.1 Purposes of an operating system (OS)

- show understanding of how an OS can maximise the use of resources
- describe the ways in which the user interface hides the complexities of the hardware from the user
- show understanding of processor management: multitasking, including:
 - the concept of multitasking and a process
 - the process states: running, ready and blocked
 - the need for scheduling
 - the concept of an interrupt
 - how the kernel of the OS acts as the interrupt handler and how interrupt handling is used to manage low-level scheduling
- show understanding of paging for memory management: including:
 - the concepts of paging and virtual memory
 - the need for paging
 - how pages can be replaced
 - how disk thrashing can occur

3.4.2 Virtual machine

- show understanding of the concept of a virtual machine
- give examples of the role of virtual machines
- show understanding of the benefits and limitations of virtual machines

3.4.3 Translation software

- show understanding of how an interpreter can execute programs without producing a translated version
- show understanding of the various stages in the compilation of a program: lexical analysis, syntax analysis, code generation and optimisation
- show understanding of how the grammar of a language can be expressed using syntax diagrams or Backus-Naur Form (BNF) notation
- show understanding of how Reverse Polish Notation (RPN) can be used to carry out the evaluation of expressions

3.5 Security

Candidates should be able to:

3.5.1 Asymmetric keys and encryption methods

- show understanding of the terms: public key, private key, plain text, cipher text, encryption and asymmetric key cryptography
- show understanding of how the keys can be used to send a private message from the public to an individual/organisation
- show understanding of how the keys can be used to send a verified message to the public

3.5.2 Digital signatures and digital certificates

- show understanding of how a digital certificate is acquired
- show understanding of how a digital certificate is used to produce digital signatures

3.5.3 Encryption protocols

- show awareness of the purpose of Secure Socket Layer (SSL)/Transport Layer Security (TLS)
- show awareness of the use of SSL/TLS in client-server communication
- show awareness of situations where the use of SSL/TLS would be appropriate

3.5.4 Malware

- show understanding of malware: viruses, spyware, worms, phishing, pharming
- describe vulnerabilities that the various types of malware can exploit
- describe methods that can be used to restrict the effect of malware

3.6 Monitoring and control systems

Candidates should be able to:

3.6.1 Overview of monitoring and control systems

- show understanding of the difference between a monitoring system and a control system
- show understanding of sensors and actuators and their usage
- show understanding of the additional hardware required to build these systems
- show understanding of the software requirements of these systems
- show understanding of the importance of feedback in a control system

3.6.2 Bit manipulation to monitor and control devices

- show understanding of how bit manipulation can be used to monitor/control a device
- carry out bit manipulation operations: test a bit and set a bit (using bit masking) using the instructions from Section 1.4.3 and those listed below
- show understanding of how to make use of appropriate bit manipulation in monitoring systems and control systems

Instruction			Explanation
Label	Op Code	Operand	
	AND	#n	Bitwise AND operation of the contents of ACC with the operand
	AND	<address>	Bitwise AND operation of the contents of ACC with the contents of <address>
	XOR	#n	Bitwise XOR operation of the contents of ACC with the operand
	XOR	<address>	Bitwise XOR operation of the contents of ACC with the contents of <address>
	OR	#n	Bitwise OR operation of the contents of ACC with the operand
	OR	<address>	Bitwise OR operation of the contents of ACC with the contents of <address> <address> can be an absolute address or a symbolic address
	LSL	#n	Bits in ACC are shifted n places to the left. Zeros are introduced on the right hand end
	LSR	#n	Bits in ACC are shifted n places to the right. Zeros are introduced on the left hand end
<label>:	<op code>	<operand>	labels an instruction
<label>:		<data>	gives a symbolic address <label> to the memory location with contents <data>

Section 4 Further Problem-solving and Programming Skills

4.1 Computational thinking and problem-solving

Candidates should be able to:

4.1.1 Abstraction

- show understanding of how to model a complex system by only including essential details, using:
 - functions and procedures with suitable parameters (as in procedural programming, see Section 2.3)
 - ADTs (see Section 4.1.3)
 - classes (as used in object-oriented programming, see Section 4.3.1)
 - facts, rules (as in declarative programming, see Section 4.3.1)

4.1.2 Algorithms

- write a binary search algorithm to solve a particular problem
- show understanding of the conditions necessary for the use of a binary search
- show understanding of how the performance of a binary search varies according to the number of data items
- write an algorithm to implement an insertion sort
- write an algorithm to implement a bubble sort
- show understanding that performance of a sort routine may depend on the initial order of the data and the number of data items
- write algorithms to find an item in each of the following: linked list, binary tree, hash table
- write algorithms to insert an item into each of the following: stack, queue, linked list, binary tree, hash table
- write algorithms to delete an item from each of the following: stack, queue, linked list
- show understanding that different algorithms which perform the same task can be compared by using criteria such as time taken to complete the task and memory used

4.1.3 Abstract Data Types (ADT)

- show understanding that an ADT is a collection of data and a set of operations on those data
- show understanding that data structures not available as built-in types in a particular programming language need to be constructed from those data structures which are built-in within the language

```
TYPE <identifier1>  
    DECLARE <identifier2> : <data type>  
    DECLARE <identifier3> : <data type>  
    ...  
ENDTYPE
```

- show how it is possible for ADTs to be implemented from another ADT
- describe the following ADTs and demonstrate how they can be implemented from appropriate built-in types or other ADTs: stack, queue, linked list, dictionary, binary tree

4.1.4 Recursion

- show understanding of the essential features of recursion
- show understanding of how recursion is expressed in a programming language
- trace recursive algorithms
- write recursive algorithms
- show understanding of when the use of recursion is beneficial
- show awareness of what a compiler has to do to implement recursion in a programming language

4.2 Algorithm design methods

Candidates should be able to:

4.2.1 Decision tables

- describe the purpose of a decision table
- construct a decision table for a given problem with a maximum of three conditions
- simplify a decision table by removing redundancies

4.2.2 Jackson Structured Programming (JSP)

- construct a JSP structure diagram showing repetition
- construct a JSP structure diagram showing selection
- write equivalent pseudocode from such structure charts
- construct a JSP structure diagram to describe a data structure
- construct a JSP data structure diagram:
 - using sequence
 - using selection
 - using iteration
- construct a JSP diagram for a program design

4.2.3 State-transition diagrams

- use state-transition diagrams to document an algorithm
- use state-transition diagrams to show the behaviour of an object

4.3 Further programming

Candidates should already have practical experience of the content in Section 2.3 Programming. Candidates should be able to:

4.3.1 Programming paradigms

- show understanding of what is meant by a programming paradigm
- show understanding of the characteristics of a number of programming paradigms (low-level, imperative (procedural), object-oriented, declarative)
 - low-level programming
 - demonstrate an ability to write low-level code that uses various address modes: immediate, direct, indirect, indexed and relative (see Section 1.4.3 and Section 3.6.2)
 - imperative programming
 - see details in Section 2.3 (procedural programming)
 - object-oriented programming (OOP)
 - demonstrate an ability to solve a problem by designing appropriate classes
 - demonstrate an ability to write code that demonstrates the use of classes, inheritance, polymorphism and containment (aggregation)
 - declarative programming
 - demonstrate an ability to solve a problem by writing appropriate facts and rules based on supplied information
 - demonstrate an ability to write code that can satisfy a goal using facts and rules

4.3.2 File processing (see also Section 2.2.3)

- write code to define a record structure
- write code to perform file-processing operations: open or close a file; read or write a record to a file
- use pseudocode for random file handling:

```
OPENFILE <filename> FOR RANDOM
SEEK <filename>, <address> // move a pointer to the disk address for the record
GETRECORD <filename>, <identifier>
PUTRECORD <filename>, <identifier>
```
- write code to perform file-processing operations on serial, sequential and random files

4.3.3 Exception handling

- show understanding of an exception and the importance of exception handling
- show understanding of when it is appropriate to use exception handling
- write code to use exception handling in practical programming

4.3.4 Use of development tools/programming environments

- describe features in editors that benefit programming
- know when to use compilers and interpreters
- describe facilities available in debuggers and how and when they should be deployed

4.4 Software development

Candidates should be able to:

4.4.1 Software development resources

- show understanding of the possible role of program generators and program libraries in the development process

4.4.2 Testing

- show awareness of why errors occur
- show understanding of how testing can expose possible errors
- appreciate the significance of testing throughout software development
- show understanding of the methods of testing available: dry run, walkthrough, white-box, black-box, integration, alpha, beta, acceptance
- show understanding of the need for a test strategy and test plan and their likely contents
- choose appropriate test data (normal, abnormal and extreme/boundary) for a test plan

4.4.3 Project management

- show understanding that large developments will involve teams
- show understanding of the need for project management
- show understanding of project planning techniques including the use of GANTT and Program Evaluation Review Technique (PERT) charts
- describe the information that GANTT and PERT charts provide
- construct and edit GANTT and PERT charts

5 Description of components

5.1 Scheme of assessment

Each examination paper will consist of a variable number of short-answer and structured questions of variable mark value. Candidates must answer all questions. Candidates will answer on the question paper.

Calculators are **not** allowed in these papers.

Paper 1 Theory Fundamentals

This is a compulsory paper consisting of questions set on Section 1 of the syllabus.

Paper 2 Fundamental Problem-solving and Programming Skills

This is a compulsory paper consisting of questions set on Section 2 of the syllabus.

Paper 3 Advanced Theory

This is a compulsory paper consisting of questions set on Section 3 of the syllabus.

Paper 4 Further Problem-solving and Programming Skills

This is a compulsory paper consisting of questions set on Section 4 of the syllabus.

The assessment is by written papers, but the learning should be done in a mainly practical way: problem-solving and programming. Questions will require the candidate to think, use knowledge with understanding and demonstrate understanding gained through practising practical skills.

5.2 Paper 2 and Paper 4 Problem-solving and Programming Skills pre-release material

The pre-release material for Paper 2 and Paper 4 will be made available to centres the January before the June examination and the July before the November examination. Centres are advised to encourage their candidates to develop solutions to tasks using a high-level programming language. Centres must choose a high-level programming language from this list: Visual Basic (console mode), Pascal/Delphi (console mode) or Python. The purpose of the pre-release material tasks is to direct candidates to some of the topics which will be examined in Paper 2 and Paper 4. Teachers are expected to incorporate these tasks into their lessons and give support in finding methods and reaching solutions. Questions will be included that test candidates' understanding gained from developing programmed solutions to these tasks. The tasks will be appropriate for all ability levels.

The examination questions will require candidates to have practical programming experience, including writing their own programs, executing (running), testing and debugging them. Candidates are to be encouraged to extend their practical programming beyond the scope of these tasks. It is appreciated that in an examination, candidates will not have access to a compiler, interpreter or any other aid to writing correct syntax. Therefore, minor syntax errors in candidates' programs will be ignored.

6 Notes for the guidance of teachers

Introduction

The purpose of these notes is to provide assistance for teachers preparing candidates for the Cambridge AS and A Level Computer Science examination. They contain notes on equipment, facilities and resources and sources of further information.

Equipment and facilities

Computer science is a practical subject and the Cambridge AS and A Level syllabus places emphasis on the use of procedural high-level programming languages. Centres must ensure that their equipment and facilities are adequate for candidates to be able to satisfy the requirements of the syllabus. The hardware facilities needed will depend on the number of candidates, but should be sufficient for all candidates to have enough time to practise their programming skills.

Hardware

Candidates need to have access to a system with direct-access file capability on backing store and hardcopy facilities.

Software

Candidates should have experience of using a high-level programming language (Pascal/Delphi, Visual Basic or Python), chosen by the centre.

Books

Provision of textbooks is difficult as new titles are available all the time. The British Computer Society (BCS) book list for schools and colleges lists books which are suitable for use as reference books. Teachers will need to consult several books to cover the whole syllabus adequately. There is a suggested book list on our website. Many schools prefer to have a wide range of reference books rather than a class textbook.

Practical skills

Computing is a practical subject and a range of practical exercises should supplement the study of most parts of the syllabus.

It is important that centres encourage candidates, as early as possible in the course, to develop a systematic approach to practical problem-solving using appropriate resources.

7 Other information

Equality and inclusion

We have taken great care in the preparation of this syllabus and related assessment materials to avoid bias of any kind. To comply with the UK Equality Act (2010), we have designed this qualification with the aim of avoiding direct and indirect discrimination.

The standard assessment arrangements may present unnecessary barriers for candidates with disabilities or learning difficulties. Arrangements can be put in place for these candidates to enable them to access the assessments and receive recognition of their attainment. Access arrangements will not be agreed if they give candidates an unfair advantage over others or if they compromise the standards being assessed. Candidates who are unable to access the assessment of any component may be eligible to receive an award based on the parts of the assessment they have taken.

Information on access arrangements is in the *Cambridge Handbook* at www.cambridgeinternational.org/examsOfficers

Language

This syllabus and the associated assessment materials are available in English only.

Making entries

Exams officers are responsible for submitting entries to Cambridge International. We encourage them to work closely with you to make sure they enter the right number of candidates for the right combination of syllabus components. Entry option codes and instructions for submitting entries are in the *Cambridge Guide to Making Entries*. Your exams officer has a copy of this guide.

Estimated entries

You **must** make estimated entries for this syllabus. This will enable us to send you early question papers and pre-release materials, and ensure you have the necessary materials to carry out assessments at the specified time.

Further information about making estimated entries can be found in the *Cambridge Handbook* for the relevant year at www.cambridgeinternational.org/examsOfficers

Exam administration

To keep our exams secure, we produce question papers for different areas of the world, known as administrative zones. We allocate all Cambridge schools to one administrative zone determined by their location. Each zone has a specific timetable. Some of our syllabuses offer candidates different assessment options. An entry option code is used to identify the components the candidate will take relevant to the administrative zone and the available assessment options.

Grading and reporting

Cambridge International A Level results are shown by one of the grades A*, A, B, C, D or E, indicating the standard achieved, A* being the highest and E the lowest. 'Ungraded' indicates that the candidate's performance fell short of the standard required for grade E. 'Ungraded' will be reported on the statement of results but not on the certificate. The letters Q (result pending), X (no result) and Y (to be issued) may also appear on the statement of results but not on the certificate.

Cambridge International AS Level results are shown by one of the grades a, b, c, d or e, indicating the standard achieved, 'a' being the highest and 'e' the lowest. 'Ungraded' indicates that the candidate's performance fell short of the standard required for grade 'e'. 'Ungraded' will be reported on the statement of results but not on the certificate. The letters Q (result pending), X (no result) and Y (to be issued) may also appear on the statement of results but not on the certificate.

If a candidate takes a Cambridge International A Level and fails to achieve grade E or higher, a Cambridge International AS Level grade will be awarded if both of the following apply:

- the components taken for the Cambridge International A Level by the candidate in that series included all the components making up a Cambridge International AS Level
- the candidate's performance on the AS Level components was sufficient to merit the award of a Cambridge International AS Level grade.

How students, teachers and higher education can use the grades

Cambridge International A Level

Assessment at Cambridge International A Level has two purposes:

- to measure learning and achievement
The assessment:
 - confirms achievement and performance in relation to the knowledge, understanding and skills specified in the syllabus, to the levels described in the grade descriptions.
- to show likely future success
The outcomes:
 - help predict which students are well prepared for a particular course or career and/or which students are more likely to be successful
 - help students choose the most suitable course or career.

Cambridge International AS Level

Assessment at Cambridge International AS Level has two purposes:

- to measure learning and achievement
The assessment:
 - confirms achievement and performance in relation to the knowledge, understanding and skills specified in the syllabus.
- to show likely future success
The outcomes:
 - help predict which students are well prepared for a particular course or career and/or which students are more likely to be successful
 - help students choose the most suitable course or career
 - help decide whether students part way through a Cambridge International A Level course are making enough progress to continue
 - guide teaching and learning in the next stages of the Cambridge International A Level course.

'While studying Cambridge IGCSE and Cambridge International A Levels, students broaden their horizons through a global perspective and develop a lasting passion for learning.'

Zhai Xiaoning, Deputy Principal, The High School Affiliated to Renmin University of China

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