MY REVISION NOTES

HODDER EDUCATION

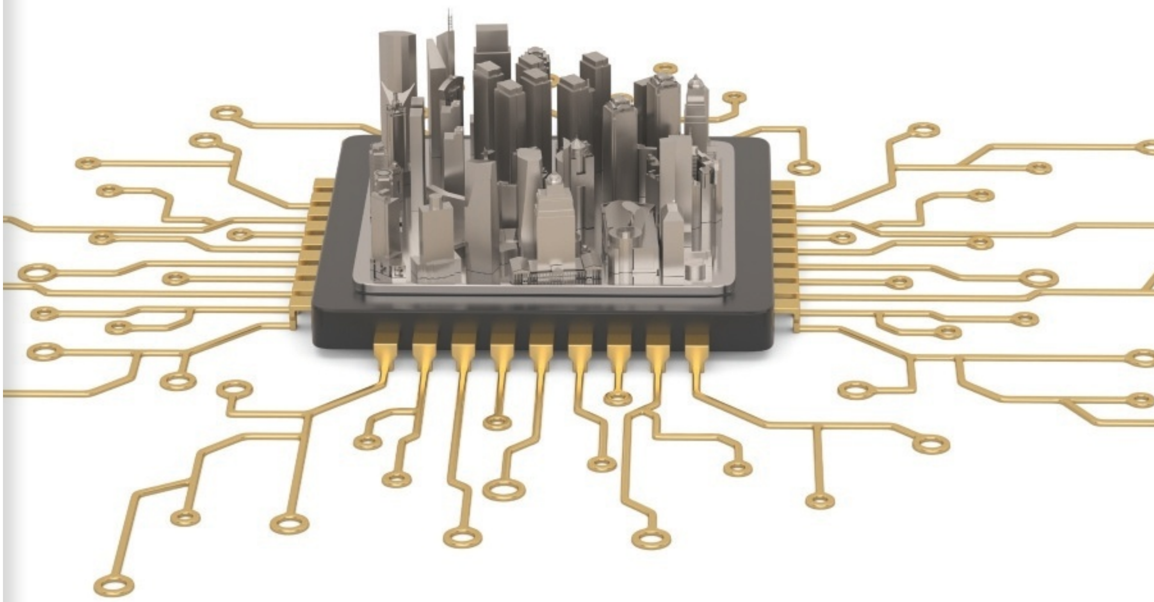
OCR

A Level

COMPUTER SCIENCE

SECOND EDITION

- Plan and organise your revision
- Reinforce skills and understanding
- Practise exam-style questions



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George Rouse

Boost

HODDER EDUCATION
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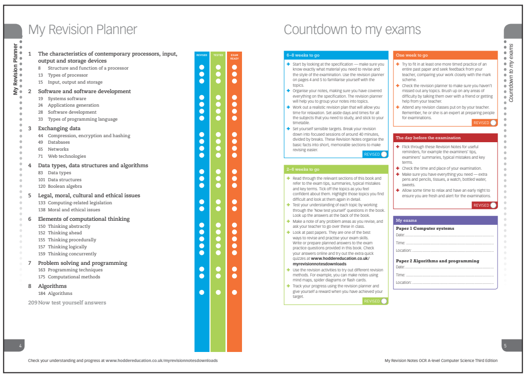
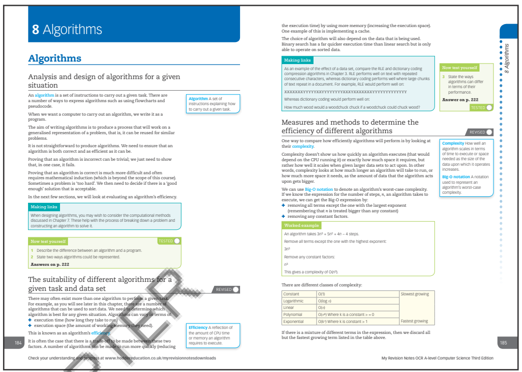
Get the most from this book

Everyone has to decide his or her own revision strategy, but it is essential to review your work, learn it and test your understanding. These Revision Notes will help you to do that in a planned way, topic by topic. Use this book as the cornerstone of your revision and don't hesitate to write in it — personalise your notes and check your progress by ticking off each section as you revise.





Tick to track your progress

Use the revision planner on pages 4 and 5 to plan your revision, topic by topic. Tick each box when you have:

- revised and understood a topic
- tested yourself
- practised the exam questions and gone online to check your answers and complete the quick quizzes

You can also keep track of your revision by ticking off each topic heading in the book. You may find it helpful to add your own notes as you work through each topic.

Features to help you succeed

Exam tips

Expert tips are given throughout the book to help you polish your exam technique in order to maximise your chances in the exam.

Typical mistakes

The authors identify the typical mistakes candidates make and explain how you can avoid them.

Now test yourself

These short, knowledge-based questions provide the first step in testing your learning. Answers are at the back of the book.

Definitions and key words

Clear, concise definitions of essential key terms are provided where they first appear.

Key words from the specification are highlighted in bold throughout the book.

Making links

This feature identifies specific connections between topics and tells you how revising these will aid your exam answers.

Exam skills

These summaries highlight how to specific skills identified or applicable in that chapter can be applied to your exam answers.

Revision activities

These activities will help you to understand each topic in an interactive way.

Exam practice

Practice exam questions are provided for each topic. Use them to consolidate your revision and practise your exam skills.

Summaries

The summaries provide a quick-check bullet list for each topic.

Online

Go online to find answers to the exam practice questions and try out the extra quick quizzes at **www.hoddereducation.co.uk/myrevisionnotesdownloads**

My Revision Planner

	REVISED	TESTED	EXAM READY

Countdown to my exams

6–8 weeks to go

- Start by looking at the specification — make sure you know exactly what material you need to revise and the style of the examination. Use the revision planner on pages 4 and 5 to familiarise yourself with the topics.
- Organise your notes, making sure you have covered everything on the specification. The revision planner will help you to group your notes into topics.
- Work out a realistic revision plan that will allow you time for relaxation. Set aside days and times for all the subjects that you need to study, and stick to your timetable.
- Set yourself sensible targets. Break your revision down into focused sessions of around 40 minutes, divided by breaks. These Revision Notes organise the basic facts into short, memorable sections to make revising easier.

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2–6 weeks to go

- Read through the relevant sections of this book and refer to the exam tips, summaries, typical mistakes and key terms. Tick off the topics as you feel confident about them. Highlight those topics you find difficult and look at them again in detail.
- Test your understanding of each topic by working through the 'Now test yourself' questions in the book. Look up the answers at the back of the book.
- Make a note of any problem areas as you revise, and ask your teacher to go over these in class.
- Look at past papers. They are one of the best ways to revise and practise your exam skills. Write or prepare planned answers to the exam practice questions provided in this book. Check your answers online and try out the extra quick quizzes at **www.hoddereducation.co.uk/myrevisionnotesdownloads**
- Use the revision activities to try out different revision methods. For example, you can make notes using mind maps, spider diagrams or flash cards.
- Track your progress using the revision planner and give yourself a reward when you have achieved your target.

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One week to go

- Try to fit in at least one more timed practice of an entire past paper and seek feedback from your teacher, comparing your work closely with the mark scheme.
- Check the revision planner to make sure you haven't missed out any topics. Brush up on any areas of difficulty by talking them over with a friend or getting help from your teacher.
- Attend any revision classes put on by your teacher. Remember, he or she is an expert at preparing people for examinations.

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The day before the examination

- Flick through these Revision Notes for useful reminders, for example the examiners' tips, examiners' summaries, typical mistakes and key terms.
- Check the time and place of your examination.
- Make sure you have everything you need — extra pens and pencils, tissues, a watch, bottled water, sweets.
- Allow some time to relax and have an early night to ensure you are fresh and alert for the examinations.

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My exams

Paper 1 Computer systems

Date: ....

Time: ....

Location: ....

Paper 2 Algorithms and programming

Date: ....

Time: ....

Location: ....

1 The characteristics of contemporary processors, input, output and storage devices

Structure and function of a processor

The central processing unit (CPU) carries out the instructions in computer programs. Essentially it's what makes a computer a computer! Inside a processor there are billions of transistors (effectively electronic switches). This section looks at how CPUs work and different developments in CPU technology.

Central processing unit (CPU) The central processing unit 'runs programs' by continually fetching, decoding and executing instructions.

The arithmetic logic unit, control unit and registers

REVISED

The main components of the CPU are the arithmetic logic unit, control unit and registers. These are connected to the system's main memory using pathways called buses.

Arithmetic logic unit

The arithmetic logic unit (ALU) carries out the calculations and logical decisions. The results of its calculations are stored in the accumulator.

Control unit

The control unit (CU) sends out signals to co-ordinate how the processor works. It controls how data moves around parts of the CPU and how it moves between the CPU and memory. Instructions are decoded in the control unit.

Registers

Registers are areas of memory within the processor itself. They can be accessed at extremely fast speeds so can be used by the processor without causing a bottleneck. Registers in the processor that have a specific use are called special purpose registers.

Register A discrete piece of memory built onto the CPU that holds a single piece of data.

The special purpose registers you need to know are listed below.

Register	Purpose
Program counter (PC)	Keeps track of the memory location of the line of machine code being executed. With each iteration of the fetch–decode–execute cycle, it gets incremented to point to the next instruction, allowing the program to be executed in sequence, instruction by instruction. The program counter can also be changed by instructions that alter the flow of control (for example, branch like BRA, BRP and BRZ)
Memory data register (MDR)	Stores the data or instructions that are to be fetched from or sent to memory
Memory address register (MAR)	Stores the address of the data or instructions that are to be fetched from or sent to memory
Current instruction register (CIR)	Stores the most recently fetched instruction, which will be decoded and executed
Accumulator (ACC)	Stores the results of calculations made by the ALU

Processors may also have general purpose registers. These can temporarily store data being used rather than sending data to and from memory. (Memory data access times are slow compared to special purpose registers but still much faster than secondary storage.)

Buses

Buses are the communication channels through which data can be sent around the computer. You need to know about three buses:

1. The **data bus** carries data between the processor and memory.
2. The **address bus** carries the address of the memory location being read from or written to.
3. The **control bus** sends control signals from the control unit.

Exam tip

A common mistake is to talk about the control bus carrying *instructions* around the processor. This is not the case. Instructions are sent to and from memory via the data bus. The control bus carries the *signals* orchestrating the fetch–decode–execute signal.

Now test yourself TESTED

1. Describe the purpose of the control unit.
2. State the names of the three buses used by the CPU.
3. State the name of the part of the CPU responsible for calculations.

Answers on p. 209

The fetch–decode–execute cycle, including its effects on registers

REVISED

Making links

In order to fully understand this section you need to know about the Little Man Computer instruction set. You should revisit this section after studying Chapter 2, Assembly language.

The processor works by continually fetching, decoding then executing instructions. You need to be aware of how the registers are used during the process.

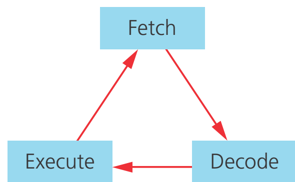

Figure 1.1 Fetch–decode–execute cycle

Fetch

1. The contents of the PC are copied to the MAR.
2. The read signal is sent across the control bus and the contents of the MAR are sent across the address bus.
3. The contents of the memory location stored in the MAR are then sent across the data bus and stored in the MDR.
4. The contents of the MDR are then copied to the CIR.
5. The PC is incremented by one.

Decode

6. The contents of the CIR are sent to the control unit.
7. The control unit then decodes the instruction.

Execute

8. The registers can be changed in different ways during the execution phase, depending on the instruction.

   For instance, if the instruction is for a memory location to be read from or written to (that is, LDA or STA), then the address stored within the instruction will be loaded into the MAR. In the case of STA, the data stored in the ACC is sent to memory. In the case of LDA, the data is loaded from memory into the ACC.

   If the instruction is to carry out a calculation (that is, ADD or SUB) then the contents of the MDR and ACC are sent to the ALU and the result sent back to the ACC.

Now test yourself TESTED

4 Give an example of when the contents of the ACC might be changed.
5 State the name of the bus that carries the contents of memory to the MDR.
6 Explain why the PC is incremented by 1 in each cycle.

Answers on p. 209

The factors affecting the performance of the CPU

REVISED

- clock speed
- number of cores
- amount of cache memory
- use of pipelining.

Clock speed

Processors work at incredible speeds, dictated by the clock signal. The speed of this signal, known as the clock speed, is measured in hertz (Hz).

Unit	Pulses per second
1 Hertz (Hz)	1
1 Kilohertz (kHz)	1000
1 Megahertz (MHz)	1000000
1 Gigahertz (GHz)	1000000000

Modern desktop processors tend run in the order of Gigahertz. The processor on the computer being used to write this chapter runs at a speed of 2.8GHz. That means its processor has a clock producing 2.8 billion pulses per second.

Number of cores

A core is a processing unit within the CPU. Modern CPUs have multiple cores that can operate independently.

- Each core is a distinct processing unit on the CPU that can run independently.
- When multitasking, different cores can run different applications.
- It is also possible for multiple cores to work on the same problem.
- The more cores you have, the easier it is to run more things simultaneously. More cores also mean that tasks that can have their work shared will run more quickly.

Core A core is a processing unit within the CPU.

Cache memory A fast memory that is built on or close to the CPU and is designed to reduce the need to access RAM, which has slower access speeds.

Cache

Random access memory's (RAM's) access speed is significantly slower than the speed at which the CPU operates. To compensate for this, processors have a small amount of fast memory called cache memory:

- Cache memory is a temporary store.
- Cache memory is built into the processor itself, reducing the distance data has to travel to it. Data and instructions that are likely to be regularly accessed are kept in cache memory, ready for fast access.
- By allowing the processor to access cache, the overall speed at which it operates is less likely to be limited by RAM's access speed.
- Because cache memory is faster when it is smaller, different levels of cache are used.
- Level one cache is the smallest and built directly into the CPU. Often each core will have its own level one cache.
- Each subsequent cache level is larger and further away from the heart of the CPU and is therefore slower to access.
- Modern CPUs tend to have three or four levels of cache.

Making links

Having a cache is a common concept in computing, and isn't just used in the CPU. Web browsers cache files on your computer to avoid them having to be repeatedly downloaded. You can find out more about caches in Chapter 6.

The use of pipelining in a processor to improve efficiency

REVISED

The processor works by repeatedly fetching, decoding and executing instructions. If it does this one instruction at a time, then parts of the processor are potentially left sitting idle. To overcome this, using **pipelining** in the CPU means that different parts of the CPU performing different parts of the fetch–decode–execute cycle on a sequence of instructions. While one instruction is being executed, the next can be decoded and the one after that fetched.

Pipelining When discussing a CPU, it means different parts of the CPU performing different parts of the fetch–decode–execute cycle on a sequence of instructions.

	Fetch	Decode	Execute
Step 1	Instruction 1		
Step 2	Instruction 2	Instruction 1	
Step 3	Instruction 3	Instruction 2	Instruction 1
Step 4	Instruction 4	Instruction 3	Instruction 2

This works as long as subsequent instructions can be predicted. This isn't always the case. For example, if there is a branch instruction, the CPU may not be able to tell it should fetch the instruction immediately after it, or needs to jump to a different part of the program until it is time to execute the branch instruction. If the wrong instruction is chosen to be fetched in advance, it has to be thrown away and the correct one fetched.

Making links

Pipelining can be seen as a more general process, not just specific to the CPU. You can read about how pipelining can be applied to other problems when looking at computational methods in Chapter 7.

Now test yourself

TESTED

7 Explain why CPUs have cache memory.
8 Explain how pipelining improves the performance of a processor.
9 Describe a situation in which more cores will improve the performance of a CPU.

Answers on p. 209

Von Neumann, Harvard and contemporary processor architecture

REVISED

A computer's **architecture** is the approach taken to its design. Computers with the same architecture aren't necessarily identical but will follow a specific design philosophy.

Architecture When discussing computers, this refers to the approach taken in a computer's design.

Von Neumann architecture

The Von Neumann architecture has:

- a single control unit
- a single arithmetic logic unit
- a single memory store that contains *both instructions and data*.

Storing data and instructions in the same memory unit and having them travel along the same bus can hold things up.

If an instruction is being read, then because memory and the data bus are in use, it is not possible to read and write data at the same time.

Harvard architecture

Harvard architecture differs from Von Neumann in that it has separate memory units and buses for data and instructions and therefore doesn't suffer from the restriction of having a single memory store.

Contemporary processors

While modern processors have many of the features of the model described at the start of the chapter, in practice, they are many times more complex. Over time, processor designers have come up with many ideas to improve performance and efficiency. A number are described below but there are many more, with new ones being developed all the time.

Simultaneous multithreading

- A 'thread' is the sequence of instructions that have been sent to the CPU to be processed.
- Simultaneous multithreading allows two threads to run on each core at one time.
- The core is designed so that the part of it that fetches and decodes, the 'front end', is duplicated. This means that it is capable of fetching and decoding two threads at once.
- As the execution part of the core is not continuously being used, it can switch between the two threads.
- It should be noted that while simultaneous multithreading will improve performance, two cores that are not multithreading will outperform one similar core with two threads.

Out of order execution

- In the model you have studied, each instruction is fetched, decoded then executed.
- In reality, some instructions may take longer than others to execute, leaving other parts of the CPU idle.
- Out of order execution allows instructions to be executed ahead of when they usually would be if the required resources are available, preventing delays. This requires the CPU to check that the instruction to be executed out of order isn't dependent on data yet to be processed.

Branch prediction

- We have seen that one issue with pipelining is that the pipeline has to be cleared if the prediction is wrong, costing time.
- Modern CPUs use branch prediction to try and work out where a program will go at a decision point. This reduces how often the pipeline has to be cleared, improving overall speed of execution.

Variable clock speed

- Modern processors are able to change their clock speeds. They may temporarily be able to increase it during intensive tasks to give a performance boost
- There is, however, a limit as to how long this can be done for before overheating means it has to return to its normal speed.
- Some CPUs can also reduce their clock speed to reduce power consumption and extend battery life in portable devices.

Power conservation

As well as adjusting clock speed to conserve power, modern CPUs are able to shut off parts of their circuitry that aren't being used at a given point in time. This might, for example, be parts dedicated to video processing. All this helps to reduce power consumption.

Exam tip

You may come across the term Hyper-Threading. This is the processor manufacturer Intel's proprietary name for their version of simultaneous multithreading. In an exam you should always give generic and not proprietary names. Therefore always use the term simultaneous multithreading not Hyper-Threading.

Now test yourself TESTED

10 Describe one difference between the Von Neumann and Harvard architectures.

11 Give one example of a feature a contemporary processor might have.

Answers on p. 209

Exam practice

1. Explain why smartphones use flash memory. [2]
2. Describe the purpose of the address bus. [1]
3. Give two differences between RISC and CISC processors. [2]
4. Describe the Von Neumann architecture. [2]
5. Explain what is meant by a GPU. [2]
6. State two output devices a programmer might have, justifying your choices. [4]
7. Discuss the differences between a CPU in a smartwatch and one in a PC designed for gaming. [9]

Answers available online

MY **REVISION** NOTES

OCR A Level

COMPUTER SCIENCE

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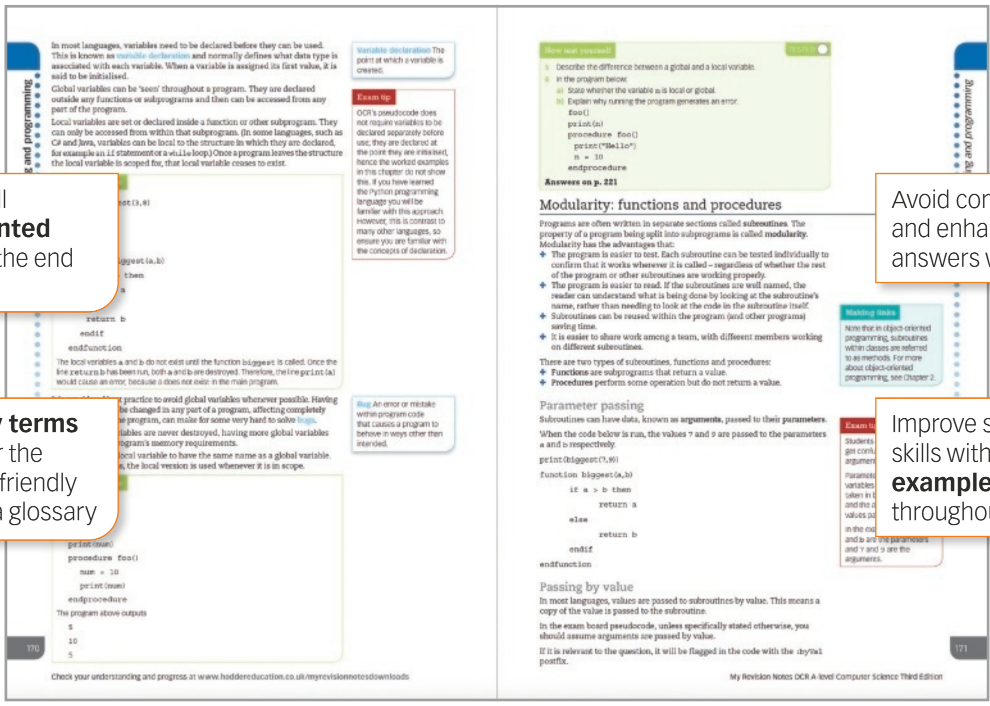

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Improve subject-specific skills with '**worked example**' boxes throughout

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