Murphy Resources

AQA GCSE 9-1 COMPUTER SCIENCE *REVISION GUIDE*

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Acknowledgments

Thanks to The Open University, with whom I am studying with, for their fantastic distance learning degrees.

Thanks to Amazon for the opportunity to sell this resource

Thanks to Kelly & Emma for inspiration to teach (You also make nice tea!)

Thanks to you for purchasing this resource via Amazon ☺

More Information

Individual sources can be found on the corresponding page in the notes section

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MORE INFORMATION

Active Content

- Whenever you see this symbol on a slide, it means there is active content on the page
- Active content consists of a series of animations of on-screen objects which you can activate using the right arrow key or clicking on a blank space – the sequence may require multiple clicks
- These have been created to help you understand various topics that may otherwise be difficult to explain in writing – e.g. Sort Algorithms
- They may also be used to add information on-screen that otherwise would not fit on

Videos

- Videos have been included in this resource to enable you to gain a better understanding of the topic
- You need to click on the play button on the video to watch it – you will also need a method of listening to the video's sound
- Videos increase the size of this file, so to reduce this file size simply delete the videos

WHAT IS COMPUTER SCIENCE? & WHAT HAPPENED TO ICT?

- As you may already know, the government is no longer accrediting or approving ICT GCSEs or A Levels and have instructed the exam boards to offer Computer Science only.
  - But what is the difference?
- Let's imagine ICT is like driving a car, and Computer Science is building a car…
- Many people drive cars without paying any interest into how they work as such, and others like to build and modify cars as a hobby or job
- Now that technology is introduced to us at such an early age, we are expected to know how to operate technology in the same way as we would know how to drive a car if we had practice from a young age
- With Computer Science, not only do you learn about the technology behind the systems we use each day, but you learn how to think in a computational way which is a transferable skill into other subjects such as Mathematics, Science and ironically Engineering!
- Although you may not particularly enjoy or wish to study Computer Science, the skills and techniques you learn throughout the qualification are valuable, and you wouldn't gain these skills as much in an ICT course
- Computer Science is more of a hands on subject than the old ICT courses, and reduces repetitiveness of the skills you may learn earlier on in High School

Fact Early electronic computers, developed around the 1940's, were the size of a large room and consumed huge amounts of electricity. They were vastly different to the modern computers we use today, especially when compared to small and portable laptop computers.

TOPIC 1

FUNDAMENTALS OF ALGORITHMS

1.1

REPRESENTING ALGORITHMS

WHAT THE SPECIFICATION SAYS…

1.1 Content:

- Understand and explain the term algorithm.
- Understand and explain the term decomposition.
- Understand and explain the term abstraction.
- Use a systematic approach to problem solving and algorithm creation representing those algorithms using pseudo-code and flowcharts
- Explain simple algorithms in terms of their inputs, processing and outputs.
- Determine the purpose of simple algorithms.

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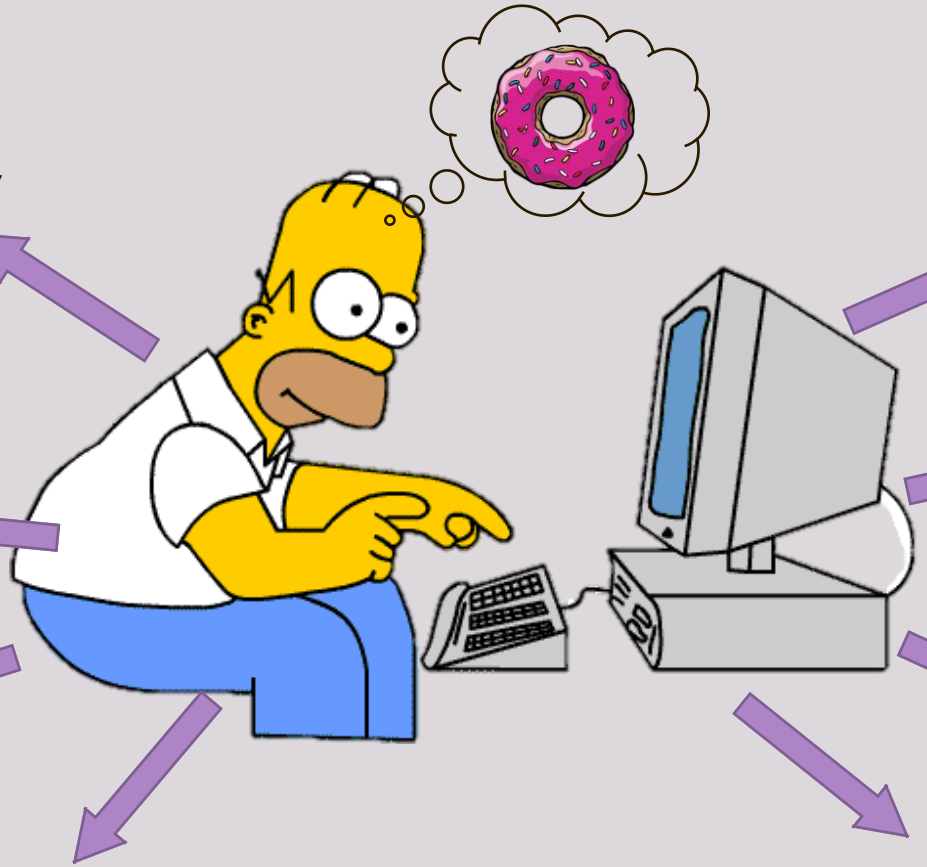
COMPUTERS VS. HUMANS



Human
Needs lunch breaks & may be lazy (Inefficient)

Human
May make mistakes… DOH!

Human
Won't perform repetitive tasks

Human
Skills may be limited or use different methods to others

Computer
Can perform tasks 24/7

Computer
Will not make mistakes (Providing programming is correct!)

Computer
Will perform repetitive tasks

Computer
Can solve difficult calculations efficiently

INTRODUCTION TO ALGORITHMS

- An algorithm is a set of instructions that instruct a computer system
- An algorithm will produce output data by following the instructions step-by-step
- Algorithms are used in day to day life by humans
  - For example following a cooking recipe
  - We would follow the recipe from start to finish
- It is important to know that algorithms are followed in order from start to finish by computer systems, unlike humans where our own judgment will vary the process
  - E.g. Using an alternative ingredient in cooking when the one in the recipe is not available
- A good algorithm will have pre-conditions which illustrate what resources are required to perform the instructions, in terms of processing power or additional files
- It should also have post-conditions that illustrate what the algorithm should have achieved and to check that the criteria (has been met) is true.

ALGORITHMS IN COMPUTER SYSTEMS

- Algorithms are also used in mathematics
  - For example solving a mathematical problem
  - We would follow a series of steps to produce an answer (output data)
  - If the order of steps was changes, the output may be incorrect
- Computer systems work in this way, without using substitution or judgment unless instructed to do so by the algorithm
- For this reason, algorithms can become complex due to every possibility requiring an instruction in order to ensure that output data is produced
- Once the algorithm is ready however, the computer system will be able to perform run it and perform the instructions in a fast and efficient way
- The computer system will also be able to perform the same algorithm on loop, or a string of multiple algorithms repetitively without becoming tired or making mistakes

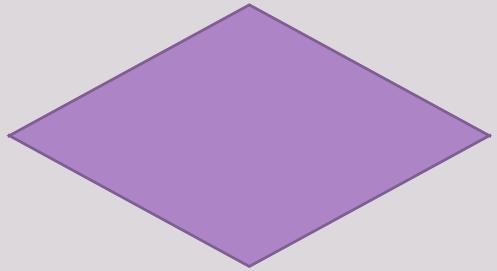
ALGORITHM CONSTRUCTION

- When creating an algorithm, you must consider the sequence of events that the you want the computer system to follow
- The computer system will follow all of these events or actions without skipping or pausing, unless instructed to do so
- You can use a decision or selection that acts as a question with two boolean outcomes
  - The question is known as the condition, and if the condition is TRUE then the sequence will continue with the TRUE or YES action
  - If the condition is FALSE, the sequence will continue with the FALSE or NO action
- A sequence may also contain loops, the loops will run either a set number of times or until a condition is met and becomes TRUE
  - This is known as iteration
  - For example, a loop could have been used in our flow chart to keep running until the cards run out
  - An alternative example would be to run the loop 52 times as there are 52 playing cards per pack

USING FLOWCHARTS

- Flowcharts can be used in order to break down the steps in which an algorithm represents
  - This makes it easier to design or understand an algorithm
- You need to know the elements of a flowchart, each element is linked using a connector that indicates the direction of steps

Start / End



Decision

Data input / output

Process

Delay

Stored Data

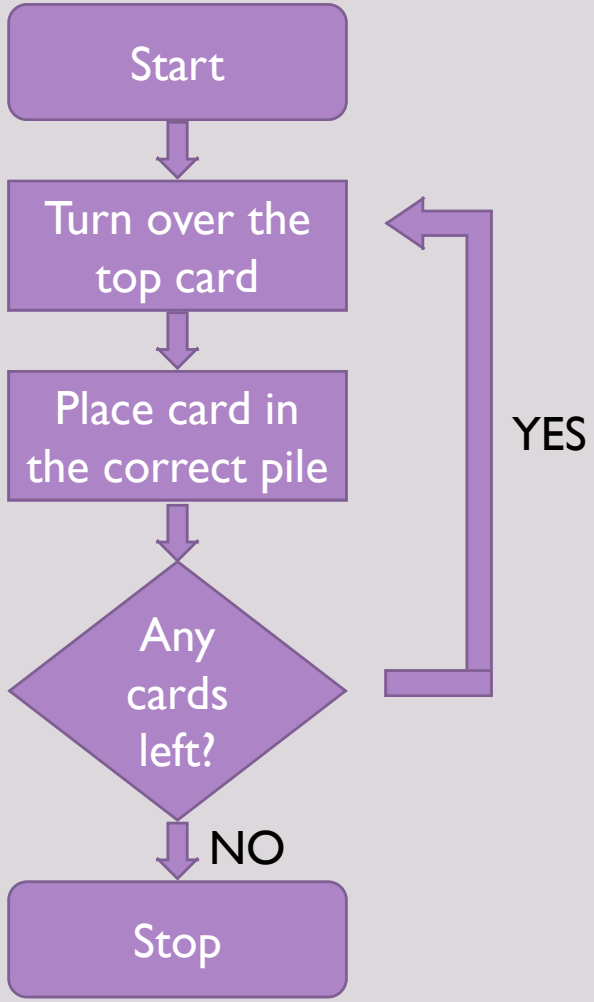
CONSTRUCTING A FLOWCHART

- A pack of playing cards has both red and black cards. Lets imagine the cards have been shuffled and we need to create a flow chart to sort them into two piles. One red pile and one black.

The initial pile would be mixed red and black cards

The end result after following the flowchart would be a pile of red cards and a pile of black.

Other elements are added to more complex flowcharts such as input/output data, delays and database searches.



PSEUDO CODE

- Pseudo code acts as a practice or working practice code before being programmed in a specific programming language (E.g. Visual.Basic, Python, C++, Java)
- Pseudo code is like the notes you use before writing up an assignment or piece of coursework
- Pseudo code can be easily read by humans, but not computers, and changes can be made to solve problems before implementation
  - Implementation is the stage in which the real thing is made, in programming the implementation stage would be writing the program up to the final version
- Although pseudo code acts like practice or notes, there are common phrases that are used so that it still makes sense to other people
  - This is the same as making notes, you probably use common abbreviations such as 'E.G.' or 'N/A'
- These common phrases are called pseudo code notations… some examples are:
  - INPUT
  - OUTPUT
  - THEN
  - OR
  - ELSE
  - IF
  - LOOP
  - DELAY
  - STORE

1.2

EFFICIENCY OF ALGORITHMS

WHAT THE SPECIFICATION SAYS…

1.2 Content:

- Understand that more than one algorithm can be used to solve the same problem.
- Compare the efficiency of algorithms explaining how some algorithms are more efficient than others in solving the same problem.

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IMPLEMENTATION

- Once the programmer has completed plans such as a flowchart or pseudo code, the algorithm can be implemented
- It is important to remember at this point that the computer system will not understand the algorithm, it will simply follow the instructions to execute it (run it)
- The programmer can now test it - It would be useful at this point to use a separate copy of data in case the algorithm is incorrect
  - This data is called test data, and may differ from the data that is intended to be used
- The programmer will implement the algorithm using high-level programming language
  - E.g. Java, Python, C, C+, Pascal, Visual Basic
- This high level language is not directly understood by computers
- We will cover this further in section 3.1

DATA STRUCTURES

- Data structures are used in programming to store data – there are two main types…

Arrays

- An array consists of a single row containing integers, just like a single row of a table
- Arrays use place value in terms of naming each value in the list – this is called indexing
- The first integer in the array is 'index 0', the second 'index 1', the third 'index 2' and so on…
  - Computers start at zero - it's important to remember this

Record

- A record data structure contains fields to store data in in the same way as a database
- A record groups together related data fields
- In Python, dictionaries are used as records

CHOOSING ALGORITHMS

- When choosing a suitable algorithm the programmer must consider the type of data being used, the resources available, the memory available and the efficiency required
- We will look at two different categories of algorithm – sort algorithm and search algorithm
  - For each of these, we will use two different types of algorithm, two search and two sort
- Sort algorithms are used to sort data in an array in ascending or descending order
  - An array is simply a set of values that are usually the output of previous programs or algorithms
- Search algorithms are used to retrieve data based on search criteria
  - These are the only algorithms you need to be familiar with for your exam

1.3

SEARCHING ALGORITHMS

WHAT THE SPECIFICATION SAYS…

1.3 Content:

- Understand and explain how the linear search algorithm works.
- Understand and explain how the binary search algorithm works.
- Compare and contrast linear and binary search algorithms.

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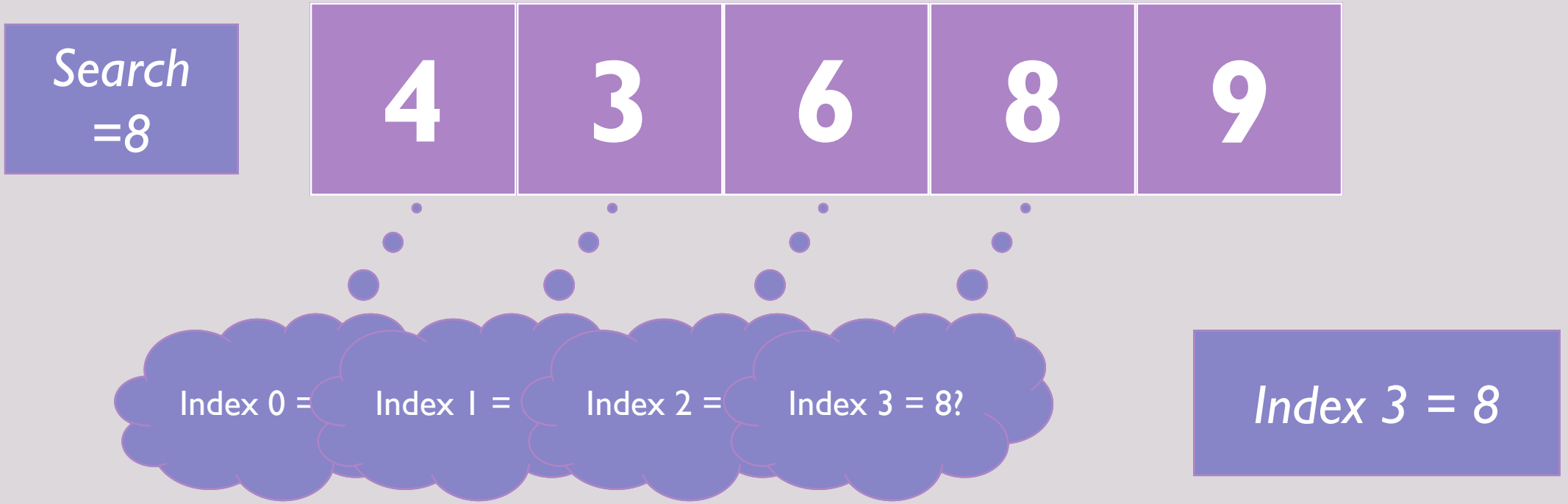
LINEAR SEARCH ALGORITHM

Search =8	4	3	6	8	9

- Linear simply means working through a sequence in order, so therefore the linear search algorithm will search for an integer by comparing the search integer to each integer in an array
  - Remember, computer systems for logically so where as we could identify a matching integer from an array, a computer would have to compare each one sequentially
- In this example, the program is searching the array for the integer '8'
- The program will start at the first integer in the list, named index 0, and carry out a simple mathematical operation such as "Compare 8 = index 1"
- The program will continue the search in sequence until true that "8 = index n" where n is the matching index
  - In this example, 8 would equal index 3

LINEAR SEARCH ALGORITHM IN ACTION



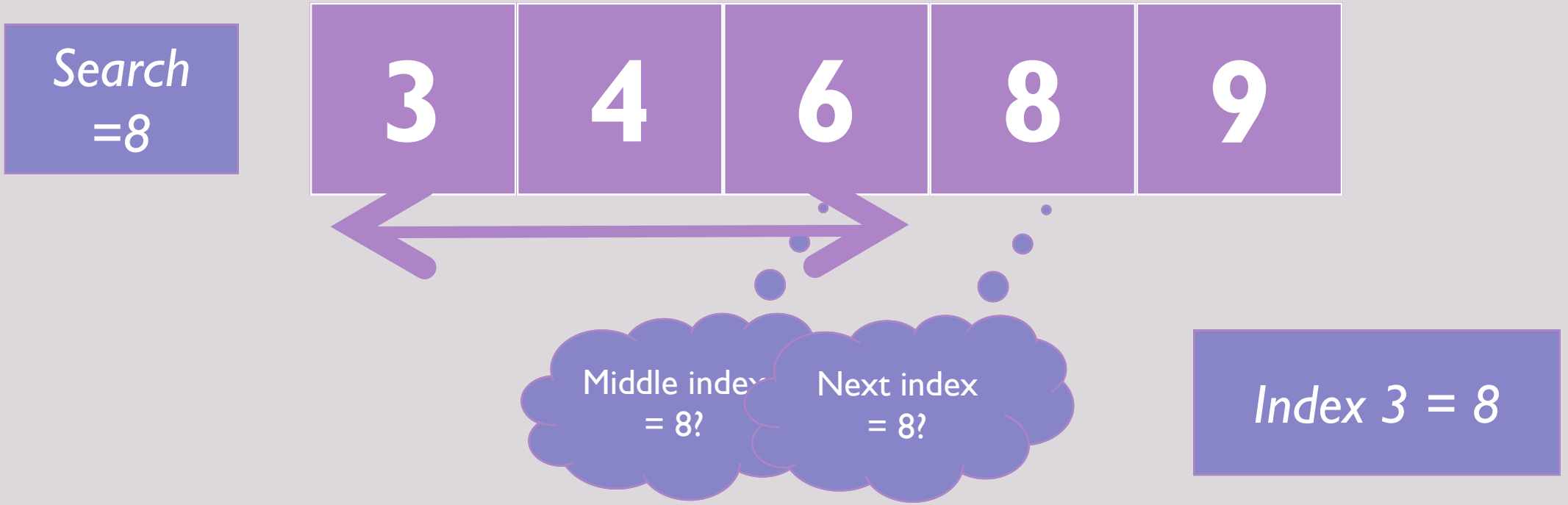
FALSE ***TRUE***

BINARY SEARCH ALGORITHM

Search =8	3	4	6	8	9

- The binary search algorithm can only be used with sorted arrays
  - E.g. previously sorted by bubble or merge sort
- This algorithm works by starting at the middle integer and initially identifying whether this matches the criteria - in many cases it wont, and if this is the case the algorithm will continue
- Next the program will work out whether the values in the array are sorted in ascending (smallest to largest) or descending (largest to smallest) order
- It will then disregard the half which will not contain the criteria
  - In this case the left half of the array will be disregarded as these values decrease from 6
- The algorithm will then identify the matching criteria, at this point it is quicker than the linear search algorithm as the integers in the array are ordered
  - However the initial sorting and splitting takes much longer

BINARY SEARCH ALGORITHM IN ACTION



FALSE ***TRUE***

1.4

SORTING ALGORITHMS

WHAT THE SPECIFICATION SAYS…

1.4 Content:

- Understand and explain how the merge sort algorithm works.
- Understand and explain how the bubble sort algorithm works.
- Compare and contrast merge sort and bubble sort algorithms.

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BUBBLE SORT ALGORITHM

5	2	3	7	6

- The bubble sort algorithm works by comparing each integer in the list, or "array", to the next integer in the list, working from left to right
  - Remember, where humans can place these numbers into size order from a young age, computers work in logic and therefore cannot perform tasks without a suitable algorithm
- The first integer in this example is 5… the algorithm will compare this number to the following integer which is 2
- If the first integer is greater than (>) the following integer, both integers will swap positions
  - In this example, 5 will swap with 2
- This process runs until the end of the list (array) where the algorithm will repeat from the beginning of the list continuously, until the list is in the correct order
  - The outcome would be a list of: 2, 3, 5, 6, 7
- Each time the algorithm runs through the list, the largest integer shifts to the end
  - Each run is called a "pass"; i.e. the algorithm will pass the array x times

BUBBLE SORT ALGORITHM IN ACTION

5<7
No change!

The algorithm will need to pass once more through the list, where 6 and 7 will swap… the list will then be complete and the algorithm will stop

MERGE SORT ALGORITHM

- The merge sort algorithm works in a similar way to the bubble sort algorithm, except in a more efficient way as the 'problem' is broken down into smaller 'problems'
  - Once solved, the smaller 'problems' are merged back into the original form – a single array
- The array is split into individual integers of their own array
  - Now we have – [5] [2] [3] [7] [6]
- Then the integers are paired from left to right and placed into their own sorted array
  - Note we do not sort BEFORE the pairing process, only afterwards (i.e. 5 and 2 swap)
  - Now we have - [2, 5] [3, 7] [6] – 6 goes in its own as there are no pairs left
- As we never compare two integers from the same array, we compare the first integer from each of the three arrays – that is 2, 3, 6 – and place the smallest into a new array
- We then compare the first available integers from each array (note that 2 is no longer available) – that is 5, 3, 6 – and place the smallest into the above array
  - We now have [2, 3]
- We continue this process comparing 5, 7, 6 followed by 7, 6
  - The final outcome is our completed array in order – [2, 3, 5, 6, 7]

MERGE SORT ALGORITHM IN ACTION

TIP

Remember to work from left to right. Never compare integers within the same array, use the next available integer in the adjacent array

ALGORITHMS – OVER TO YOU

1. Explain what an algorithm is and how one is used
2. Define what is meant by an array, using an example to demonstrate indices
3. Draw a flowchart that will sort a bag of counters into their colours
   - There are 6 of each colour – Red, Green, Blue, Yellow
4. Write pseudo code for the above problem
5. List the two types of search algorithm and explain how they work
6. Use the two types of sort algorithm for the following array of values…
   - Use bubble sort and merge sort

9	2	6	7	5

TOPIC 2

THIS IS A PRACTICAL BASED PROGRAMMING TOPIC WHICH IS NOT INCLUDED IN THIS RESOURCE

SOME ELEMENTS ARE INTEGRATED INTO TOPIC 3 (E.G. DATA STRUCTURES)

PROGRAMMING CHOICE

- You will be using one of the following programming languages for your coursework…

Fact The first computer programmer was a female, named Ada Lovelace

TOPIC 3

FUNDAMENTALS OF DATA REPRESENTATION

3.1

CLASSIFICATION OF PROGRAMMING LANGUAGES

WHAT THE SPECIFICATION SAYS…

3.1 Content:

- Know that there are different levels of programming language:
  - • low-level language
  - • high-level language.
- Explain the main differences between low-level and high-level languages.
- Know that machine code and assembly language are considered to be low-level languages and explain the differences between them.
- Understand that ultimately all programming code written in high-level or assembly languages must be translated into machine code.
- Understand that machine code is expressed in binary and is specific to a processor or family of processors.
- Understand the advantages and disadvantages of low-level language programming compared with high-level language programming.
- Understand that there are three common types of program translator:
  - • interpreter
  - • compiler
  - • assembler.
- Explain the main differences between these three types of translator.
- Understand when it would be appropriate to use each type of translator.

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PROGRAMMING

- Programmers will write their applications in what is known as a high-level programming language
- High-level programming languages can be understood by us as humans, whereas it will need to be translated into a more complex language for a computer to be able to execute it
  - For example: Java, Python, C, C+, Pascal, Visual Basic etc.
- Low-level programming languages, also known as machine language, is understood by computers but no so much by humans
  - This could simply be a line of binary or hexadecimal
- High level language must be translated to low level language before a computer is able to use it
- There are two methods of achieving this:
  - Compilation translates the whole high-level code into low-level code using a compiler
  - Interpretation translates the whole high-level code into smaller low-level instructions using an interpreter
- We will look at these methods in further detail…

COMPILING & TRANSLATING

COMPILATION

- A compiler uses the original code from the high-level programming language as the input to the compiler
- The entire source code is compiled into low level machine language known as object code which is ready to be executed

✓ The advantage of using compilation is that it is versatile and widely compatible

x A disadvantage is that the whole original code must be re-translated if any changes are made which is inefficient for programmers

INTERPRETATION

- An interpreter translates a single high-level program into several low-level instructions
- An interpreter only translates each instruction when required, therefore no object code is generated

✓ The advantage of using interpretation is that when the source code is updated, only the effected instructions require re-translating

x A disadvantage of using interpretation is that the process has to take place each time the program is executed which uses processing power and inefficient for the end users

3.2

NUMBER BASES

WHAT THE SPECIFICATION SAYS…

3.2 Content:

- Understand the following number bases:
  - • decimal (base 10)
  - • binary (base 2)
  - • hexadecimal (base 16).
- Understand that computers use binary to represent all data and instructions.
- Explain why hexadecimal is often used in computer science.

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SYMBOLIC REPRESENTATION

- There are different ways of communicating without using words or the English language
- Symbolic representation is where communication takes place without the use of common language
  - I.e. any type of communication that doesn't involve talking or writing using a geographical language like English or French
- Any method of communication will work providing that all devices or persons involved understand the rules and meanings set out
  - An example is the use of Morse code where sounds in the form of dots and dashes represent letters which can be decoded by the recipient using
  - Imagine if computers used dots and dashes, a dot could represent 'on' and a dash could represent 'off'
- When rules and meanings are followed and become commonly understood by different computer systems, this is known as standardisation
- One of the methods of communication that are standard is numbers…

AN INTRODUCTION TO DENARY

- Denary is another term for a decimal number, which is any number from 0 to 9
- A denary number could be as simple as '3' or complex as '89234689534'
- This system is known as a base-10 system, simply due to using ten different digits
- We commonly use the denary system every day without much thought, however if you think back to how you were taught in primary school to count, we use a place value system
  - Numbers from *Zero* to *Nine* consist of a single digit
  - When we reach *Ten*, we add a column to the left which represents the number of tens we have plus the one to nine on the right column
  - So we can read the number *17* as *one ten plus seven digits*
- This demonstrates how we use single digits to represent any number using a series of numbers in place value
- Not all numerical systems or bases use place value – E.G Roman Numerals

AN INTRODUCTION TO BINARY

- Binary is a numerical system that computer systems use to perform instructions and communicate
  - Each digit is just a single bit in size, the smallest size in computing
- Binary is a type of system called a base-2 system; simply because it uses only two types of digit
  - Those digits are 1 and 0
- These 0's and 1's may seem simple, but they can be used to represent on/off or true/false in long sequences within a computer system
- Binary can be extended to include more digits to perform more complex instructions
  - For example an instruction for on, off, on, off could be 1010
  - This longer line of binary digits is called a string (i.e. a string of digits or a binary string)
- When you then start using Boolean operators such as "IF" and "OR", things can get complicated!
- A good computer system will be able to run the binary instruction quickly and reliably

SCIENTIFIC NOTATION

- We can use scientific notation to represent long sums in short
  - For example $8x8x8x8x8x8x8$ can be converted into a value that uses scientific notation
  - The new value would become 8^6
- The number to the left is called the base number, with the superscript number to the right being the notation which is called the power
- We would read 8^6 as "*eight to the six*" or "*eight to the power of six*"
  - By this we mean eight multiplied by itself 6 times
- If we make this into a more general rule, we could say x^y where x is the base and y is the power
  - This would mean that x is multiplied by itself y times
  - Remember to use $*$ instead of x or x to avoid confusion when multiplying numbers
- Over to you – Represent 2x2x2x2x2 using scientific notation

BINARY SCIENTIFIC NOTATION

- With a single binary digit there is only two possible outcomes – 0 or 1
- With two binary digits there are four possible outcomes – 00, 01, 10, 11
- Each time the number of binary digits increases, the possible outcomes double
- When referring to these, we can use scientific notation:
  - 2 bits can form 4 binary outcomes which is 2 x 2 or 2^2
  - 3 bits can form 8 binary outcomes which is 2 x 2 x 2 or 2^3
  - 4 bits can form 16 binary outcomes which is 2 x 2 x 2 x 2 or 2^4
  - This pattern continues for more binary bits…
- It is good practice to write your answers like this, just like in maths where you would write your answer to the asked significant figures or a fraction in its simplest form

AN INTRODUCTION TO HEXADECIMAL

- Hexadecimal is a place-value system used by computer systems in many different ways
  - HTML, the code used to build websites, uses hexadecimal values to represent colours
- Hexadecimal is also much easier to interpret by humans than binary
- A single hexadecimal digit is a nibble in size, which is equal to four bits
- Hexadecimal is a base-16 system; simply because there are 16 types of values
  - Those values are - 1 2 3 4 5 6 7 8 9 A B C D E F
- They can range from 00 to FF… for example 28 or 5A or BE or C9 etc.
- You may have noticed that this system uses both letters and numbers
- In HTML, RGB colours are represented as three hexadecimal values in the form of "RRGGBB"

For example, the eyedropper tool in Adobe Photoshop™ indicated this pink colour is - AD84C6

3.3

CONVERTING BETWEEN BASES

WHAT THE SPECIFICATION SAYS…

3.3 Content:

- Understand how binary can be used to represent whole numbers.
- Understand how hexadecimal can be used to represent whole numbers.
- Be able to convert in both directions between:
  - • binary and decimal
  - • binary and hexadecimal
  - • decimal and hexadecimal.

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CONVERTING DECIMAL TO BINARY: METHOD 1

- You can convert any decimal value (0-255) to an eight digit binary string
- To do this you should lay out an 8x2 table as shown…

Decimal	128	64	32	16	8	4	2	1
Binary								

- Now you need to take the given decimal number and take away the values in the table
- If the table value is larger than the current number place a zero, if it is larger place a 1 and continue the calculation until all eight binary digits are complete
- Let's do a worked example over six steps (A to F)…

DECIMAL TO BINARY METHOD 1 EXAMPLE

A

- Our number is 199, so lets start by taking 199 minus 128 = 71 (As this calculation is possible we place a 1 in the first box

128	64	32	16	8	4	2	1
1							

B

- Next we take the 71 and minus 64 = 7 (As this calculation is possible we place a 1 in the box)

128	64	32	16	8	4	2	1
1	1						

C

- We cannot calculate 7 minus 32 or 16 or 8, so we place 0's in these boxes

128	64	32	16	8	4	2	1
1	1	0	0	0			

DECIMAL TO BINARY
METHOD 1 EXAMPLE CONTINUED

D

E

F

- We can calculate 7 minus 4 so we place a 1 in that box and complete the calculation (7-4=3)

128	64	32	16	8	4	2	1
1	1	0	0	0	1		

- We are now left with 3 which 2 can be taken from, so we place a 1 in that box and complete the calculation (3-2=1)

128	64	32	16	8	4	2	1
1	1	0	0	0	1	1	

- Finally we can calculate 1 minus 1 to equal zero, so we place a 1 in the final box leaving us with our binary conversion which is… 199 = 11000111

128	64	32	16	8	4	2	1
1	1	0	0	0	1	1	1

CONVERTING DECIMAL TO BINARY METHOD 2

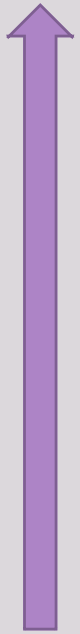
- This is an alternative method with which you can do using a calculator (Or in your head if you're really good at maths!!)
- You don't need to draw a table – just draw two or three columns
- In this method, we divide the decimal whole number by 2 continuously until we reach zero or 0.5
- Each time we divide by 2 we make a note of the answer
  - We write a 0 in the binary column and continue dividing with the answer
- Not all numbers will divide to equal a whole number
  - When this occurs we write a 1 in the binary column and continue
  - It is important to ignore the 0.5 and divide by the number without 0.5; so for example if the calculation is 7/2 = 3.5 we must ignore the .5 and divide 3 next

Decimal	____
D	B
E	I
C	N
I	A
M	R
A	Y
L	

DECIMAL TO BINARY METHOD 2 EXAMPLE

- In this example, we are converting 145 into binary…
- We start by dividing 145 by 2 which equals 72.5
  - As this is not a whole number, we write a 1 in the binary column
- We then divide 72 (without the .5) by 2 which equals 36
  - As this is a whole number, we write a zero in the binary column
- We then divide 36 by 2 which equals 18
  - As this is a whole number, we write a zero in the binary column
- We then divide 18 by 2 which equals 9
  - As this is a whole number, we write a zero in the binary column
- We then divide 9 by 2 which equals 4.5
  - As this is not a whole number, we write a 1 in the binary column
- We then divide 4 (without the .5) by 2 which equals 2
  - As this is a whole number, we write a zero in the binary column
- We then divide 2 by 2 which equals 1
  - As this is a whole number, we write a zero in the binary column
- We finally divide 1 by 2 which equals 0.5
  - As this is not a whole number, we write a 1 in the binary column
- We stop at 0.5 or zero

Decimal 145	
/2 = 72 (.5)	1
/2 = 36	0
/2 = 18	0
/2 = 9	0
/2 = 4 (.5)	1
/2 = 2	0
/2 = 1	0
/2 = (.5)	1
Binary 10010001	



Once the column is complete, we write the binary digits from BOTTOM to TOP which gives us our binary answer:
145 = 10010001

CONVERTING HEXADECIMAL TO BINARY

- As we previously discussed, hexadecimal values go from 1 to F
  - In denary these convert to 1 to 15
  - In binary these convert to 1 to 1111
- This means that when we represent longer hexadecimal numbers in binary, we need to use 4 bit binary throughout to accommodate for the highest hexadecimal number
  - Remember that each binary digit is 1-bit in size, so 4-bit binary is 4 digits in length
- To do this, we convert each hexadecimal value to denary and then from denary to binary
  - For example we know that A in hex is 10 in denary, and 10 in binary is 1010
- This process continues until the complete hexadecimal figure has been converted

CONVERSIONS – OVER TO YOU

1. Convert the decimal number 228 to binary… You can use either methods 1 or 2.
2. Convert the decimal number 251 to binary… You can use either methods 1 or 2.
3. Convert the decimal number 156 to binary… You can use either methods 1 or 2.
4. Convert the decimal number 178 to binary… You can use either methods 1 or 2.
5. Convert the decimal number 195 to binary… You can use either methods 1 or 2.
6. Convert the hexadecimal number D2 to binary
7. Convert the hexadecimal number F8 to binary
8. Convert the hexadecimal number 44 to binary
9. Convert the hexadecimal number 7AB8 to binary
10. Convert the hexadecimal number C17E to binary

3.4

UNITS OF INFORMATION

WHAT THE SPECIFICATION SAYS…

3.4 Content:

- Know that:
  - • a bit is the fundamental unit of information
  - • a byte is a group of 8 bits.
- Know that quantities of bytes can be described using prefixes.
- Know the names, symbols and corresponding values for the decimal prefixes:
  - • kilo, 1 kB is 1,000 bytes
  - • mega, 1 MB is 1,000 kilobytes
  - • giga, 1 GB is 1,000 Megabytes
  - • tera, 1 TB is 1,000 Gigabytes.

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BIT OR BYTE?

bit (b)	• Smallest size
Nibble	• Made up of 4 bits • Less commonly used
Kilobit (Kb)	• Made up of 1000 bits
Megabit (Mb)	• Made up of 1000 kilobits
Gigabit (Gb)	• Made up of 1000 megabits
Terabit (Tb)	• Made up of 1000 gigabits

Always written in lower case, bits are used for communications such as file transfer speed

Byte (B)	• Smallest size
Kilobyte (KB)	• Made up of 1024 Bytes
Megabytes (MB)	• Made up of 1024 Kilobytes
Gigabytes (GB)	• Made up of 1024 Gigabytes
Terabytes (TB)	• Made up of 1024 Gigabytes

Always written upper case, Bytes are used for file sizes and hard drive capacity

CONVERTING BETWEEN BYTES

- The first thing you need to remember is that there are 1024 kilobytes in 1 megabyte, 1024 megabytes in 1 gigabyte and so on…
- To convert a file size UP you need to DIVIDE the value by 1024 once for each step
  - E.g. if you are converting from Kilobytes to Gigabytes, there are two steps and therefore you should divide by 1024 and then by 1024 again
- To convert a file size DOWN you need to MULTIPLY the value by 1024 once for each step
  - E.g. if you are converting from Gigabytes to Kilobytes, there are two steps and therefore you should multiply by 1024 and then by 1024 again
- Lets work through an example…
  - Q: A video file is 1.91 Megabytes, convert the file size into Bytes [2]
  - A: $1.91\ x\ 1024 = 1{,}955.8\ KB\ x\ 1024 = 2{,}002{,}780.2\ B$
  - Remember to round the answer and ensure units are written correctly

CONVERTING BETWEEN BITS

- The first thing you need to remember is that there are 1000 kilobits in 1 megabit, 1024 megabits in 1 gigabit and so on…
- To convert a file size UP you need to MULTIPLY the value by 1000 once for each step
  - E.g. if you are converting from Kilobits to Gigabits, there are two steps and therefore you should divide by 1000 and then by 1000 again
- To convert a file size DOWN you need to DIVIDE the value by 1000 once for each step
  - E.g. if you are converting from Gigabits to Kilobits, there are two steps and therefore you should multiply by 1000 and then by 1000 again
- Lets work through an example…
  - Q: Ben uses 168,000 kilobits of data on his phone, convert to megabits
  - A: $168{,}000 \div 1000 = 168\ Mb$
  - Tip: As the conversion rate is 1000 for bits, you can shift the decimal point

MEASURING DATA SPEEDS

- Data speeds are measured in bits per second (bps) and kilobits per second (kbps)
- You can measure data speeds how long it takes for a file to be transferred from one drive to another or how long a file takes to transfer using the internet
- You will need to know the following conversion rates for speed
  - There are 1000 bits in 1 megabit
  - There are 1000 megabits in 1 gigabit
- You will also need to know how to convert sizes of files
  - There are 8 bits in a Byte
  - There are 1024 Bytes in 1 Kilobyte
  - There are 1024 Kilobytes in 1 Megabyte
- Using the above conversion rules you can calculate the time taken for a file to transfer over a given data rate…

TRANSFER SPEED CALCULATION

Firstly, you will need to convert the file into kilobits…

- *Kilobytes to kilobits*
- $1\ Byte = 8\ bits$
- $1024\ Bytes = \ 1\ Kilobyte$
- $8 * 1024 = 8192\ bits = \ 1\ Kilobyte$
- $File\ size * 8192 = file\ in\ bits$
- $File\ in\ bits\ divide\ by\ 1000 \ = \ file\ in\ kilobits$

- *If the size of the file is not in Kilobytes, you need to convert it first by using the rule that you times by 1024 to the number of jumps in size for example:*
- *Gigabytes in Megabytes = *1024 (First jump)*
- *Megabytes in Kilobytes = *1024 (Second jump)*
- *So Gigabytes in Kilobytes = *1024 then *1024 again*

Now you can calculate the data rate using the given speed in kbps

- $\frac{file\ size\ in\ kb}{data\ rate\ in\ kbps} = amount\ of\ time\ taken\ for\ transfer\ in\ seconds$
- *You may wish to use scientific notation to complete your answer*
  - *E.g.* 0.0867 *seconds would be* $8.67 * 10^{-2}$ *because the decimal has moved two places to the right*
  - *Scientific notation was discussed in section 3.1*

DATA CALCULATIONS – OVER TO YOU

1. Show how many bytes are in one kilobyte (1KB) then how many bits are in one kilobit (1Kb)
2. Explain the difference between a bit and a Byte
3. Convert 3,450 Megabytes into Bytes, show your working and units
4. Convert 500 Gigabytes into Megabytes, show your working and units
5. Convert 4,678,000 Bytes into Kilobytes, show your working and units
6. Convert 780 Kilobytes into Megabytes, show your working and units
7. Convert 5,800 Megabits into bits, show your working and units
8. Convert 232 Gigabits into Megabits, show your working and units
9. Convert 24754Kbp/s into Mbp/s, show your working and units
10. Convert 1.65Gbp/s into Mbp/s, show your working and units

3.5

CHARACTER ENCODING

WHAT THE SPECIFICATION SAYS…

3.5 Content:

- Understand what a character set is and be able to describe the following character encoding methods:
  - • 7-bit ASCII
  - • Unicode.
- Understand that character codes are commonly grouped and run in sequence within encoding tables.
- Describe the purpose of Unicode and the advantages of Unicode over ASCII.
- Know that Unicode uses the same codes as ASCII up to 127.

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INTRODUCING ASCII

- Every word is made up of characters or symbols, in computer systems these are represented as numbers known as character codes
  - A complete language in character code is called a character set
- ASCII stands for American Standard Code for Information Exchange and is the code for representing letters in the English language using numbers
- Standard ASCII stores up to 128 characters at just 7 bits
  - Those 128 characters make up every character or digit on a keyboard including punctuation, upper and lower case letters and numbers
- Extended ASCII stored up to 256 characters at 8 bits and is used for European letters
  - Examples include - á é í ó ú Á É Í Ó Ú

3.6

REPRESENTING IMAGES

WHAT THE SPECIFICATION SAYS…

3.6 Content:

- Understand what a pixel is and be able to describe how pixels relate to an image and the way images are displayed.
- Describe the following for bitmaps:
  - • size in pixels
  - • colour depth.
- Describe how a bitmap represents an image using pixels and colour depth.
- Describe using examples how the number of pixels and colour depth can affect the file size of a bitmap image.
- Calculate bitmap image file sizes based on the number of pixels and colour depth.
- Convert binary data into a black and white image.
- Convert a black and white image into binary data.

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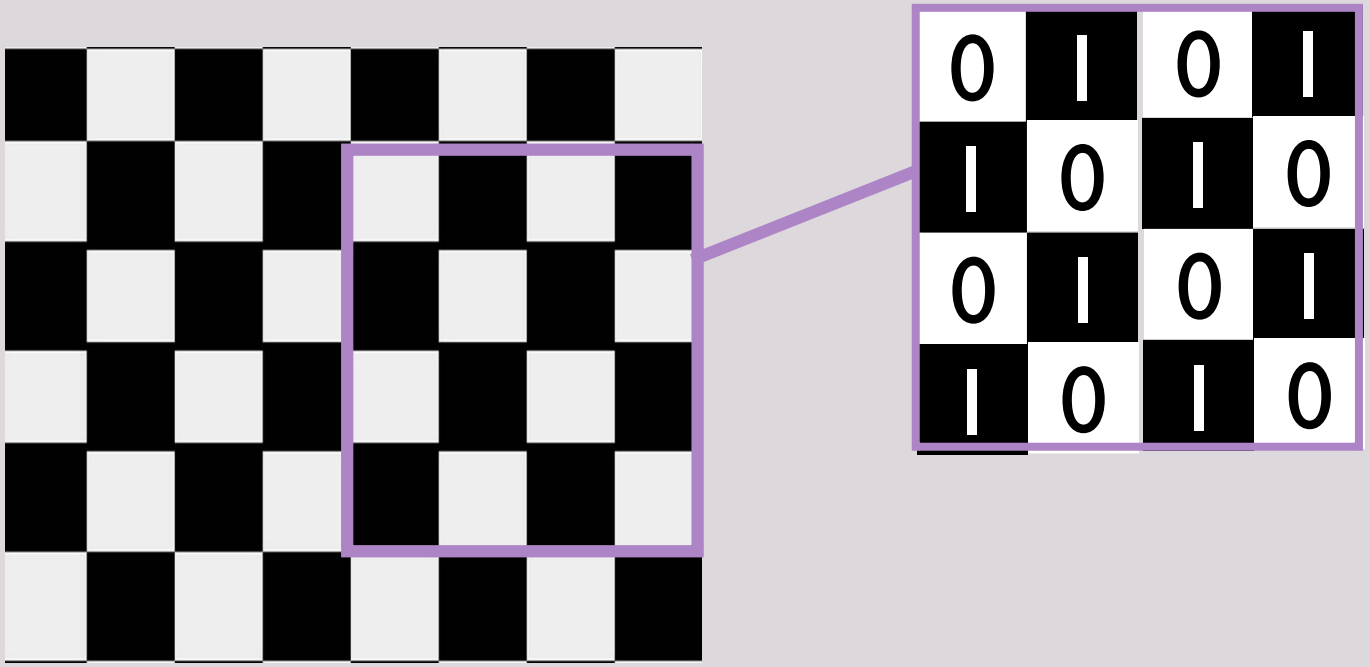
BASIC IMAGE REPRESENTATION

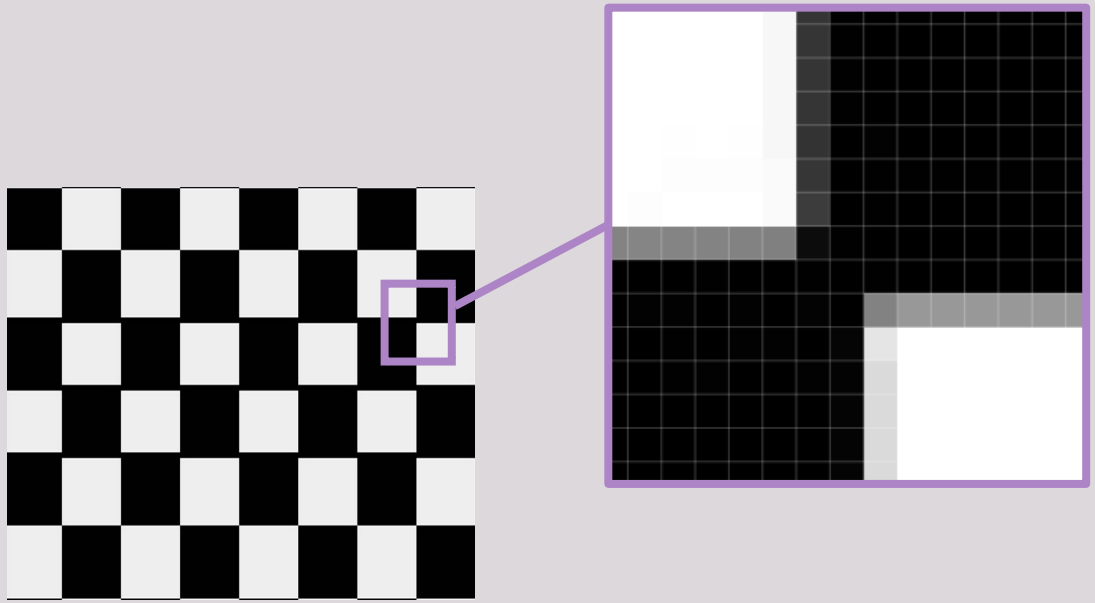
- Images are also represented in binary – the most simple images in black and white are represented simply as 0 for white and 1 for black – each one pixel in size
- The below example shows binary representation of a section of the chess board, assuming each square is 1 pixel in pure black and white with no other shades



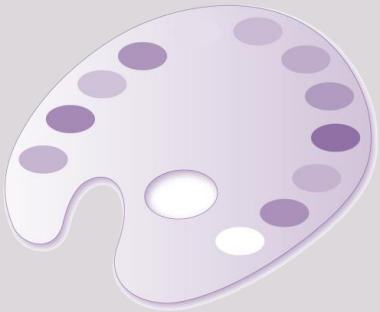
A LITTLE MORE COMPLEX…

- In order to add multiple shades of grey, the colour between black and white, more binary integers can be added to each colour
- For example, 2-bit binary could be used to allow four colours in depth:
  - White = 00 | Light Grey = 01 | Grey = 10 = Dark Grey | Black = 11
  - More colours can be added by using longer binary strings such as 8-bit and 16-bit
- The below example shows that the chess board actually uses an estimate of 3-bit…

The image has technically been saved with 24-bit capability, although to the eye it only looks like 3-bit



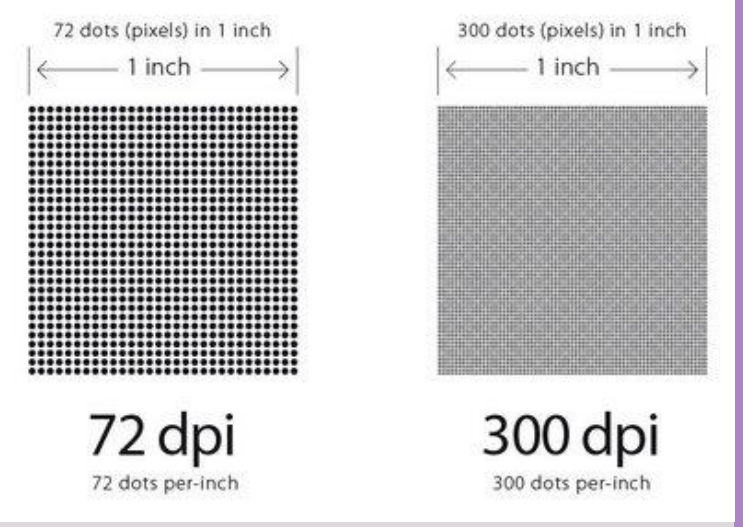
HOW MANY COLOURS?



- 1-bit binary is just a single bit in size and length
  - i.e. 1 or 0 – and therefore allows two colours
- 2-bit binary is two bits in size and length
  - – i.e. 00, 01, 10, 11 – and therefore allows four colours
- 3-bit binary is three bits in size and length
  - – i.e. 000, 010, 001, 011, 111, 110, 101, 100 – and therefore allows eight colours
- You can also represent the colour depth using scientific notation, as we learned in part **3.1**
  - 1-bit binary would be represented as 2^1 (which is equal to 2)
  - 2-bit binary would be represented as 2^2 (two multiplied by itself once = 2x2)
  - 3-bit binary would be represented as 2^3 (two multiplied by itself twice = 2x2x2)
- Using scientific notation, you can work out the number of possible colours from any given value
  - Question: How many colours would be available in a 6-bit image?
  - Answer: 6-bit = 2^6 = 2x2x2x2x2x2 = 64 colours

This pattern continues…

IMAGE RESOLUTION



- The resolution of an image is the number of pixels in a given area
- That given area is a one inch square when using 'dpi' (dots per inch)
- Resolution is used to determine the quality of an image and estimate it's file size
- If an image has a resolution of 72dpi, each square inch will be 72 pixels wide and 72 pixels high and therefore by calculating 72x72 we can work out that the number of pixels is 5184 per square inch
- A higher resolution, indicated by higher dpi, the better the image quality will be
- Typically, 200dpi is the minimum standard you would use when scanning a text based document, it is also the minimum requirement to allow Optical Character Recognition
  - OCR is a function used by software that allows scanned documents to be edited as if they had just been typed up on screen, therefore a good quality scan is required for accuracy of identifying text
- For a photograph, the minimum standard you would use when saving and printing would be 400dpi (perhaps higher at 600dpi depending on the printer technology and paper)

3.7

REPRESENTING SOUND

WHAT THE SPECIFICATION SAYS…

3.7 Content:

- Understand that sound is analogue and that it must be converted to a digital form for storage and processing in a computer.
- Understand that sound waves are sampled to create the digital version of sound.
- Describe the digital representation of sound in terms of:
  - • sampling rate
  - • sample resolution.
- Calculate sound file sizes based on the sampling rate and the sample resolution:
  - • File size (bits) = rate x res x secs
  - • rate = sampling rate
  - • res = sample resolution
  - • secs = number of seconds

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BINARY REPRESENTING SOUND

- Any type of sound that is from a natural source is analogue, and for a computer to be able to recognise and work with it, the analogue sound must be converted into digital sound
  - The medium in which the sound is received by the computer is simply the device used – such as a microphone – and sample frequencies are recorded in Hertz (Hz)
- To do this, analogue to digital converter software takes samples of the sound waves it detects at regular intervals, these samples are in the form of binary which is digital
- The more samples there are, and the closer they are together, the better the quality of the sound will be – this is because the sound wave isn't followed in-between samples
- When analogue is converted to digital, a process called modulation takes place
  - When using radiowaves, the type of modulation used is called frequency modulation
  - Frequency modulation is also used with WiFi technology – you will visit this in part 5.1
- Soundwave sampling can be represented on a graph…

Click the right arrow to view an example graph

DATA REPRESENTATION – OVER TO YOU

1. Explain what is meant by ASCII and how it is used
2. Explain how basic black and white images are represented in machine language
3. Calculate the number of possible colours in an 8-bit binary image
4. Explain what is meant by image resolution
5. Assess why image resolution might be important in a printing company, and suggest what the graphic designers should consider
6. What might be a suitable resolution for a magazine? Give a reason
7. If an image has a resolution of 160dpi, how many pixels are present per square inch?
8. Explain what is meant by the term 'sampling' and how it is used
9. Explain the term 'Modulation' using an example
10. Read section **3.3**, then return and suggest the likely effects of lossy compression on a piece of music

3.8

DATA COMPRESSION

WHAT THE SPECIFICATION SAYS…

3.8 Content:

- Explain what data compression is.
- Understand why data may be compressed and that there are different ways to compress data.
- Explain how data can be compressed using Huffman coding.
- Be able to interpret Huffman trees.
- Be able to calculate the number of bits required to store a piece of data compressed using Huffman coding.
- Be able to calculate the number of bits required to store a piece of uncompressed data in ASCII.
- Explain how data can be compressed using run length encoding (RLE).
- Represent data in RLE frequency/data pairs.

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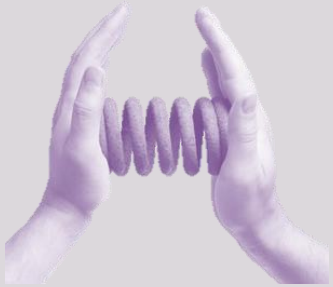
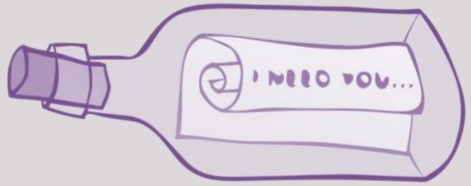
FILE COMPRESSION



- File formats are standardised ways of storing and organising the data that makes up a file; whether it be an image file, sound file or even this presentation file and so on…
  - There are common formats that software packages use to write a file (save) to a drive - these are given extensions such as .jpeg or .mp3 - many of which compress the file in the process
- Compression is the process of reducing the size of digital data – i.e. making files smaller
- There are two main types of compression you need to know:
  - Lossy compression which reduces file size by removing some data, this can cause lower quality
  - Lossless compression which reduces file size without losing data or compromising much quality
- The compression method chosen will be based on several factors such as:
  - The type of file – if it's an image file you may not want to lose quality
  - The use of file – if you need to send by email, you will need to meet small file restrictions
  - The purpose of file – is the file for print? projector? HD screen? website?
  - The software – if the output file is not compatible or readable by the user, it's not fit for purpose
- The most common times a file may need to be compressed is to publish as part of a website, which if too large may cause slow loading speeds, or to send via email which will have restrictions

BASIC DATA ENCODING



- Imagine you want to send a secure letter to a friend, you write the letter in a made up language (encoding) and send it to your friend with instructions on how to decode the message
- Imagine the instructions are written in UV ink which only your friend can read using a UV torch, so that anybody who intercepts the letter cannot understand it or read the instructions
- When the letter is received by your friend, they use the UV torch to read the instructions and decode the message
- The ‘coding’ we are reefing to here is called encryption, and the ‘decoding’ is called decryption
- Now that you have an understanding of sending messages using encryption, lets go back through this technique in more computer science terms…

RUN-LENGTH ENCODING (RLE)

- Run-length encoding is a lossless method of file compression carried out using an algorithm
- RLE works by replacing strings of repeated values with simply one of the values with its quantity and a break asterisk to differentiate it from the rest of the string
  - This works much like simplification in algebra e.g. x+x+x = 3x
- By using this method, no data is lost, but the data representation of it is simply shortened
- Here is an example of how RLE might work:

ABBBCCCCDDEFFFFF → **A*3BC*2DE*5F**

- RLE is used in PDFs (portable document files) which are commonly used document files
- An advantage of this compression method is that it uses very little processing power as it is so simple
- A disadvantage of this compression method is that it will only be beneficial when there is lots of repetitive data, as if there are only two repeating values consecutively it will actually increase the file size as RLE uses three values – asterisk, quantity, value

RUN-LENGTH ENCODING JOKE

- This is a clip from Family Guy where Peter is reading out his number to his house keeper, Consuela
- As Peter reads his number out, Consuela is confusing a string of numbers with a quantity of numbers
  - For example, "2, 5" intended as separate numbers was misunderstood as 2 lots of 5 or "5, 5"
- This is an example of how Run-Length Encoding works – replacing a string of consecutive numbers with their quantities
  - For example, BBBB would be compressed to 4B

Click to play

3.9

DATA ENCRYPTION

DATA ENCRYPTION IN CONTEXT

- When we transfer data over the internet, it can be easy for criminals to get hold of it
- When you want to keep the data packets secure, you can use encryption which changes how the data looks within the packet
- The data without encryption is known as plaintext which is encrypted using a tool known as a cipher which encrypts the data packet into a new form called ciphertext
- As the data packet is encrypted, a key is added which contains an algorithm only accessible to the intended recipient – i.e. only the device you want to send it to can view the key
- When the data packet reaches the receiving device, it will use the algorithm to reverse the encryption process (decryption) and transform the ciphertext back into plaintext

ENCRYPTION-DECRYPTION PROCESS

Cipher function transforms plaintext into ciphertext and adds key

Data packet containing key is sent to recipient

Recipient device receives data and uses decryption function to read key

The data is decrypted and transformed from ciphertext back into plaintext

Over to you questions

1) Why is data encrypted and what might be an appropriate task to do so? [2]
2) What does the decryption function use from the key to perform the decryption process? [1]
3) What do you think might affect the speed of the encryption and decryption processes? [2]

CAESAR CIPHER

- Caesar cipher is a basic encryption technique which is thought to have been used by Julius Caesar in BC roman times
- This technique is a type of character substitution where each letter of the alphabet is shifted by a number of, or x, characters to the left or right
- If we apply this in computing, the algorithm within the key would contain the instructions on how to decrypt the message – i.e. the number of shifts to which direction
- E.g. 3 shifts left would look like this:
  - Plain: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
  - Cipher: X Y Z A B C D E F G H I J K L M N O P Q R S T U V W
- …and therefore a message would look like this:
  - Plaintext: THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG
  - Ciphertext: QEB NRFZH YOLTK CLU GRJMP LSBO QEB IXWV ALD

WHY ENCRYPT?

- Encrypting data is important in order to keep messages and files secure and hidden from unauthorised persons – i.e. anybody that you don't want to see
- You wouldn't send personal information in the post to a friend, so why send data across the internet without encryption?
- You also wouldn't write down sensitive information and leave it laying around the house, so why save sensitive data on your computer or in the cloud?
- You don't need to encrypt everything, however there are many aspects of computing that can be targeted by hackers and used in their favour
- Ask yourself the question – If this piece of information got accessed by a stranger, would I be okay with it?
  - If you answer YES then you probably don't need to encrypt the information
  - If you answer NO then you should consider whether encryption is of likely value to this

ENCRYPTING DATA FOR THE WEB

- Data on the internet can sometimes need to be encrypted – for example when making an online purchase or disclosing private information on a web form
- Data online is protected using an SSL protocol, which stands for Secure Sockets Layer
  - Whenever you visit a website that begins with "https" instead of "http" it is using the protocol
- SSL works in a cryptographic method, much like the Cipher method, except more complex encryption with two keys
- This technology has since been redeveloped to form a new protocol known as TLS, meaning Transfer Layer Security which initializes a secure temporary connection between client and server before transferring the encrypted data
  - This initial connection is known as a three-way handshake and is used in a TCP connection… we will learn more about TCP and the internet in section 5.1

Fact *Did you know that the word 'data' is plural, meaning that you should refer to data as "data are" instead of "data is"… datum is singular*

TOPIC 4

COMPUTER SYSTEMS

4.1

BOOLEAN LOGIC

WHAT THE SPECIFICATION SAYS…

4.1 Content:

- Construct truth tables for the following logic gates:
  - • NOT
  - • AND
  - • OR
- Construct truth tables for simple logic circuits.
- Interpret the results of simple truth tables.
- Create, modify and interpret simple logic circuit diagrams.

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BOOLEAN LOGIC

- One of the components found in computers is a transistor
- A transistor is a component that acts as a switch
  - Transistors are microscopic in size, and millions can be implanted into a single chip
- These transistors along with additional wiring form what is known as a logic gate which are able to understand Boolean expressions
- A Boolean expression is simply an instruction containing Boolean operators
  - For example NOT, AND, OR
- The logic gate is able to calculate the outcome of Boolean expressions in a much more efficient way than we can as humans
  - The outcome will always be TRUE or FALSE

TAKE OUT THE CONTEXT

- Computers require very specific instructions, as you will have learned when writing algorithms
- Boolean expressions may seem rather complex to us, but are very simple for computers
  - Many expressions could be written much easier for us as humans, but a computer wouldn't understand!
- To help us understand what Boolean expressions are, and how a logic gate would interpret and output one, we can remove the computing context and create some real life expressions…

Let's write a Boolean expression to determine whether to wear a coat

- First we need an input – "If it is raining outside OR it is cold, I will wear a coat"
- So, if the expression is "It is raining outside but NOT cold" should I wear a coat?
  - The outcome of this statement would be yes, which in computer terms we say TRUE
- If the expression is "It is raining outside AND cold" should I wear a coat?
  - The outcome once again would be yes, or TRUE
- If the expression is "It is NOT raining outside AND NOT cold" should I wear a coat?
  - The outcome this time would be no, or FALSE

USING LOGIC GATES

- Truth tables are used to represent the outcomes of Boolean expressions
- There is always one output – TRUE or FALSE – but there can be several inputs
  - Inputs are named A, B, C etc. and can represent any variable
- The most simple truth table contains a single input:

Input A	Output
TRUE	TRUE
FALSE	FALSE

Expression
"IF A = TRUE"

- More complex truth tables contain multiple inputs that use Boolean operators to define what the outcome should be…
- "A AND B" would mean that when both A and B are TRUE, the output is also TRUE
  - Or when A alone is TRUE, B alone is TRUE or neither are TRUE, the output is FALSE
- "A OR B" would mean that when A or B are TRUE, the output is also TRUE
  - Or when neither A or B are TRUE, the output is FALSE

TRUTH TABLES WITH BOOLEAN OPERATORS

Expression

"IF A **NOT** *B = TRUE"*

Input A	Input B	Output
TRUE	TRUE	**FALSE**
TRUE	FALSE	**TRUE**
FALSE	TRUE	**FALSE**
FALSE	FALSE	**FALSE**

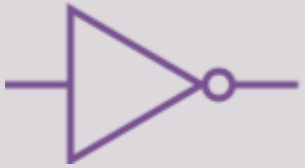
Now A must be true and B must be false…
We know that the output will be FALSE when A is FALSE, regardless of B. Then when A is TRUE, B must be FALSE.

LOGIC GATE DIAGRAMS

- Logic gates can be drawn as diagrams to demonstrate how the expression will work and what the output will be
- More complex logic gates with multiple Boolean operators will combine multiple symbols that each represent an operator
- You may be asked to create a diagram, or fill in the blanks, in your exam so make sure you learn the symbols and are able to use them!
- This example shows how an AND logic gate would look as a diagram:

AND

OR



NOT

COMPUTER LOGIC – OVER TO YOU

1. Explain what is meant by a transistor and how they are used
2. List the Boolean operators you have learned
   - Indicate using Green, Orange or Red how well you understand each one
   - For each operator, draw the symbol that represents it
3. Define what is meant by a Boolean expression
4. Write a simple Boolean expression to determine whether to close the window based on the weather and whether or not it is night time
5. Complete the following truth table for:
   A. A OR B
   B. A AND B
   C. A NOT B

Input A	Input B	Output
TRUE	TRUE	
TRUE	FALSE	
FALSE	TRUE	
FALSE	FALSE	

4.2

SOFTWARE CLASSIFICATION

WHAT THE SPECIFICATION SAYS…

4.2 Content:

- Explain what is meant by:
  - • system software
  - • application software.
- Give examples of both types of software.
- Understand the need for, and functions of, operating systems (OS) and utility programs.
- Understand that the OS handles management of the:
  - • processor(s)
  - • memory
  - • I/O devices
  - • applications
  - • security.

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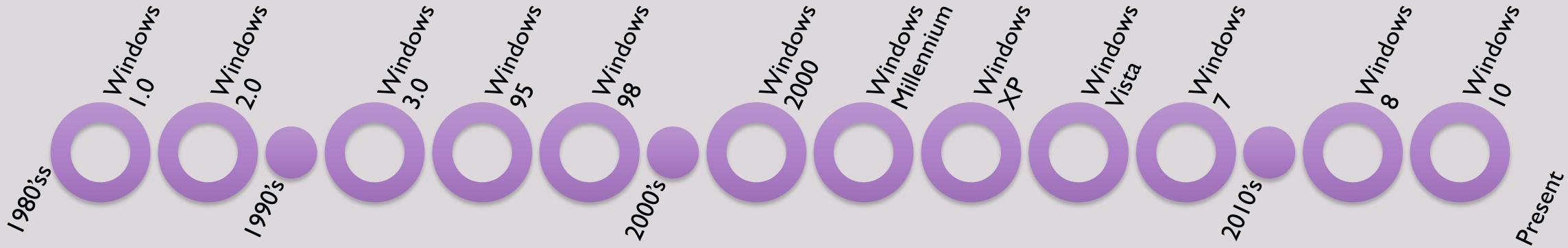
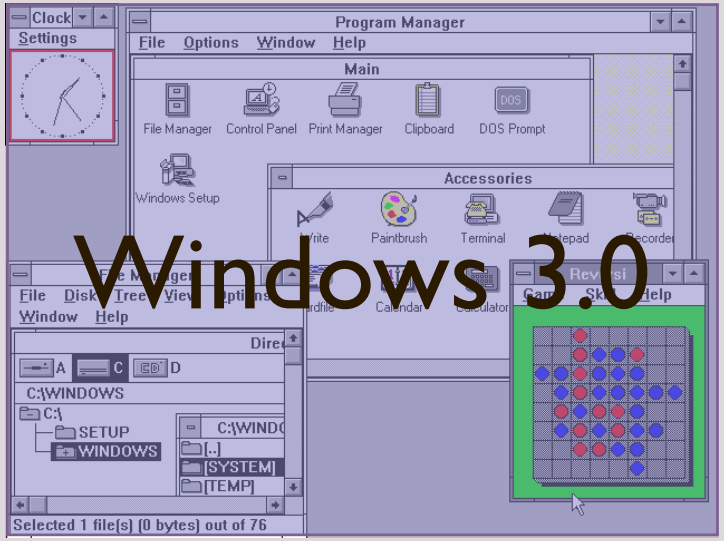
INTRODUCING OPERATING SYSTEMS

- The role of an operating system is to facilitate the link between software and hardware to the end user – it has a number of functions including:
- Manage Settings
  - Allows the end user to change or upgrade hardware drivers and they way they work
- Manage Files
  - Allows the end user to copy, rename, move and delete files and folders
- Manage Hardware
  - Allows the end user to install software which uses resources such as graphics and drivers
- Manage Resources
  - Allows the end user to use peripherals such as keyboard, printer etc. for different purposes
- The operating system has a User Interface (UI) which is mainly a graphical user interface (GUI) which makes tasks accessible to many different people without requiring code such as MS-DOS…

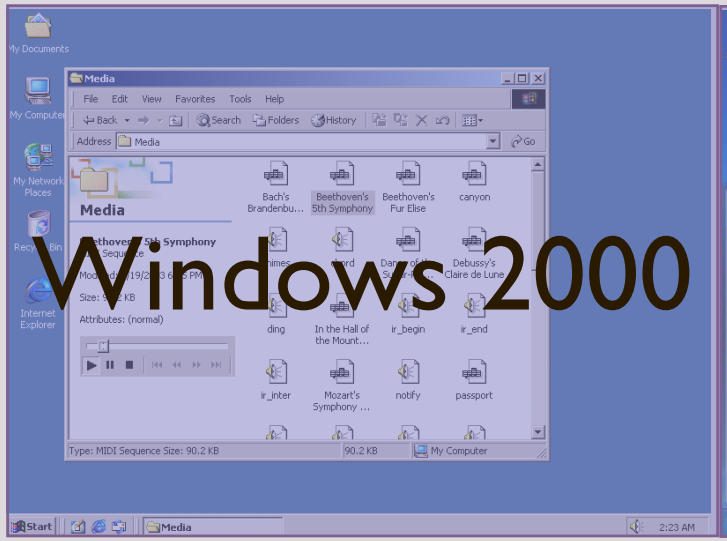
THE HISTORY OF WINDOWS

- Microsoft Windows® is the most used operating system in the world, followed by Apple Mac OS® and Linux OS…





Windows 3.0



Windows 2000

Windows 7

SOFTWARE

There are two types of software…

- Custom-made (Bespoke)
  - Custom-made or bespoke software is produced for organisations to meet specific requirements
  - Custom-made software may perform similar tasks to others, but is otherwise unique
- Off-the-shelf (Consumer)
  - Off-the-shelf software can be bought by any consumer online or in a store such as Currys
  - Off-the-shelf software is consistent and instantly accessible (E.g. Microsoft Office Suite)
- Bought software like this often come on a disk, but in recent years the use of digital downloads has increased and with many packages now you will only receive an activation card
- Off-the-shelf software also covers programs that come with operating systems, such as Microsoft Paint with Windows OS
  - One of the most important operating system/bought software types is utility software…

UTILITY SOFTWARE

- Utility software applications are designed to improve and maintain computer systems in terms of both software (i.e. operating system) and hardware (i.e. hard drive)
- There are many features and functions of utility software, depending on whether it was included in the operating system or bought as an extra…

Back-up Systems

- When disks fail, the data on them can be lost forever, backing up files is important
- Back-up functions of utility applications make this simpler; they can also back-up settings and a copy of the operating system producing what is called as an 'image'

Disk Cleaners/Bleaching

- Disk cleaning functions work by deleting temporary files created by software packages that are no longer required
- Bleaching is a process that removes any trace of deleted files that may otherwise be restorable

UTILITY SOFTWARE CONTINUED

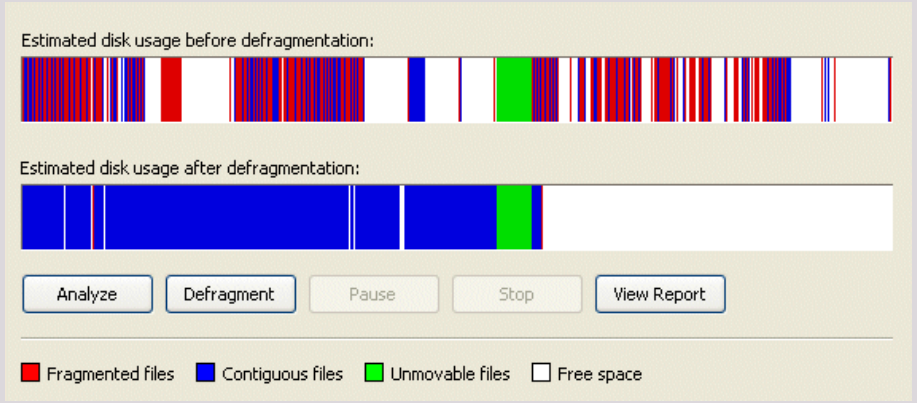
File Compression

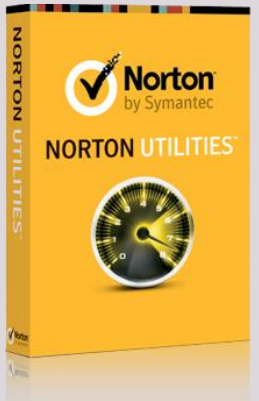
- Some utility applications will allow the user to compress files on the disk drive to enable more space availability on the drive (See section 3.3)

Disk Defragmenters

- These make hard drives run faster which moves the contents of the disk into a single group, rather than pieces of data stored throughout the disk with gaps when files are deleted
  - Note this process does not delete files or create new space

Before and after defragmentation





Norton Utilities is an example of off-the-shelf utility software

SIMULATION MODELLING

- Simulation modelling is the use of computing devices to replicate a real-life situation
- There is a lot of software and hardware required:
  - Multiple monitors/screens
  - Controls – possibly replica controls
  - Sounds/Audio
  - Sensors and motors
- Simulation modelling can be used for entertainment
  - One example could be playing a simulation game such as a virtual reality headset
- Simulation modelling can be used for training and work
  - One example could be training to drive a train or perform an operation using simulation
- Simulation modelling can be used to solve crimes
  - One example could be to test possible road traffic collision (RTC) scenarios using police evidence

4.3

SYSTEMS ARCHITECTURE

WHAT THE SPECIFICATION SAYS…

4.3 Content:

- Explain the Von Neumann architecture.
- Explain the role and operation of main memory and the following major components of a central processing unit (CPU):
  - • arithmetic logic unit
  - • control unit
  - • clock
  - • bus.
- Explain the effect of the following on the performance of the CPU:
  - • clock speed
  - • number of processor cores
  - • cache size
  - • cache type.
- Understand and explain the Fetch-Execute cycle.

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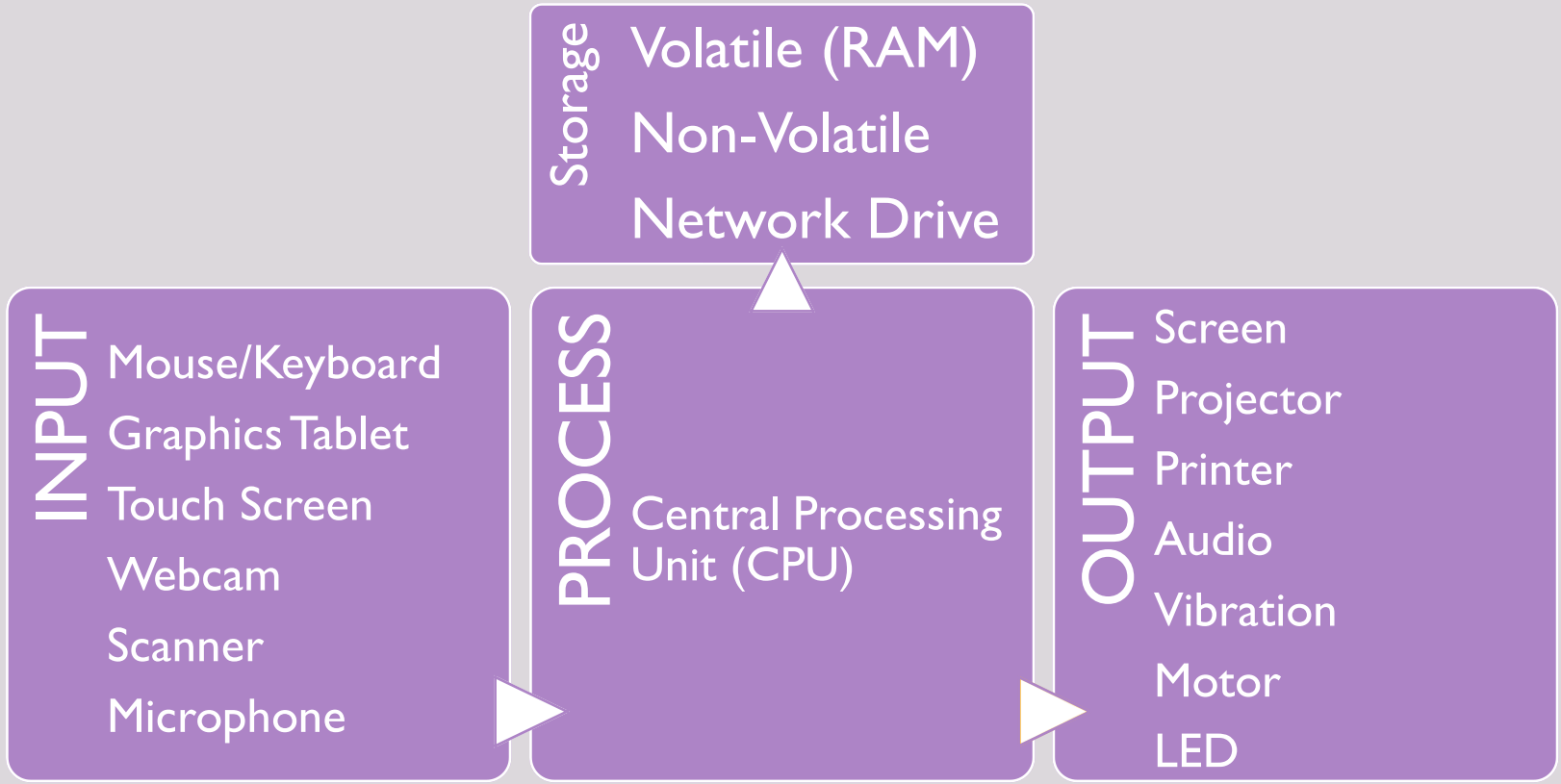
INPUT PROCESS OUTPUT MODEL

- Most modern computer systems can be described using the input, process, output model
- The model works like a flowchart, that demonstrates how data is input into the system, which is processed to create stored data or an output…



You will learn more about storage and processing in the next section

IPO MODEL EXAMPLE

Barcode Scanner, Touchscreen, Card Reader	→	Processor	→	POS Display, Audio, Receipt Printer

- This example represents a computer system in a supermarket – input devices have been highlighted green and output devices blue
- The cashier scans the items using the barcode scanner, after each item it bleeps and the item appears on screen
- The cashier begins the transaction using the touchscreen and the customer pays with cash or card using the magnetic strip or NFC reader
- The transaction is saved onto a central system
- The receipt prints and the cashier is ready for the next customer

IPO: OVER TO YOU

Place each device into the correct column…

Input Device	Process Device	Output Device

Bamboo Graphics Tablet

Intel Core i7

Microsoft Keyboard

Bang & Olufsen Speakers

Biometric Fingerprint Scanner

HP Webcam

Dymo Label Printer

AMD A6

LG LED 22" Screen

Samsung S Pen Stylus

INTRODUCTION TO PROCESSING

- So far we have looked at input and output devices, but we have yet to explore the most important component of a computer system – the processor
- The processor is called the CPU or Central Processing Unit which is the square chip most likely to be Intel or AMD – it is the brain of the computer
- The CPU transfers data between input devices, output devices and storage devices
- As it is constantly running many tasks during the time the computer is switched on, it requires its own fan and an application of heat conducting paste to prevent the chip overheating
- The CPU contains other components:
  - The ALU (Arithmetic & Logic Unit) contains electronic circuits that perform simple binary and logical operations
  - Registers are fast areas of memory inside the CPU used for storing temporary instructions and data during the execution of a program
  - Cache memory is used by registers to temporarily store small amounts of data, faster than storing in the main memory

PROCESSING POWER

- Every processor contains a clock, but not the type you use to tell the time!
- A processor clock keeps the electrical circuits synchronised by sending small electrical pulses
  - Think of it like the beat used by orchestras to keep each member in sync
- The electrical pulses are measured in megahertz (MHz) and gigahertz (GHz)
  - A typical middle-market laptop in 2016 would be around 2.5 GHz
- The faster the pulses, the more instructions the processor can execute per second
  - The processor clock sends 1 billion pulses per second, per gigahertz
  - Therefore a 2 GHz processor sends 2 billion pulses per second!
- Most devices on the market now have more than one processing core
  - Currently there is dual-core, quad-core and octa-core
- Each processing core can execute instructions simultaneously (at the same time) and therefore the higher the number of cores, the more tasks the CPU can carry out
  - A dual-core processor can execute two sets of instructions simultaneously, a quad-core processor can execute four sets and an octa-core processor can execute eight sets

BUSSES

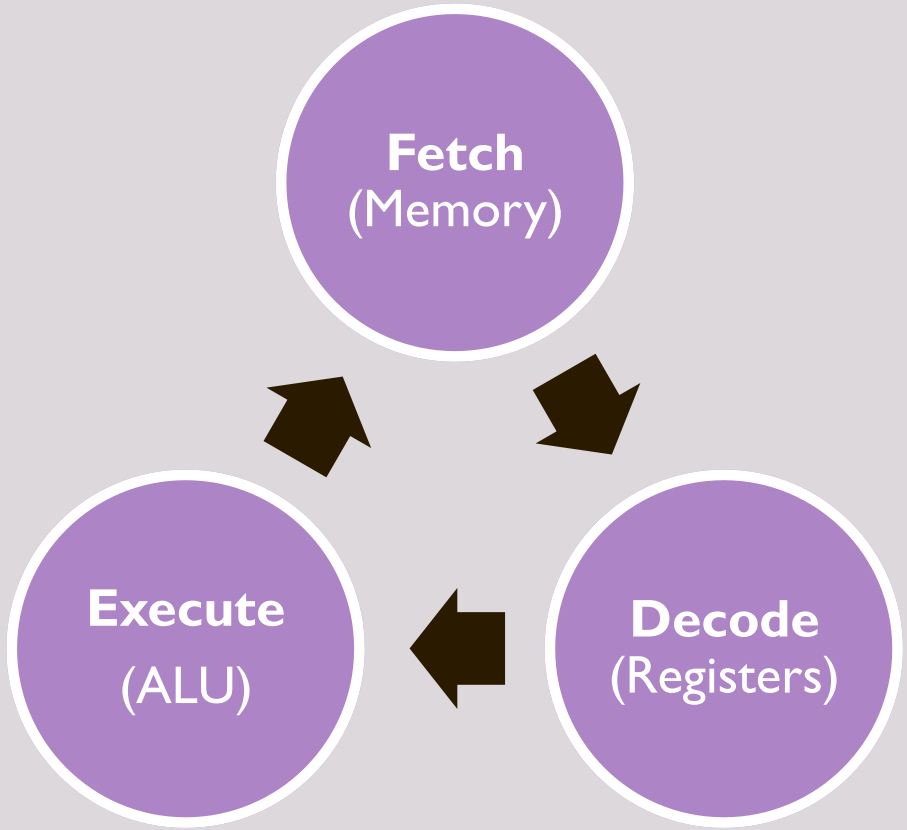
- Busses are the connections between components in the motherboard and CPU
- There are three main types of bus:
  - The Control Bus sends and receives symbolic data representing control information
  - The Address Bus sends and receives binary representing addresses of memory locations
  - The Data Bus sends and receives binary data between all components on the motherboard
- Busses also extend externally where external ports are used to connect peripherals
- These ports connect to the motherboard and internal busses allowing exchanges of binary data and control signals
  - The most common port is the USB which stands for Universal Serial Bus and is used for many peripherals such as mice and keyboards etc.
  - The latest version of USB is USB 3.0 which enables faster data transfer speeds than USB 2.0

MEMORY

- There are two main types of computer memory – RAM and ROM
  - Both of these are solid state, meaning there are no moving parts
- **RAM** (Random Access Memory) is used to store programs and data being processed by the CPU that the user has accessed
  - **RAM** requires a constant power supply as it is volatile, when the power is disconnected the data stored is lost
  - Data stored on RAM memory can be changed and deleted as required by the CPU
- **ROM** (Read-only Memory) is used to store setup information such as the boot sequence that is required by the operating system when the computer is switched on
  - **ROM** does not require a constant power supply as it is persistent, when the power is disconnected the data remains stored
  - As you may have guessed, ROMs are read-only meaning you can't change or delete data

BRINGING IT ALL TOGETHER

- The fetch decode execute cycle is used to describe the process instructions go through
  - This all occurs inside the CPU
- Fetch
  - Firstly the instruction code is located in the memory using an address
- Decode
  - Next the instruction is decoded in the processor's registers, depending on the type of encoding used
- Execute
  - Finally the ALU performs operations on the instruction, and stores the output in the main memory or sent to an output device
- This cycle continues…



4.4

DATA STORAGE

WHAT THE SPECIFICATION SAYS…

4.4 Content:

- Understand the differences between main memory and secondary storage.
- Understand the differences between RAM and ROM.
- Understand why secondary storage is required.
- Be aware of different types of secondary storage (solid state, optical and magnetic).
- Explain the operation of solid state, optical and magnetic storage.
- Discuss the advantages and disadvantages of solid state, optical and magnetic storage.
- Explain the term 'cloud storage'.
- Explain the advantages and disadvantages of cloud storage when compared to local storage.
- Understand the term 'embedded system' and explain how an embedded system differs from a non-embedded system.

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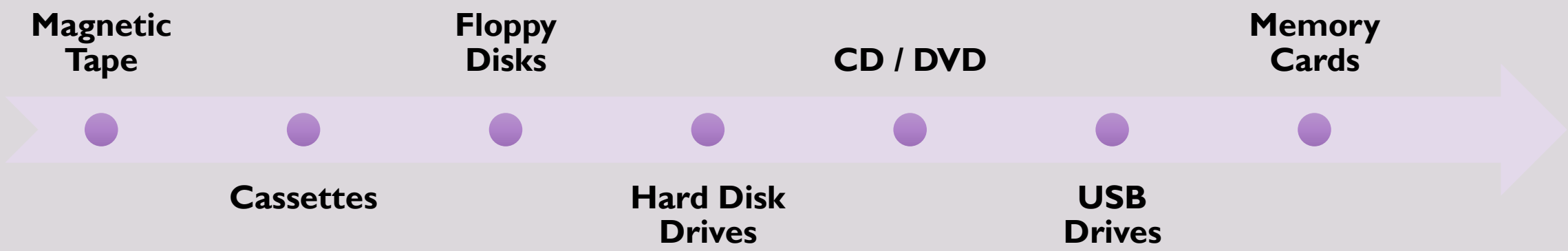
INTRODUCTION TO DATA STORAGE

- Data storage has improved over time, from storing on magnetic tape to the cloud…



- We can categorise these methods of physical data storage into three categories
  - Magnetic
  - Optical
  - Solid State

DATA STORAGE FORMATTING

- There are two different types of formatting that are used by physical data storage devices
- Linear Access is when data is stored from the beginning to the end of the drive and therefore when accessing data at a later point, the whole drive has to be searched to find it
  - Remember the linear search algorithm?
- CDs, DVDs, BluRay, Magnetic Tape, Floppy Disks all use linear access format
  - You can think of linear access like writing in a book, at a later date when you search for a piece of information you have written, you have to browse through from the start until you locate it
  - For example, data is written from the start of a magnetic tape to the end
- Random Access format is when data is stored on a drive but can be accessed quickly due to each file having a unique address that can be located
- Hard Disk Drives, Solid State Drives, Memory Cards, USB Drives all use random access format
  - You can think of random access like a book shelf, you can quickly identify the book you are looking for sing the name on the spine without searching from the beginning
  - For example, data stored on a USB drive can be found by a computer search in seconds

DATA STORAGE METHODS

Magnetic Storage (Tape)

- Advantages
  - Cheap method of storage
- Disadvantages
  - Write once only
  - Linear Access

Optical

- Advantages
  - HDDs Fast and large capacity
  - Easily backed up using copies
- Disadvantages
  - Moving parts can fail
  - HDDs make laptops bulkier
  - CDs/DVDs limited storage

Solid State Storage (SSD)

- Advantages
  - Faster than HDDs
  - No moving parts to fail
  - Random Access format
- Disadvantages
  - Can be expensive

Cloud Storage (Internet)

- Advantages
  - Accessible from anywhere
  - Storage capacity can expand
- Disadvantages
  - Can be expensive
  - Risk of being hacked

OVER TO YOU - CASE STUDY DROPBOX

"*Dropbox works just like any other folder on your computer, but with a few differences. Any files or folders inside Dropbox will get synchronized to Dropbox's servers and any other computer linked to your account. Green checkmarks will appear on top of your files to let you know that they're synced and up to date. All data is transferred over SSL and encrypted with AES-256 before storage. Dropbox keeps track of every change made to any of its contents. It is one of the most reliable ways to store and share files remotely on a PC, all while ensuring they are protected against loss or damage.*" - CNET

1. Suggest what type of storage Dropbox is, and summarise how it works. [3 Marks]
2. Identify 2 potential threats that are still present with this type of storage. Use Dropbox as an example. [3 Marks]
3. Explain how data encryption is used. Use Dropbox as an example. [3 Marks]
4. Assess the likely benefits and drawbacks, to a personal user, of using this type of storage. Use Dropbox as an example. [6 Marks]

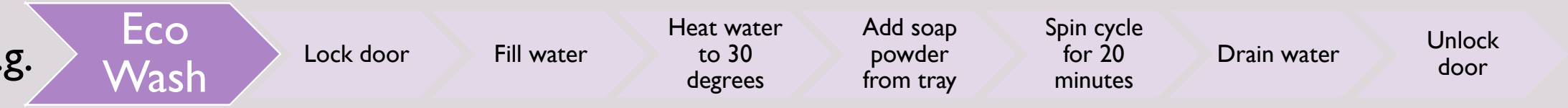
OVER TO YOU ANSWERS

	Question	Answer Scheme
Q1	Suggest what type of storage Dropbox is, and summarise how it works. [3]	1 Mark for identifying cloud storage as the type of storage • Accept remote storage 2 Marks for any of the following two points: • A folder on your computer that syncs with data servers • Selected files on your computer that are synced with data servers • Files automatically uploaded and stored on data servers • The files are encrypted and transferred using SSL • The files are stored securely • The files are accessible from any device logged into your account • The files are kept up to date / Changes are tracked Or any other relevant points that summarise cloud storage, in or out of context
Q2	Identify 2 potential threats that are still present with this type of storage. Use Dropbox as an example. [3]	2 Marks for any two of the following points • External Crime/Hacking • Misconduct/Internal Crime • Inadequate physical/technological security • Company Liquidation 1 Mark for Dropbox context
Q3	Explain how data encryption is used. Use Dropbox as an example. [3]	2 Marks for any two of the following points • Type of data scrambling • Algorithm used to change data • Transfers plaintext into ciphertext • Used to keep files secure if hacked • Used to keep files secure during transfer • Requires decryption/key/algorithm 1 Mark for Dropbox Context
Q4	Assess the likely benefits and drawbacks, to a personal user, of using this type of storage. Use Dropbox as an example. [6]	[3] Any 3 benefits of cloud storage [3] Any 3 drawbacks of cloud storage [S] Dropbox context used to secure answer

EMBEDDED SYSTEMS

- Embedded systems are a type of computer system which is not directly interacted with by the end user, but can still perform operations
- Embedded systems can control, monitor and instruct other components such as a sensor, motor or digital display
- The components within an embedded system are controlled using a user interface, either a touch screen or series of tangible buttons and controls
- We use embedded systems every day in devices and appliances as simple as digital scales or as complex as a washing machine
  - A washing machine would require temperature sensors to keep the water at a specific temperature. It would also require a motor to spin the barrel as a set speed for a set time
- Embedded systems use Read Only Memory (ROM) as it is persistent and does not require any changes to the data stored
  - The stored data for a washing machine would be instructions of it's user-controlled settings such as the different types of washes
- Embedded systems tend to work in sequences or patterns, such as in a washing machine

E.g.



EMBEDDED SYSTEMS - CARS

- Cars use embedded computer systems to control many functions as shown in the mind map →
- Each element of a car is controlled by an embedded computer system – you don't interact directly with it
  - You don't enter code on a screen to wind the windows down, you use buttons!
- Many elements are automatic based on sensors, such as the Airbags, activated by accelerometers that activate the airbags upon a sudden change in movement
  - The sensors make decisions in 1/30th of a second!
- Modern advances in embedded systems are allowing engineers and scientists to build driverless cars
  - There are safety concerns, however

Fact *The average residential broadband speed in the UK is 22.8mbps and 61% of people in the UK browse the internet using their smartphone*

TOPIC 5

FUNDAMENTALS OF COMPUTER NETWORKS

5.1

NETWORK ARCHITECTURE

WHAT THE SPECIFICATION SAYS…

5.1 Content:

- Define what a computer network is.
- Discuss the benefits and risks of computer networks.
- Describe the main types of computer network including:
  - • Personal Area Network (PAN)
  - • Local Area Network (LAN)
  - • Wide Area Network (WAN).
- Understand that networks can be wired or wireless.
- Discuss the benefits and risks of wireless networks as opposed to wired networks.
- Explain the following common network topologies:
  - • star
  - • bus.

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INTRODUCING NETWORKS

- A network is a group of computers that are able to communicate with each other
- A network can consist of Laptops, Desktop PCs, Tablets, Smartphones, Printers, Servers etc.
- Networks are used for a number of reasons…
  - Sharing files between devices
  - Sharing hardware
  - Sharing software
  - Ability to back up files
  - Central maintenance and support
- A network can be both wired and wireless or a combination of both
- You may be part of a network now as you use this resource
  - At school you will be connected to servers that store your data and provide an internet connection
  - At home you may be connected to a router which could allow you to share files with other connected computers

NETWORK SIZES – LAN & WAN

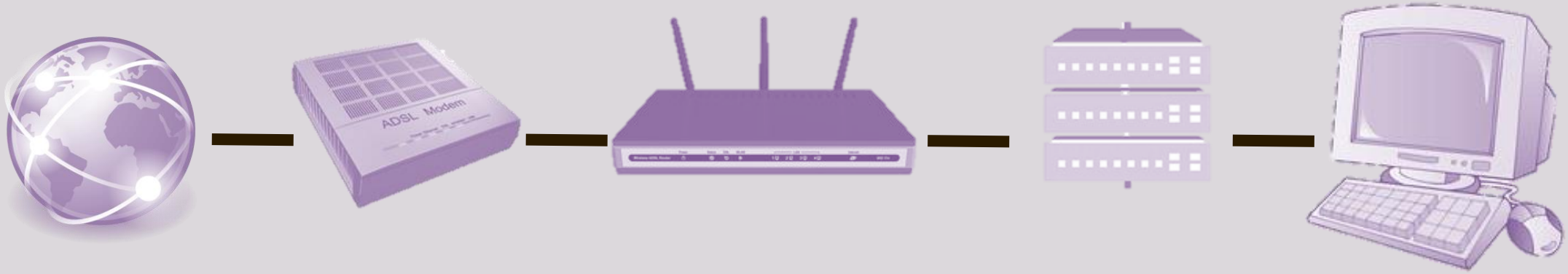
- A network can be one of several different sizes, all you need to learn is the most common three:
- A Local Area Network (LAN) is a network that are within a single building or site
  - The owners of the business using the LAN will own all of the components and devices, and therefore everything beyond the telephone line is of responsibility to the owner
  - In a home, the bill payer may not own the router if it's part of a contract agreement (E.g. Sky), but the rest of the components and devices within the network will be owned
- A Wide Area Network (WAN) is a network that is spread over a wider area and multiple sites
  - The owners of the business using the WAN will be using components between sites that are not owned, e.g. telephone wires between buildings that are owned by BT
  - This means that the communication links between sites are owned and looked after by another company (such as BT) and therefore there is most likely a cost for the service
- A Personal Area Network (PAN) is a network consisting of just a few devices in a short distance
  - PANs are often used with Bluetooth technology to send and receive files between devices such as a mobile phone to a tablet or computer – Bluetooth can only reach a few metres
  - Body Area Networks (BANs) are a form of PAN that consist of devices connected on the body, such as organ monitors or an ECG (heart trace) – these can be wireless to form a WBAN

CONNECTING TO A NETWORK

- Before a computer can be connected to a network it needs to have a piece of hardware known as a network interface card (NIC) or wireless network interface card (WNIC)
  - A network interface card is simply a small circuit with a socket for an Ethernet cable
  - A wireless network interface card is simply a small circuit with an antenna to send/receive data
    - On older generation computers this antenna will stick out the back, on modern computers it won't
- The computer will then need to connect to a hub or switch
  - A hub is a device that is able to connect multiple computers to a network and send data round the network
  - A switch is the same as a hub, except is able to process data and direct it to the intended device which improves overall speed
- The hub/switch is connected to a router which connects to a modem which uses a phone line to provide access to the internet
  - Most modern routers contain a modem, especially those used in the home (E.g. from Sky)

COMPONENTS OF A NETWORK (HARDWARE)

- The previous page may be a little confusing, so lets put words into pictures and show the hardware components between a computer and the internet:

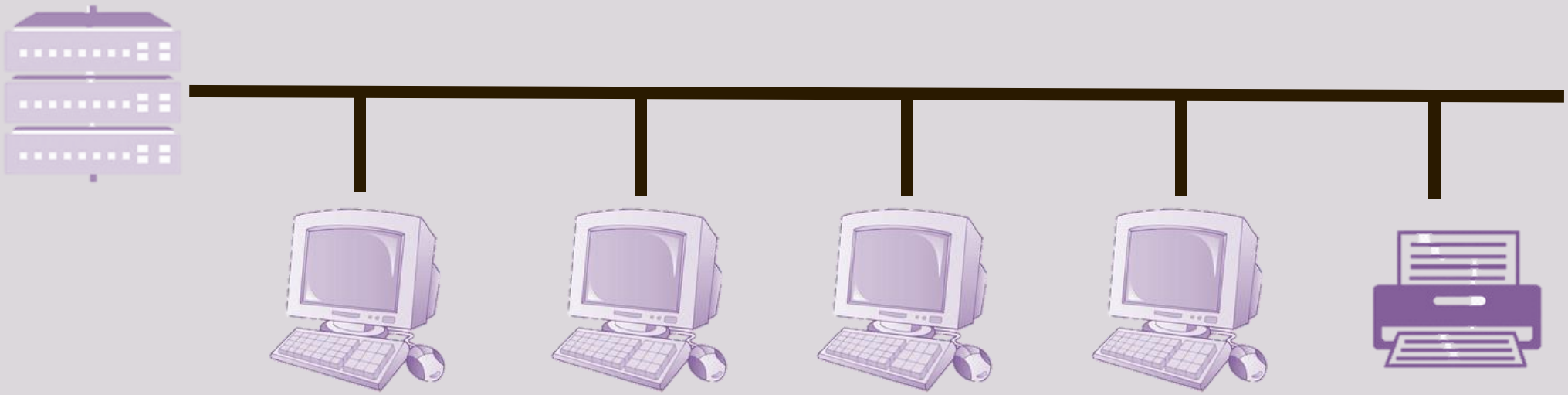


Internet — Modem — Router (May contain modem) — Switch/Hub — Computer (Containing NIC)

- As you can see, this is a very basic layout that summarises the components of a network
- There are different layouts of a network, known as topologies…

NETWORK TOPOLOGIES: BUS

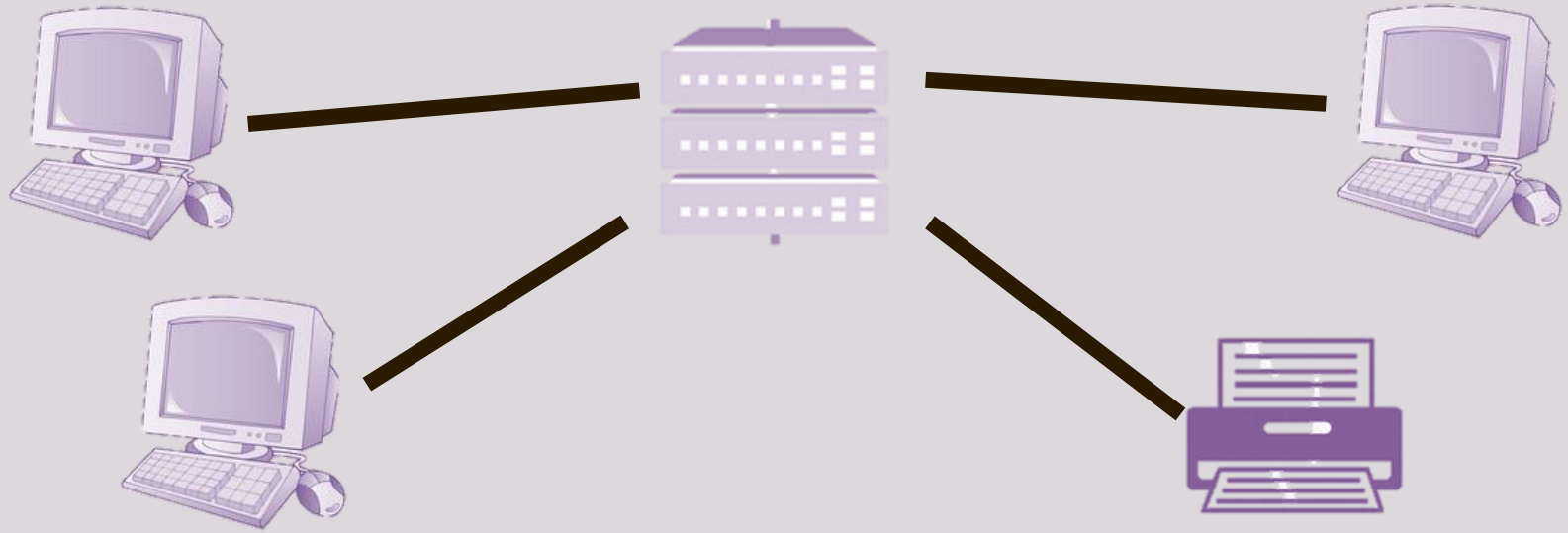
- This is an example of a Bus topology…



- Each device is connected to the main cable run known as the ‘backbone’
- This topology is cost effective and simple to set up due to the small amount of cables used
- This topology may not be the most practical, if the backbone breaks or fails then no device will have access to the network

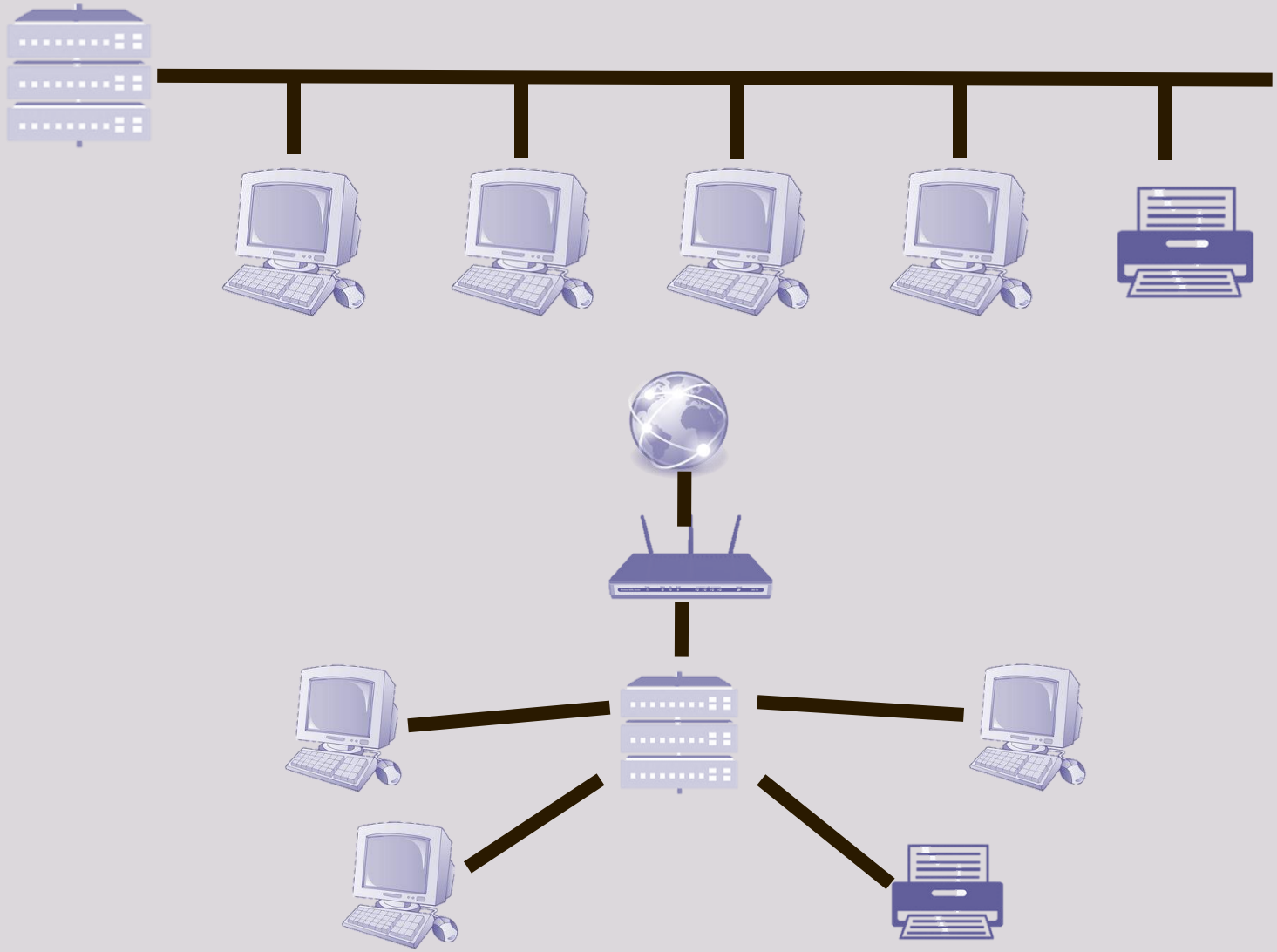
NETWORK TOPOLOGIES: STAR

- This is an example of a Star topology…



- Each device is connected using its own connection to the hub or switch
  - This topology will also represent a wireless network where the cables represent wireless signals
- This topology makes adding additional devices simple and if one of the cables breaks or fails, the other device are still able to connect to the network
- This topology may not be the most cost effective due to more cable being used

COMPLETE TOPOLOGIES



NETWORK TOPOLOGIES – OVER TO YOU

1. Star network topology
   a) Draw this topology with 3 computers and a printer
   b) Name an advantage & disadvantage of a Star topology
2. Bus network topology
   a) Draw this topology with 3 computers and a printer
   b) Name an advantage & disadvantage of a Bus topology
3. A small business with 30 members of staff are seeking to upgrade their network, currently they only provide an internet connection to staff who use email attachments to share files using their stand-alone computers
   a) Explain why the business should invest into a network, instead of their current stand-alone model
   b) Suggest a suitable network topology for this business, back up your suggestion using reasons
   c) List the likely components the business will require based on the topology you suggested in part b

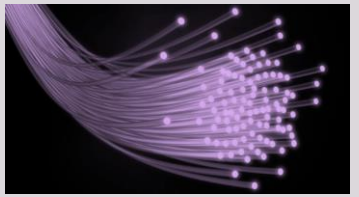
ROUTING & SWITCHING

- Routing is the process of using paths within networks to send packets of data
- Switching is the method of directing the data packets to the correct paths within a network
- Switching comes in two forms:
  - Circuit Switching is a continuous path that is established before the data is sent by a stream of continuous bits at the maximum data rate
  - Packet Switching is where individual packets of data are sent across the network instead of using a continuous connection – this is used over the internet
- You can think of circuit switching as a continuous roll of labels containing data, and packet switching as individual labels
- Sending data within a network uses a model known as peer-to-peer
  - Imagine a peer-to-peer network being your classroom and each pupil can transfer data to eachother
- When we transfer data from a server, such as requesting a website on the internet, this uses a model known as client-server
  - You will learn more about this in section 5.2

WI-FI

- Wi-Fi works by the use of antennas that send and receive radio signals which are carried by radio waves
- Radiofrequency waves for Wi-Fi are used at 2.4ghz and 5ghz at up to 360°
  - The higher the frequency, the shorter the potential range, but the faster the data will transfer
- When an antenna sends out an analogue signal, the radiofrequency wave must be converted into binary (as would the signal through a cable), this process is called modulation
- The type of modulation used for radiofrequency waves is known as frequency shift modulation which varies each radio wave into two different frequencies to represent binary digits 1 and 0
  - Frequency shift modulation is also used for other wireless data transmission technologies such as mobile data on your smartphone (3G, 4G)
- When the data is received by the destination antenna, the modulation process is reversed in a process called demodulation
  - By demodulating the data, it converts it from binary back into its original form in a similar way to encryption and decryption
- In order for a computer to connect to a WiFi network it needs to know the SSID which is simply the name of the router to differentiate it from others
  - Many WiFi networks require a password as a security measure
- Once devices are connected, the router can recognise them by their unique MAC address
  - The MAC address can be used to monitor the status of devices and to send data packets to the correct device

FIBRE OPTICS



- Fibre optic cables are becoming more common in networks and home broadband connections due to the much faster data seeds it can achieve compared to copper wires (used in Ethernet)
- Fibre optic cables work by sending pulses of infrared light down strands of fibre thinner than a human hair
  - The lights that are sent represent binary digits 1 and 0 (on and off)
  - This is known as on/off keying
- The infrared light is then received by the device connected at the other end
- Infrared light becomes weaker the further it travels and therefore longer runs of fibre optic may require regenerator devices which receive a weaker pulse and send out a new one – think of it like Chinese whispers!
- Fibre optic broadband is available in many parts of England and Wales, where fibre optic cables are laid underground between the local telephone exchange and the cabinet at the end of streets
  - This is known as FTTC meaning Fibre to the cabinet, the rest of the journey is existing copper wire
  - Some areas are trialling fibre from the local exchange all the way to homes or businesses, called Fibre to the premises or FTTP, creating even faster speeds up to 1gigabyte per second!
- The advantage of fibre optic networks is that data speeds are much faster than traditional copper wires
- The disadvantage of fibre is that equipment that uses it can be expensive to buy and set up

5.2

NETWORK PROTOCOLS AND THE INTERNET

WHAT THE SPECIFICATION SAYS…

5.1 Content:

- Define the term 'network protocol'.
- Explain the purpose and use of common network protocols including:
  - • Ethernet
  - • Wi-Fi
  - • TCP (Transmission Control Protocol)
  - • UDP (User Datagram Protocol)
  - • IP (Internet Protocol)
  - • HTTP (Hypertext Transfer Protocol)
  - • HTTPS (Hypertext Transfer Protocol Secure)
  - • FTP (File Transfer Protocol)
- Plus email protocols:
  - • SMTP (Simple Mail Transfer Protocol)
  - • IMAP (Internet Message Access Protocol).
- Understand the need for, and importance of, network security.
- Explain the following methods of network security:
  - • authentication
  - • encryption
  - • firewall
  - • MAC address filtering.
- Describe the 4 layer TCP/IP model:
  - • application layer
  - • transport layer
  - • network layer
  - • data link layer.
- Understand that the HTTP, HTTPS, SMTP, IMAP and FTP protocols operate at the application layer.
- Understand that the TCP and UDP protocols operate at the transport layer.
- Understand that the IP protocol operates at the network layer.

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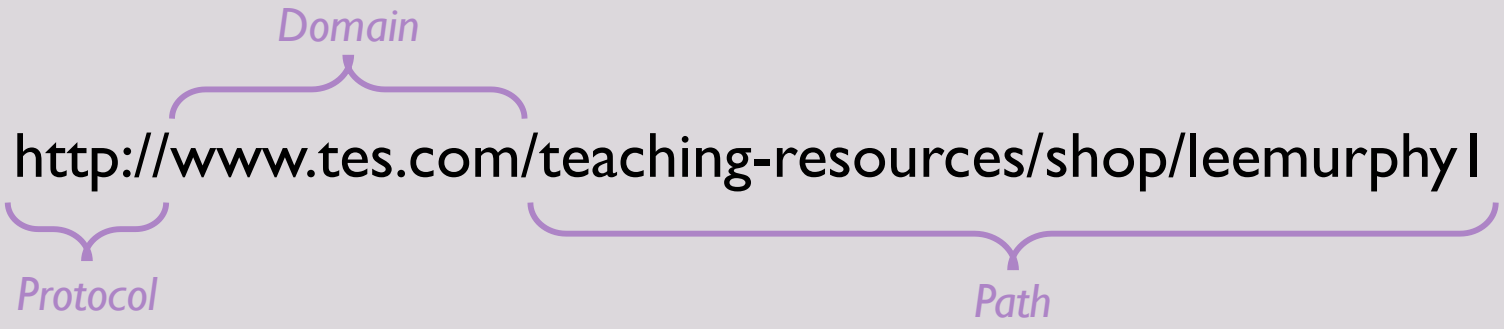
REQUESTING DATA ON THE INTERNET

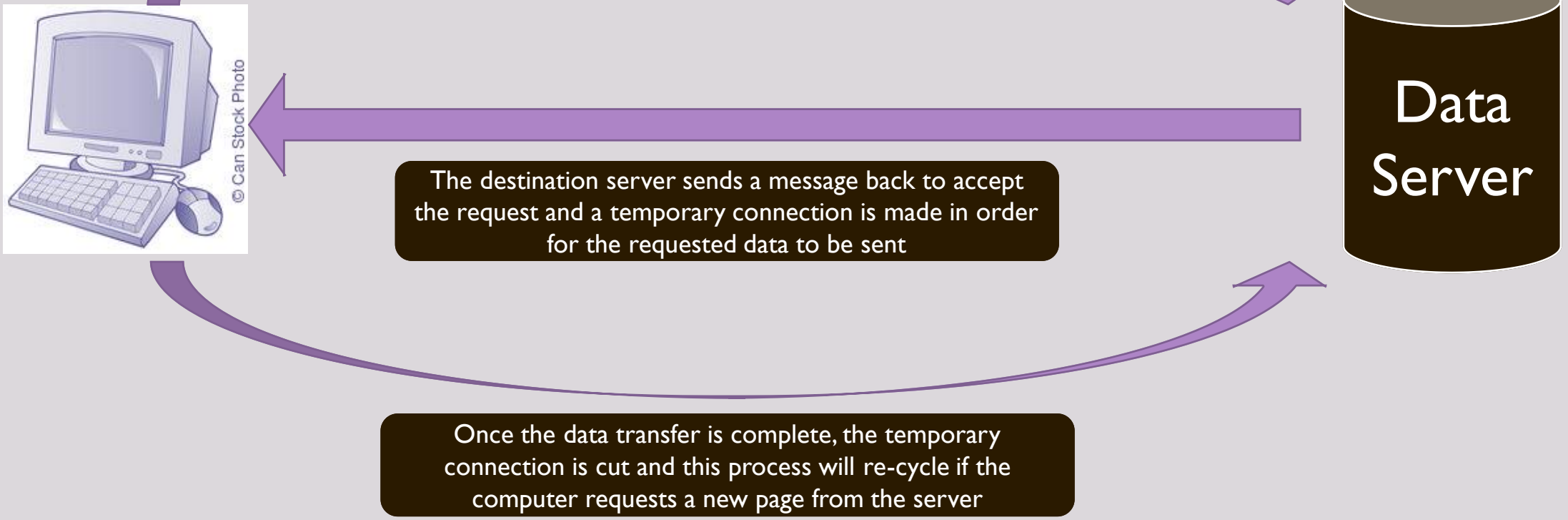
- To visit a website you have to type in a web address, or 'URL'
  - URL stands for Uniform Resource Locator
- A URL is made up of several parts
  - The initial part indicates the protocol – HTTP:// or HTTPS:// or FTP://
  - The next part is the domain which is simply the name of the website
  - The final part is the path which directs the browser to a specific page in a website
- Search engines such as Google and Bing store URLs so you don't need to know the URL of the website you wish to visit



SENDING DATA ON THE INTERNET

- When data is sent from a data server to a computer, it is formed a data packet
- The data packet contains the data itself, plus the destination address which is attached as it leaves the network
  - Think of it like when you send a letter… you don't just pop the letter in the post box, you have to place it inside an envelope and write on the address of who you are sending the letter to
  - This is the same with a data packet, where the destination address is attached as what's known as a header (Like when you add the address to a post card)
- In order to access data such as a webpage or file from the internet, a protocol called TCP is used
  - A protocol is simply a set of instructions and procedures that are followed
  - TCP stands for Transmission Control Protocol
  - The TCP protocol is known as a three-way handshake due to how it works…

TCP PROTOCOL:
THE THREE WAY HAND SHAKE



INTERNET PROTOCOL:
THE VIRTUAL POSTMAN

- Now we know that the job of TCP is to form and end the temporary connection, but how does the data packet get to its destination?
- A protocol known as IP (Internet Protocol) provides a service to TCP by sending and receiving the data packets to their correct destinations
  - IP provides a service to TCP just like the Royal Mail provides a service to residents sending and receiving mail
- IP transfers the file to its destination address, known as an global IP address, which is located in the header of the data packet
- The process so far will allow the data packet to reach the network…

PUBLIC IP ADDRESSES

- A Public IP address (Sometimes called Global) is a unique number that allows data packets to be sent to the correct destination
- IP Addresses contain four sets of numbers, each set at 1 byte in size
  - 256 is the highest number in 1 byte, therefore the highest possible public IP address would be "256.256.256.256"
  - This means that there are 4,294,967,296 total possible combinations of public IP address
  - This may seem a lot, but considering these are unique to each network, the world is running out!
- As a result of running out of Public IP addresses, there are now two different versions:
  - IPv4 (Internet protocol version 4) contains a total of 4 bytes, or 4 sets of 1 byte
  - IPv6 (Internet protocol version 6) contains a total of 16 bytes, and is structured as a hexadecimal
- Over to you - Using a calculator, work out the total possible combinations of IPv6 addresses using the standard form of $4.2 * 10^9$ compared to IPv4 with the standard form of $3.4 * 10^{38}$

LOCAL IP ADDRESSES & NAT PROTOCOL

- Now we know that each network has its own unique public IP address, but how does the data packet reach the correct device within the network?
- This works by using a protocol called Network Address Translation (NAT) which will take the public IP address located in the header of the data packet, and translate it into a local IP address that is specific to a device within the network
- Local IP addresses are only unique within the network, if you connect to another network you could be using the same local IP address or a similar one
  - Imagine your postal code is a public IP address, your house number is a local IP address… you are not the only one with that house number, however you are the only one within that postal code with that house number
  - If your postman only had your postal code (public IP), it would not know which house to deliver the letter to without a house number (local IP)
- When a data packet reaches the network router, this is the point at which the NAT protocol will direct the packet to a specific device – It could be a Laptop, Games Console, TV etc.
- The common local IP address is usually 192.168.XXX – where X is a number

HYPERTEXT TRANSFER PROTOCOL

- HTTP is a protocol that is a standard format for requests of web pages and all the content with it such as text, graphics, multimedia and sound
- It is used as soon as you open a web browser
  - A web browser is a piece of software that allows you to view web pages
  - An example of a web browser is Safari on a Mac computer, or Google Chrome on your phone
- The web browser uses HTTP that will instruct TCP to request a website based on the link the user selects, or the web address they type in
- The web address is known as a URL (Uniform Resource Locator) which is simply the address of a website (You will learn more about this in section 5.3)
  - Websites begin with HTTP, e.g. http://www.google.co.uk
- Some websites begin with HTTPS which indicates that it is a secure website and data is encrypted
  - Look back at section 3.4 for more on internet security and encryption

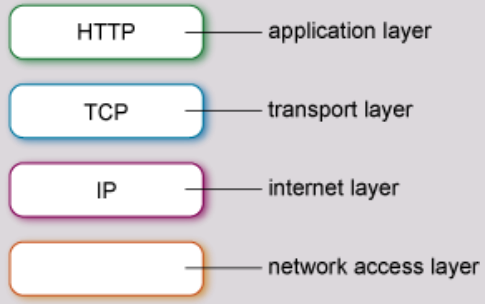
FILE TRANSFER PROTOCOL

- File transfer protocol, FTP, is a protocol used to transfer files between a computer and server
- The server in which data is being downloaded or uploaded to needs to be active to allow the connection to take place
- The connection usually uses TCP, the three way hand shake, with the requirement to enter a username and password for security
  - Remember that TCP creates a temporary connection to a server, whereas a local server on a network is always connected and accessible
- The most common use for FTP is to publish and edit websites onto web servers
- HTML and other coding can be uploaded to the server that will host the website
- A common tool used to access files on a server, known as FTP client software, is FileZilla

Click the right arrow to see Filezilla in action

PROTOCOL STACK

- So far we have looked at four different protocols related to sending and receiving data across the internet:
  - Transfer Control Protocol (TCP)
  - Internet Protocol (IP)
  - Network Address Translation Protocol (NAT)
  - Hypertext Transfer Protocol (HTTP)
  - File Transfer Protocol (FTP)



- If we place these protocols into order, we create a protocol stack
  - A protocol stack is a set of protocols, one on top of the other, that are used together to provide a complete communications service
- The layer below each given protocol provides a service to the above protocol
  - For example, when we looked at TCP/IP, we said that IP provides a service to TCP like how the Royal Mail provides a service to us - TCP is the layer above IP
- This principle applies for each layer, until we reach the network access layer which is the final layer in the stack
  - The network access layer is the point at which data is transferred through a physical medium (E.g. an Ethernet cable)

WHAT IS STREAMING?

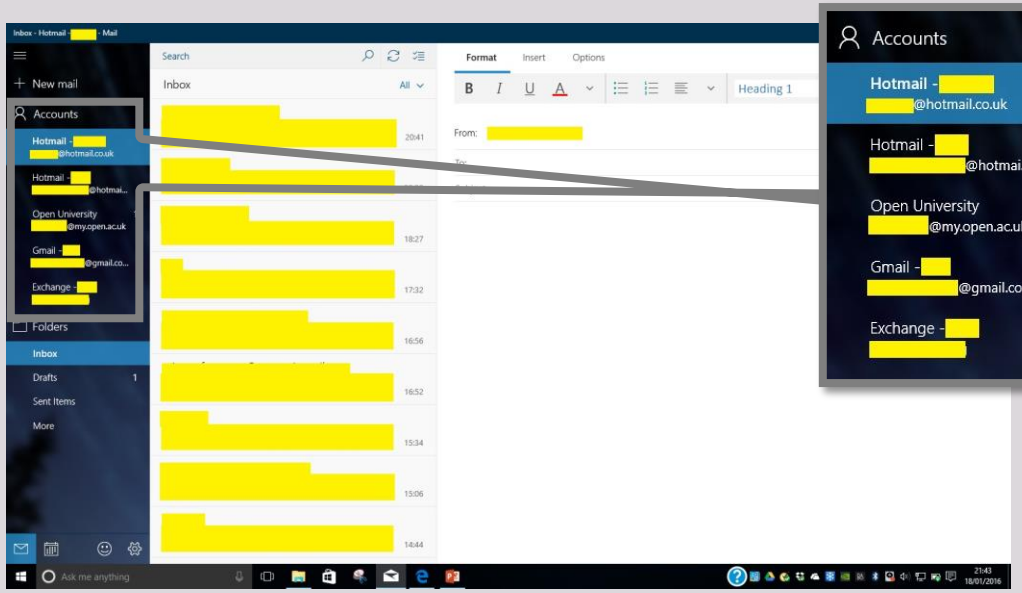
- We often use the term 'streaming' in relation to watching videos or listening to music, but what does it actually mean?
  - Streaming is the process of sending data packets from a server where the file is located
- The data packets are sent in moderation part by part, this means the full video or music track isn't downloaded entirely
  - As a result of this, buffering occurs due to slow internet connections or as a result of many people accessing the server (traffic) – this causes stopping of content periodically waiting for the next download of data packets containing the next few seconds of video/audio
- Streaming also occurs when you watch a live video or audio broadcast (webcast) as you are receiving the data in real time as it is being produced
  - As a result of this, the synchronisation between the live recording and the audience watching/listening may be behind by a couple of seconds – this is known as latency
- The most common example of streaming which we have all seen is on the news… when a correspondent is in another location sometimes there is a delay between the studio presenter asking questions and the correspondent responding
  - Although this isn't via the internet, you get the idea!

EMAIL PROTOCOLS

- A protocol is simply a set of common instructions that allow computer systems to communicate with each other
- When you receive an email, where is the data stored?
  - The answer is, it depends… it depends on the protocol used by your email provider
  - For example, if you used a Hotmail account, they support both inbox protocols…
- IMAP (Internet Message Access Protocol) is a standard protocol for receiving emails
  - With IMAP the email message is stored on the email server, but not on your computer unless you specifically open it
  - This is particularly beneficial if you have limited data speeds or storage, such as on a smartphone where you have little space, you can just open the emails you want
  - The disadvantage of IMAP is that when you delete an email from any device, it will delete it from the server and therefore you will not be able to retrieve it on another device
- POP3 (Post Office Protocol version 3) is a common protocol for receiving emails, supported by most providers
  - With POP3 the email messages are stored on both your device and the email server; This means that if you delete an email, it wont delete it from the email server and you will still be able to access it from another device
  - Another advantage of POP3 is that you can open emails and attachments without an internet connection, as they would have been downloaded previously when you had a connection
  - The disadvantage of POP3 is that if you have a slow internet connection, it can take a while for all of your emails to come through, whereas with IMAP you can download the email content one at a time
- SMTP (Simple Mail Transfer Protocol) is the standard protocol for sending email messages to a recipient

EMAIL CLIENTS

- An email client is a piece of software or app that is used to send, receive and manage emails and attachments
- Most email client software has not been created by the provider, but will allow the user to view and manage multiple accounts from different providers
- The email client software acts as a third party between the user and the provider, in a similar way as the Postman when delivering letters on behalf of somebody
- You may have already been using an email client without realising, here are some examples:
  - Windows Mail (See screenshot)
  - iMail app for Apple iPhones and iPads
  - Pre-installed Mail app for android smartphones
  - Mozilla Thunderbird
  - eM Client for Windows
  - Microsoft Outlook or Outlook Express
  - Zimbra



PROTOCOLS & CONNECTIONS – OVER TO YOU

1. Define what is meant by a 'protocol'
2. State the role of the TCP (Transfer Control Protocol) using the three-way handshake
3. State the role of the IP (Internet Protocol)
4. State the role of the HTTP (Hypertext Transfer Protocol)
5. State the role of the NAT (Network Address Translation) protocol
6. Draw the 4 layered protocol stack and label using the above protocols
7. Add TWO data transfer components in the network access layer, to your drawing
8. Explain the difference between a public and local IP address
9. Explain why buffering occurs when streaming online videos on websites such as YouTube
10. There are 4,294,967,296 total possible combinations of public IP address, express this value in standard form ($x * y^z$)

DATA PROTECTION

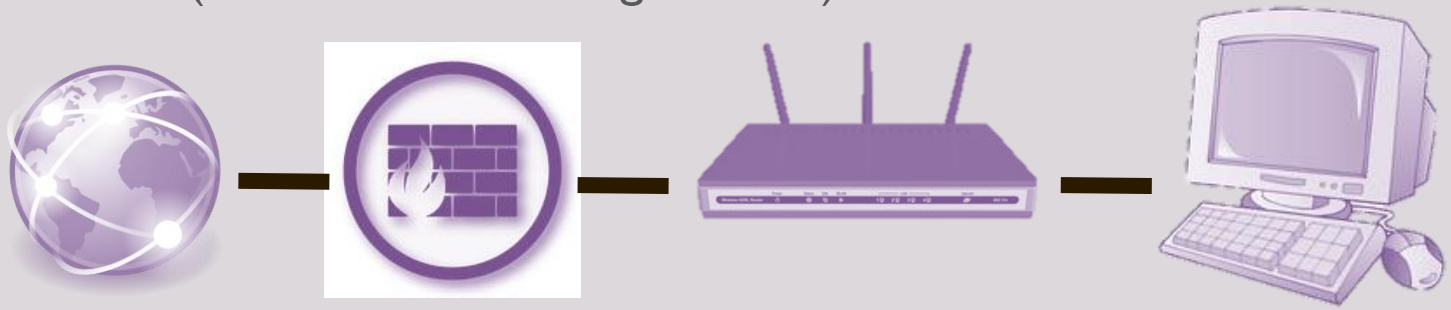
Kensington Lock on Laptop

Data can be protected in a number of different ways:

- Real-world protection
  - CCTV (Closed Circuit Television), Security doors, Kensington locks and Biometric access
- Anti-virus software
  - Software that removes viruses by scanning the hard drive and monitors new downloads
- Basic backup
  - Backing up files onto external hard drives, flash sticks, optical disks and magnetic drives
  - Storing data off-site at different locations to protect against floods and fires
- Advanced backup (RAID)
  - Redundant array of inexpensive disks – A system that mirrors hard drives onto other drives
- Cloud backup
  - Backing up files onto the cloud to protect against acts of nature, whilst allowing anytime access
- Continuous power (UPS)
  - Uninterruptable power supply – A battery that runs during a power cut to prevent computers/servers switching off
- Personal choices
  - Making sensible decisions such as not writing passwords down and ensuring nobody is 'shoulder surfing'

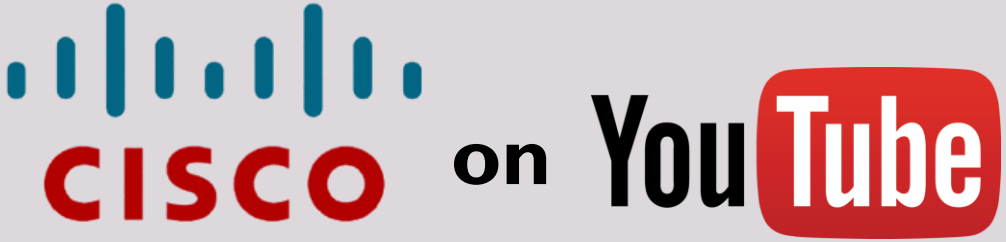
INTRODUCING FIREWALL

- Another method of data protection is firewall, which is a security system put in place to monitor and restrict incoming (and outgoing) data packets before it reaches the network and connected devices
- It acts as a security guard between the world wide web and a network (or stand alone PC)
  - This is the same as putting a lock on a door, it may not work all the time, but its still important
- Firewalls are usually in the form of software, however in large data centres such as those storing all your files for Dropbox, a physical piece of hardware can be used
- We can add in a firewall to the Internet access diagram. As you can see it sits between the internet and modem (or router containing modem):



SECURITY THREATS TO BUSINESSES – OVER TO YOU

- Watch the following video by clicking on either logos, then answer the questions below:



1. Explain how attacks to business networks and data may affect their operations.
2. Suggest how businesses may reduce the risk of these attacks, and recover from those that occur
3. Explain what is meant by a firewall and summarise its use in a network.
4. Suggest why hackers commit these types of crime and what they can do with the data they access
5. Suggest three ways in which these hackers can access data by unauthorised access.
6. Explain how a worm on one computer could affect a whole network once connected

Fact Did you know that 65% of internet users have been a victim of cyber crime, a result of virus attacks or identity theft

TOPIC 6

FUNDAMENTALS OF CYBER SECURITY

6.1

CYBER SECURITY THREATS

WHAT THE SPECIFICATION SAYS…

6.1 Content:

- Understand and be able to explain the following cyber security threats:
  - • social engineering techniques
  - • malicious code
  - • weak and default passwords
  - • misconfigured access rights
  - • removable media
  - • unpatched and/or outdated software.
- Explain what penetration testing is and what it is used for.

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RISKS TO DATA

Anti-shoulder surfing hoodie

There are many risks to data:

- Acts of nature (Natural disasters)
  - Data can be damaged in floods, fires, hurricanes, earthquakes etc.
- Acts of crime
  - Computer misuse, hacking, phishing, spyware, shoulder-surfing, theft etc.
- Accidental loss
  - Accidental deletion, physically losing mediums of storage such as memory sticks etc.
- Technology failure
  - Power cuts, power surges, hard drive failure, software failure, file corruption etc.
- Viruses & malware
  - Worms, Trojans, and Viruses…

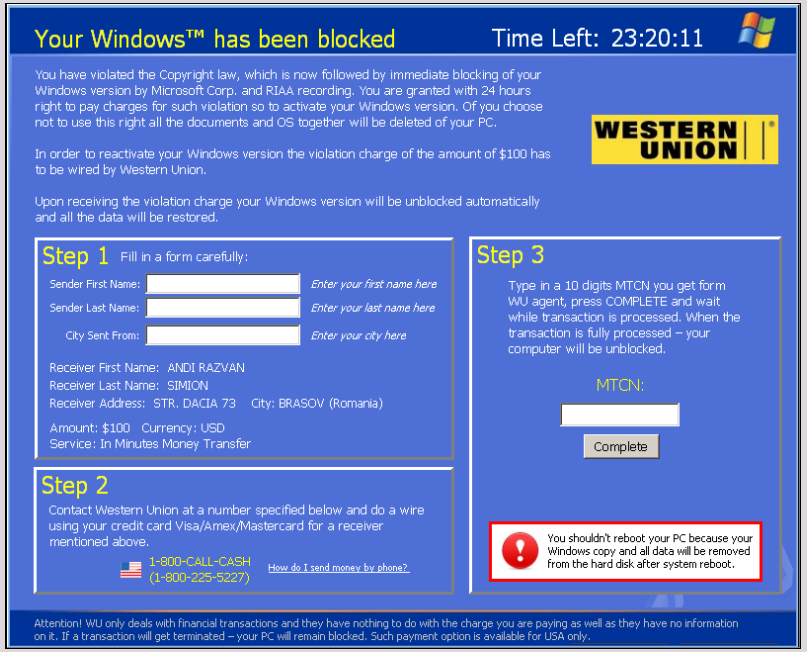
PHISHING

- Phishing is a technique to obtain sensitive information from a victims computer
- The easiest method to do this is by tricking the victim into entering their bank account details or website passwords into an online form that has been designed to look authentic
- For example, the following web page has been designed to look like PayPal, however on further inspection the URL is different to the genuine PayPal website
  - You should expect to find the genuine PayPal domain or sub domain but with a different directory page - e.g. www.paypal.com/account/security or www.security.paypal.com
  - Also, you will notice that the protocol being used is not HTTPS:// and therefore is not using SSL or TLS encryption
- Don't forget, it's not just bank or financial related information criminals want, it could be social media or email accounts too
  - For example a fake Facebook™ or Hotmail™ login page

Click the right arrow to view the example

CYBER ATTACKS

- Cyber attacks are carried out by criminals who wish to steal or destroy data
- The criminals will hack into the servers and steal the data of staff and customers
  - They most commonly occur at large companies, however the general public are also at risk
- A type of cyber attack that has been increasingly common is known as ransomware
- Ransomware is a type of hack which locks the victim's computer and forces them to phone a number or follow a link to make a payment to the criminal to unlock the computer
- Another type of cyber attack is known as a DDOS attack which is where criminals cause servers to fail by overwhelming it with data requests



TalkTalk CASE STUDY

- In October 2015 there were two cyber attacks on the website of TalkTalk; a broadband, landline and TV provider. During the attack, its thought that over 15,656 customers' private details were obtained, including bank account details.
- The hack left customers feeling very worried about their private information, and many of those affected began to receive bogus calls from scammer posing as TalkTalk or Microsoft staff in an attempt to gain access to their computers remotely.
  - One of the scams was to convince the customer they had a problem with their broadband connection or software and that they would be able to fix this for a fee of up to thousands
  - They would then convince the victim to allow remote access where they would open settings and commands to make it look like they were carrying out technical work, but in reality they were not
- Once the data had been accessed, it is easy for the hackers to sell the data on to others who may use it for further scams or to attempt to gain further access to bank accounts
- After long investigations, TalkTalk revealed that the data accessed was part encrypted and therefore the non-encrypted parts of bank details could not be used for financial gain
  - TalkTalk would not encrypt all of the data for security procedure use (ironically), for example when you are asked to confirm the last 4 digits of your bank card number
- Since the hack, as of February 2016, its thought that over 101,000 customers left TalkTalk and the entire incident has cost the company as much as £80 million

Source: Sky NEWS

6.2

MALICIOUS CODE

WHAT THE SPECIFICATION SAYS…

6.2 Content:

- Define the term 'malware'.
- Describe what malware is and how it can be protected against.
- Describe the following forms of malware:
  - • computer virus
  - • trojan
  - • spyware
  - • adware.

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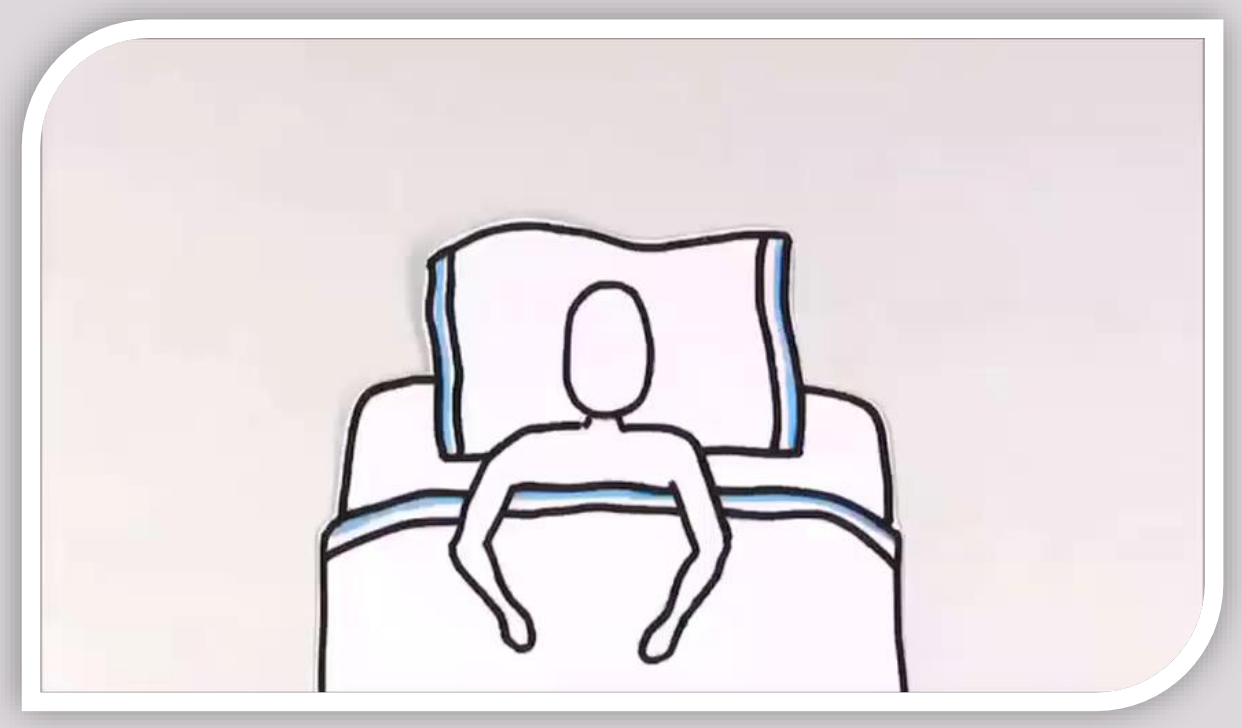
VIRUSES & MALWARE

A Trojan identified by Norton – a subscription anti-virus software.

- Virus
  - Viruses travel between devices via email attachments, networks, removable storage or internet downloads. Viruses attach themselves onto files which may then be transferred or stored on other devices. They can cause files to be destroyed and cause issues with software.
  - Think of the common cold, a type of bacterial virus, which is spread by the source (the human that sneezes!). The spread virus can be destroyed by anti-bac cleaners, but the source continues spreading.
- Worm
  - Worms work in a similar way to viruses, however do not require a source file and therefore they can travel on their own. Worms can use file transfer systems and vulnerabilities in software that requires a 'patch'.
- Trojan
  - Trojans are pieces of software that are created for malicious uses. They can be transferred by being masked as a legitimate file which will then cause the operating system to malfunction (They cannot spread by themselves).
  - Trojans can also create routes for other Trojans and Worms to enter – these are called 'backdoors'.

VIDEO…



Click to play

UNWANTED SOFTWARE

- Unwanted software can be accidentally installed either as part of a legitimate piece of software, clicking the wrong link or by encouraging advertisements on web pages
- Unwanted software may contain Trojans, or may be safe but simply take up hard drive space, change settings and use up processing power
- Here are two examples of unwanted software that may catch people out…

More advice here: http://minemum.com/safe-downloads

Fact Did you know that the average British person spends up to 9 hours per day using some form of computer? That's almost 11 days a month!

TOPIC 7

ETHICAL, LEGAL, ENVIRONMENTAL IMPACTS OF DIGITAL TECHNOLOGY ON WIDER SOCIETY

7.1

ETHICAL, LEGAL, ENVIRONMENTAL IMPACTS

WHAT THE SPECIFICATION SAYS…

7.1 Content:

- Explain the current ethical, legal and environmental impacts and risks of digital technology on society. Where data privacy issues arise these should be considered.

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ENVIRONMENTAL IMPACTS

- Using computing technologies requires sources of electricity which is mainly from unrenewable resources (It's also expensive!!)
  - E.g. Burning fossil fuels which can damage the environment and will one day run out
  - We can overcome this by using lower energy parts and switching to renewable sources
- Another problem is the level of old computers and components going to landfill
  - As technology is moving faster than ever, products we have get replaced more quickly
  - We can reduce this impact by recycling or reusing our unwanted goods
- As more people shop online, there are more vehicles on the road that deliver these goods
  - This causes more pollution in the air and more packaging being used to protect the products
  - We can reduce this by delivering to central points such as Amazon Lockers to reduce the amount of journeys couriers make, and then recycling the packaging goods arrive in
- Can you think of any other environmental impacts? How can we reduce their impacts?

E-WASTE CHINA – CASE STUDY

Click to play

SOCIAL IMPACTS

- Many people believe that technology reduces the need for jobs – this is arguable
  - Technology may replace jobs such as self-checkout lanes in supermarkets
  - Technology may create jobs such as building and maintaining networks in a business
- Technology may cause people to become anti-social and not go out as much
  - With popular social networking sites such as Facebook, people may not go out with friends as much as they used to
  - On the other hand, it allows us to stay in touch with long distance family and friends
- Playing computer games can cause young people to become unhealthy
  - When children & teenagers are playing computer games they are not getting any exercise
  - However, there are smartphone apps and wearable tech to help monitor and encourage exercise
- *Notice the structure of this slide – Statement, Expansion/Examples and Balance – Use this structure in your exam where you may be asked to discuss or argue the impacts on society*

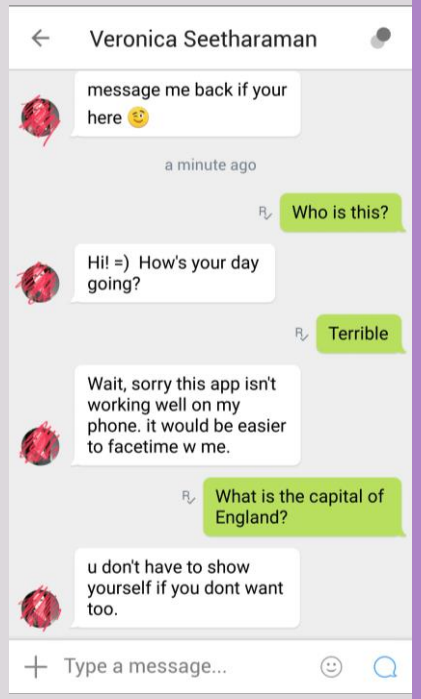
MISUSE OF THE INTERNET

- Discriminating a specific group through social groups and hate pages
  - This could be posting abuse or disallowing participation of activities based on gender, age, disability, religion, race, political preference or sexual orientation
- Sending abusive or hate messages personally or publically online to gain a reaction
  - Sometimes referred to as 'trolling', sending abuse online can be upsetting and is considered cyberbullying
- Hacking or gaining access to a social media account without the persons consent
  - Sometimes referred to as 'fraping', hacking another persons social media account can be very distressing and although not illegal, it could easily lead towards illegal crimes
- Posting sexual images or messages online without the persons consent
  - Sometimes referred to as 'revenge pornography', it is illegal to carry out this crime and offenders could face up to 2 years in prison under the Criminal Justice and Courts Act 2015

➢ Netiquette (Internet Etiquette) is the general acceptable way of using the internet

WHO AM I TALKING TO?

- Bots
  - Bots are used as virtual people that are mainly used in good faith to provide a service such as basic questions and answers (E.g. iPhone's Siri) or to direct a user to the correct page of a website
  - However, bots can also be used as fake instant messenger contacts to encourage the victim to buying something or opening a link containing a virus or worm.
  - See this example of a Bot on the instant messenger app 'Kik' – as you can see they do not answer appropriately, deliberately talk in slang and attempt to divert the conversation to another app or link…
- Fakes
  - A catfish is when somebody creates a fake social media profile (E.g. Facebook) by using somebody else's photos and creating a false name
  - A catfish may encourage an unwilling victim to send money or meet up with them where they can be taken advantage of in a sexual or violent nature
  - There is a television series on MTV called 'catfish' where the two presenters help out potential victims of fake profiles, they investigate to find out who they really are



LAWS & REGULATIONS

- Computer Misuse act 1990
  - This law prevents computer crimes such as making and distributing viruses, accessing data and files without permission, changing data and files without permission and committing fraud or identity theft using the internet
- Data protection act 1998
  - This law prevents data crimes such as sharing or keeping private data without owners permission or for financial gain, failing to keep information up to date, failing to sufficiently protect data
- Copyright, Designs and patents act 1988
  - This law prevents people using, sharing, changing, copying or selling materials or designs that have a copyright, trademark or patent associated with them unless the person has permission from the owner(s). This law also covers activities outside an agreed licence (E.g. Selling a piece of music, provided for personal educational purposes only, for financial gain)

Copyright

Registered Trademark

Unregistered Trademark

SOCIAL & LEGAL TRENDS – OVER TO YOU

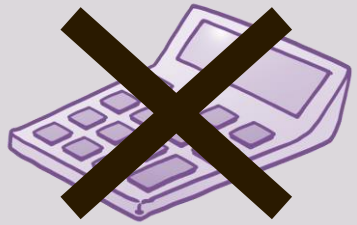
1. Using examples, discuss two environmental impacts of technology
2. Explain, using examples, how wearable technology can help young people exercise
3. Suggest three potential injuries you could sustain working at a desk
   - For each injury, state how it could be avoided
4. Explain what is meant by open source software
5. Suggest three ways somebody could misuse the internet
6. Name three laws that are used to prevent computer crime
   - Give an explanation for each act using examples where suitable
7. Explain how a piece of artwork could be protected online
8. Suggest how police may be able to trace an online crime back to the user
   - Tip: Think back to topic 5.4

Fact *Did you know that Edexcel marked more than 4.7 million exam papers in 2014? That's equal to* 12,876 papers per day for a whole year!

EXAM SUPPORT

LEARN, REVISE, PRACTICE

THE FACTS
(FOR TEACHERS!)



- There are three components (or Units) in this course…
  - Component 1 (or Unit 1) is the first examination paper which is 1 hour 30 minutes, marked out of 80 and constitutes 40% of the overall course
  - Component 2 (or Unit 2) is the second examination paper which is 1 hour 30 minutes, marked out of 80 and constitutes 40% of the overall course
  - Component 3 (or Unit 3) is the internally assessed programming project of 20 hours, marked out of 80 and constitutes the final 20% of the course
- The benefit of this course is that both external examinations assess candidates based upon a single pool of theory; thus allowing you to teach the complete theory in one block
- Both papers consist of multiple-choice, short open response, open response and extended open response answer questions
  - Calculators are not allowed in either examinations

WHAT I NEED TO REVISE

EXAM PAPER 1

- Questions will be about all topics:
  - Topic 1: Fundamentals of Algorithms
  - Topic 2: Programming
  - Topic 3: Fundamentals of Data Representation
  - Topic 4: Computer Systems
- Practice using case studies and more 'hands on' questions such as drawing flow charts or completing calculations
- You will also use Topic 1-2 in your coursework

EXAM PAPER 2

- Questions will be mainly about topics:
  - Topic 3: Fundamentals of Data Representation
  - Topic 4: Computer Systems
  - Topic 5: Fundamentals of Computer Networks
  - Topic 6: Fundamentals of Cyber Security
  - Topic 7: Ethical, legal, environmental impacts of technology on wider society
- Practice using more theoretical questions with short and long answers

‘TRIGGER’ PHRASES

Trigger Phrase	Possible Marks	Meaning
Calculate/Convert	1 - 2	Calculate values given in the question or table with workings E.g. Convert 5689 Megabytes into Bytes
Identify/Name/State	1 - 2	Multiple choice, list or short sentence answer E.g. Which of the following protocols is used for email?
Describe/Explain	2 - 4	Longer answer including a definition and one/two points E.g. Describe what is meant by run-length encoding
Complete/Construct/Amend	3 - 6	Add, update, change data or solve a problem E.g. Amend the following flowchart to correct the error
Write/Construct/Derive/Draw	3 - 8	Create code, flowchart, table, mind-map or find a solution E.g. Write pseudo code for the following problem
Discuss/Compare/Assess	6 - 8	Long answer in paragraphs with balance & conclusion E.g. Discuss the environmental impact of recycling computers

Remember, this is only a guide, and other trigger words may appear and the amount of marks awardable may vary

EXAMPLE QUESTION 1

Describe
(1 Mark per point)

0 3 . 2 Most modern washing machines are embedded systems. Embedded systems normally have less main memory than non-embedded systems.

Describe **two** other likely differences between the main memory for a washing machine and the main memory for a non-embedded system.

[2 marks]

Another difference in main memory of an embedded system is that it is likely to be non-volatile ROM rather than RAM.

Also, the memory and processor (CPU) will most likely be on a single circuit board rather than separate components.

- This question asks you to DESCRIBE TWO other differences of an embedded system compared to a non-embedded system, in terms of its main memory
- As it is a describe question two marks are available, and the question specifies two points, we know that we only need to write two sentences with no further explanation
  - i.e. This is testing knowledge only
- The above example would be awarded both marks as two correct differences have been described

EXAMPLE QUESTION 2

Calculate
(1 mark per step)

0 8 Bob purchases a 4GB SD card for use as secondary storage in his phone.

0 8 . 1 Calculate how many megabytes there are in 4GB. Show your working.

[2 marks]

1GB = 1024MB

4 X 1024 = 4,096MB in 4GB

- This question asks you to CALCULATE given values
- As there are TWO marks available, you are expected to show your working
- Firstly, show how many megabytes in 1 gigabyte and then multiply the answer by 4 to get the number of megabytes in 4 gigabytes
- If you get the final answer incorrect but the working is correct, you will achieve 1 mark

EXAMPLE QUESTION 3

Discuss
Longer response

0 5 . 4 "Schools should use a wireless network instead of a wired network".

Discuss this statement.

[6 marks]

- This question asks you to DISCUSS the given statement on wireless networks vs wires networks
- There are 6 marks available, and no specific number of points is asked for in the question so we need to make a judgment…
  - You should write around three points on wireless networks (advantages & disadvantages)
  - Do the same again for three points on wired networks (advantages & disadvantages)
  - You should give reasons for every point you make, and your points must be suitable and accurate
- In order to achieve the full 6 marks, you need to write in a suitable structure and in balance
  - Remember longer questions like these are marked in levels
  - E.g. Level 1 = 1-3 marks, Level 2 = 4-6 marks etc.

STRATEGIC STRUCTURE
(FOR LONGER WRITTEN QUESTIONS)

For each individual point you should try to follow this structure…

Knowledge
- Show what you know
- Write your first point

Application
- Apply what you know
- Use context to give an example or justification

Analysis
- Analyse what you know
- Link back to the question, is it a benefit or drawback?

For your overall answer you should try to follow this structure…

Initial definitions of key terms

KAA structure here (for 3 mark questions)

KAA structure here (for 6 mark questions)

KAA structure here (for 9 mark questions)

KAA structure here (for 12 mark questions)

Conclusion (Where appropriate)

Some teachers prefer to use 'PEE' - Point, Example, Explanation – instead of KAA

WHERE DO STUDENTS LOSE MARKS?

- Not reading the question properly
- Going off topic or not using context
- Forgetting to define key words
- Forgetting to use balance where asked
- Failing to show working out
- Not using structured paragraphs

STAY UP TO DATE!

IT'S IMPORTANT TO STAY UP TO DATE WITH THE LATEST TECHNOLOGY TRENDS AND PRODUCTS, AND YOU CAN DO SO BY WATCHING TV!

Saturdays &
Sundays 2:30pm
on Sky News

Saturdays &
Sundays 3:30pm
on BBC News

During Series
Mondays 8pm on
Channel 5

You can also follow us on Twitter for the latest news and resources! @murphyresources

GOOD LUCK!

I HOPE YOU FOUND THIS RESOURCE VALUABLE!

*TERMS & CONDITIONS AVAILABLE ON PAGE 2