Fundamentals of Algorithms and Computational Thinking

1. What is an algorithm?
2. How does decomposition work?
3. What is abstraction?
4. What is pattern recognition
5. The process of removing unnecessary detail from a problem is known as …..
6. What is the purpose of pseudocode?
7. Give an example of how data is input into a computer system.
8. Give an example of how a computer system might process data.
9. What do we mean by output?
10. Why is it typically possible to design more than one type of algorithm?
11. What is the advantage of different types of algorithm solving the same problem?
12. What is a linear search algorithm?
13. State one advantage of a linear search algorithm
14. What one disadvantage of a linear search algorithm?
15. What is a binary search algorithm?
16. What is the advantage of a binary search algorithm?
17. State one disadvantage of a binary search algorithm
18. What does a quick sort sort algorithm do?
19. What is a sublist?
20. What is produced when a pair of sublists are merged?
21. How does a bubble sort algorithm work?
22. What is the disadvantage of a bubble sort algorithm?
23. How does an insertion sort algorithm work?
24. What is the disadvantage of an insertion sort algorithm?
25. What is the advantage of an insertion sort algorithm?

The algorithm in **Figure 4** is the binary search algorithm designed to search for a value within an array.

Figure 4

- Line numbers are included but are not part of the algorithm.
- For this algorithm, array indexing starts at 1.

```
1     val ← 43
2     arr ← [3, 5, 13, 43, 655, 872]
3     left ← 1
4     right ← LENGTH(arr)
5     WHILE left ≠ right
6       mid ← (left + right) DIV 2
7       IF val ≤ arr[mid] THEN
8         right ← mid
9       ELSE
10        left ← mid + 1
11      ENDIF
12    ENDWHILE
```

Complete the trace table for the algorithm in **figure 4.** You may not have to use each row, the <- symbol is pseudocode for assigning a value to the relevant variable.

Val	left	Right	Mid	arr[mid]
43				

Why would the binary search algorithm shown in **Figure 4** not work when the array `arr` contains `[5, 3, 13, 872, 655, 43]`?

[1 mark]

The final value of `left` in the algorithm shown in **Figure** 4 is `4`. A programmer realises that they can use this value to check whether `val` has been found or not in the algorithm shown in **Figure 4**.

The programmer wants to extend the algorithm and introduce a new variable called `found` that is `true` when the value has been found in the array or `false` otherwise.

Write the pseudo-code or draw the flowchart that is needed to **extend** the algorithm so that when the algorithm finishes, the new variable `found` is:

- `true` when `val` is found in `arr`
- `false` when `val` is not found in `arr`

This code should follow on from the end of the algorithm in **Figure 4**.

[4 marks]

Figure 5 shows the start of an algorithm.

Figure 5

```
OUTPUT 'enter the 24 hour number (0-23)'
hour ← USERINPUT
```

The algorithm in **Figure 5** asks the user to enter a number between 0 and 23 that represents an hour using the 24 hour clock. The input is stored in a variable called `hour`.

Extend the algorithm in **Figure 5**, using either pseudo-code or a flowchart, so that it outputs the equivalent time using the 12 hour clock, ie a number between 1 and 12, followed by either `am` or `pm`.

For example:

- If the user enters `0`, the program outputs `12` followed by `am`.
- If the user enters `4`, the program outputs `4` followed by `am`.
- If the user enters `12`, the program outputs `12` followed by `pm`.
- If the user enters `15`, the program outputs `3` followed by `pm`.

You can assume that the variable `hour` is an integer and that the value that the user inputs will be between 0 and 23.

[7 marks]

Complete the trace table for the algorithm in **Figure 7** when the user enters 15 and then 39 (you may not need to use all of the rows in the table).

The first line has been completed for you.

[4 marks]

num1	num2
15	39

State the line number from the algorithm in **Figure 7** where selection is first used.

[1 mark]

State the line number from the algorithm in **Figure 7** where iteration is first used.

[1 mark]

How many lines in the algorithm in **Figure 7** use variable assignment?

[1 mark]

A programmer wants to implement the algorithm in **Figure 7** in their code. Explain why it could be a benefit to implement this as a subroutine.

[2 marks]

Programming exam questions

1. 3, 45, -453 are examples of what data type?
2. 34.456 and 4.10 and examples of what data type?
3. ?, 4, a are examples of what data type
4. Give an example of a string data type:
5. Is male/female a valid boolean data type? Explain your answer
6. What is the difference between data and process?
7. In Computing, define the term output
8. What is variable declaration?
9. What is the difference between a variable and constant declaration?
10. What is iteration?
11. Give two examples of iteration:
12. what is the difference between iteration and selection?
13. What is another name for a subroutine?
14. Give one advantage of a procedure
15. What is the difference between a procedure and a function
16. State the arithmetic operation for (**+**)
17. State the arithmetic operation for (**-**)
18. State the arithmetic operation for (*****)
19. State the arithmetic operation for (**/**)
20. State the arithmetic operation for (**//**)
21. Modulus to return remainder (**%**)

22. Describe the relational operation (**=**)
23. Describe the relational operation (**!=**)
24. Describe the relational operation (**<**)
25. Describe the relational operation (**>**)
26. Describe the relational operation (**<=**)
27. Describe the relational operation (**>=**)
28. Describe the Boolean operation: **NOT**
29. Describe the Boolean operation: **AND**
30. Describe the Boolean operation **OR**
31. What is meant by the function len()?
32. What is a substring?
33. Write an example of a substring
34. What is concatenation and give an example?
35. What does 'Random.randint(1,10)' generate?
36. What does 'Random.randint(1,100)' generate?
37. What does 'Random.randint(50,100)' generate?
38. List 3 advantages of using functions
39. How are local variables used with functions?
40. What is an advantage of using modular programming?
41. What is a parameter in relation to functions?
42. What is a return value in relation to functions?
43. What is the difference between a low level and high level programming language?
44. Give an example of a high level programming language
45. Give an example of a low level programming language
46. What is machine code?
47. What is assembly language and how is it translated?
48. What is the purpose of an interpreter?
49. What is a the purpose of a compiler?
50. What is the purpose of an assembler?

Figure 2 contains a subroutine that returns a value.

Figure 2

```
SUBROUTINE TotalOut(a, b)
  c ← a + b
  WHILE a < c
    a ← a + 1
    b ← b - a
  ENDWHILE
  RETURN b
ENDSUBROUTINE
```

Complete the trace table below when the subroutine call `TotalOut(3, 4)` is made (you may not need to use all of the rows in the table):

[3 marks]

a	b	c

A programmer mistakenly tries to shorten the subroutine in **Figure 2** by replacing the lines:

```
c ← a + b
WHILE a < c
```

With the line:

```
WHILE a < (a + b)
```

Explain why this change is a mistake.

[2 marks]

The variables a, b and c in **Figure 8** are assigned string values.

Figure 8

```
a ← 'bitmap'
b ← 'pixel'
c ← 'bit'
```

Shade **one** lozenge which shows the concatenation of the variables a and b shown in **Figure 8.**

[1 mark]

concatenation of the variables a and b

A bitmap pixel ⬭

B bitmappixel ⬭

C ab ⬭

Strings can also be represented as arrays of characters. For instance, the three statements below are an alternative to the statements shown in **Figure 8** where those strings are now being represented as arrays of characters.

```
a ← ['b','i','t','m','a','p']
b ← ['p','i','x','e','l']
c ← ['b','i','t']
```

- For the following questions, array indexing starts at 1.

Shade **two** lozenges which correspond to the **two true** statements about these arrays.

[2 marks]

A `a[1] = b[1] OR a[1] = c[1]` ⬭

B `LENGTH(b) ≥ LENGTH(a)` ⬭

C `NOT (a[6] = b[1] AND a[3] = c[3])` ⬭

D `a = a[5]` ⬭

E `a[LENGTH(a) - LENGTH(c)] = c[3]` ⬭

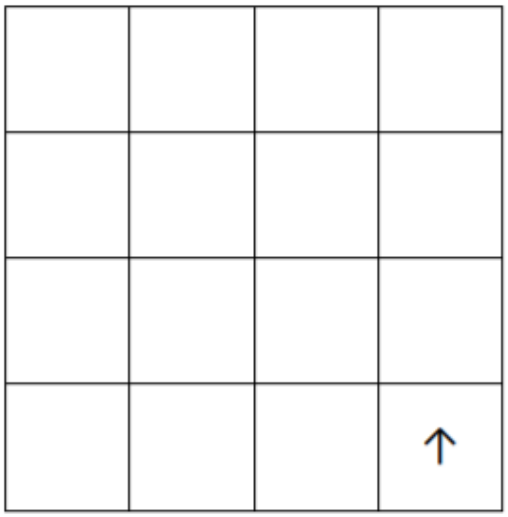
Four separate subroutines have been written to control a robot.

- `Forward(n)` moves the robot `n` squares forward.
- `TurnLeft()` turns the robot 90 degrees left
- `TurnRight()` turns the robot 90 degrees right
- `ObjectAhead()` returns `true` if the robot is facing an object in the next square or returns `false` if this square is empty.

Draw the path of the robot through the grid below if the following program is executed (the robot starts in the square marked by the ↑ facing in the direction of the arrow).

```
Forward(2)
TurnLeft()
Forward(1)
TurnRight()
Forward(1)
```

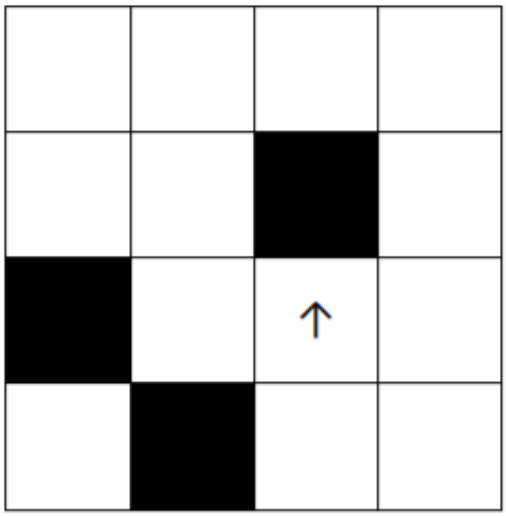
[3 marks]



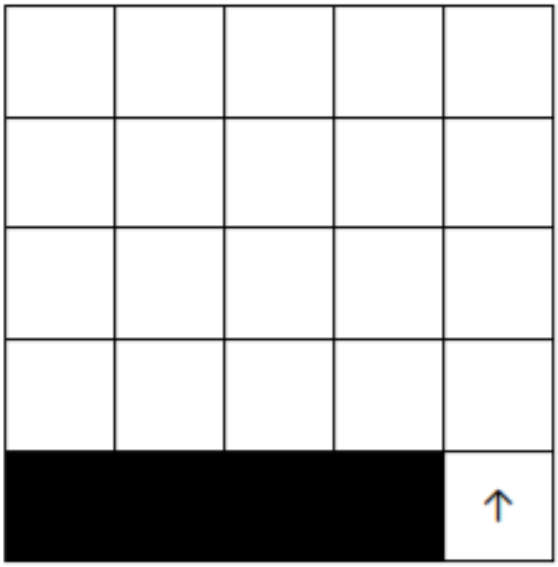
Draw the path of the robot through the grid below if the following program is executed (the robot starts in the square marked by the ↑ facing in the direction of the arrow). If a square is black then it contains an object.

```
WHILE ObjectAhead() = true
  TurnLeft()
    IF ObjectAhead() = true THEN
      TurnRight()
      TurnRight()
    ENDIF
  Forward(1)
ENDWHILE
Forward(1)
```

[3 marks]



A robot needs to visit every square in the following grid that does not contain an object:



The objects are shown as black squares.

Complete the algorithm by writing the following instructions in the correct places (you will need to use each instruction exactly once):

```
Forward(distance)
distance ← distance - 1
distance ← 4
TurnLeft()
TurnLeft()
```

```
WHILE distance > 0
    _____
    _____
     Forward(distance)
    _____
    _____
ENDWHILE
```

[4 marks]

Fundamentals of Data Representation

1. A switch only has two states which can be represented as?
2. Bit is short for?
3. A group of eight bits is called?
4. 1000 bytes equals?
5. 1,000,000 bytes equals?
6. 1,000,000,000 bytes equals?
7. 1,000,000,000,000 bytes equals?
8. 1,000,000,000,000,000 bytes equals?
9. How many digits does our decimals system use?
10. What are the column headings needed when converting to binary?
11. What is the biggest number you can represent with 8 bits?
12. When you cannot represent the number in the amount space because it's too big, this is called?
13. Shifting a binary number to the left is equivalent to?
14. Shifting a binary number to the right is equivalent to?
15. A group of four bits is known as…?
16. Base 16 is more commonly known as…?
17. 12 in Hex is…?
18. Converting the binary number 1101 to Hex is…?
19. Why use Hexadecimal?
20. ASCII characters use how many bits?
21. What is the new standard for representing the characters of all the languages of the world?
22. How many bits does Unicode use per character?
23. What's the advantage of using Unicode?
24. What is a pixel?
25. How many colours can be stored with 2 bits?
26. How many colours can be stored with 3 bits?
27. Sound waves are continuously changing and are described as what kind of signal…?
28. Anything stored on a computer must be stored in digital format as a series of…?
29. The device that takes real-world analogue signals and converts them to a digital representation is called an…?
30. The accuracy which an analogue sound wave is converted to a digital format depends on…?

A bit pattern is shown in **Figure 1**.

Figure 1

01001110

Convert the bit pattern in **Figure 1** into decimal.

[1 mark]

Convert the bit pattern in **Figure 1** into hexadecimal.

[2 marks]

A student's answer to the question "Why is hexadecimal often used instead of binary?" is shown in **Figure 2**.

Figure 2

Because it uses fewer digits it will take up less space in a computer's memory.

Explain why the student's answer is incorrect.

[2 marks]

Unicode is an alternative to the ASCII coding system.

Describe **one** advantage and **one** disadvantage of using Unicode to represent characters instead of using ASCII.

[2 marks]

Explain how a binary number can be multiplied by 8 by shifting bits.

[2 marks]

ASCII (American Standard Code for Information Interchange) is a coding system that can be used to represent characters. In ASCII the character `A` is represented by the numeric code 65.

Shade **one** lozenge to indicate which character is represented by the numeric code 70.

[1 mark]

A `E` ⬭

B `F` ⬭

C `f` ⬭

D `6` ⬭

E `e` ⬭

Computer Systems

1. Circuits in computers are made of many logic gates, name the main three
2. Boolean variables are either…?
3. A NOT gate…
4. The property of a the AND gate…
5. What is a truth table?
6. Define the term hardware?
7. Define the term software
8. Define the term system software
9. Define the term application software
10. Give examples of application software
11. What is an operating system?
12. What is memory management?
13. What are embedded systems?
14. What is utility software?
15. What is encryption used for?
16. What is the purpose of compression software and name an example?
17. What is in the Von Neumann architecture?
18. The processor responds to and processes the instructions that drive the computer. It contains the…?
19. What functions does the ALU carry out?
20. What is the purpose of the control unit?
21. What is the purpose of the clock?
22. What is the purpose of the bus?
23. Describe the fetch execute cycle
24. What happens during the fetch stage?
25. What happens during the decode part of the cycle?
26. What happens during the execute stage?
27. How does greater clock speed affect instructions?
28. How is clock speed measured?
29. What is cache memory?
30. What is the purpose of RAM?
31. State the properties of ROM

32. What does secondary storage refer to?
33. How does a magnetic disk (e.g., HDD) read and write data?
34. How does an SSD work?
35. How does an optical disk work?
36. What does cloud storage refer to?

The Central Processing Unit (CPU) is one of the hardware components of a computer system.

Define the term hardware.

[1 mark]

"Used to connect different components in the CPU" is a description of which of the following? Shade **one** lozenge to show the correct answer.

[1 mark]

A Control Unit ⬭

B Bus ⬭

C Arithmetic Logic Unit ⬭

D Clock ⬭

E Ethernet ⬭

Explain how main memory is used during the fetch-execute cycle.

[4 marks]

Increasing the amount of cache memory and changing the type of cache memory can improve the performance of a CPU.

State **two** other ways of improving the performance of a CPU.

[2 marks]

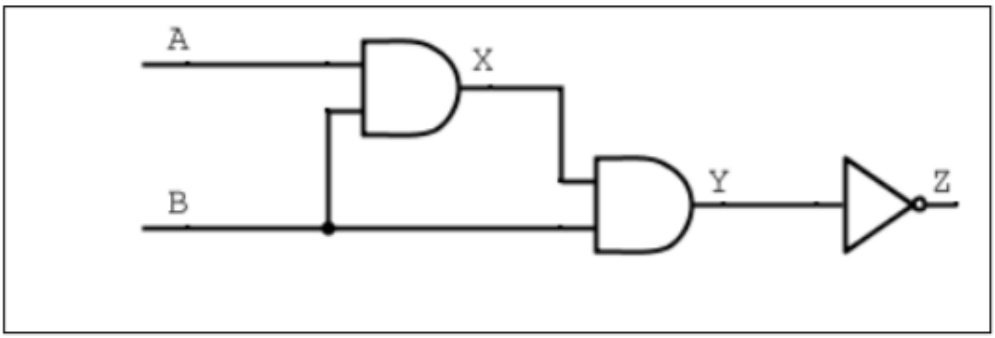
Complete the truth table for the OR logic gate:

[1 mark]

A	B	A OR B
0	0	
0	1	
1	0	
1	1	

Complete the truth table for the logic circuit shown in **Figure 6**.

Figure 6



[3 marks]

A	B	X	Y	Z
0	0			
0	1			
1	0			
1	1			

A logic circuit is being developed for an automatic door system:

- The automatic door has two sensors, one on either side of the door, sensor **F** and sensor **B.** The door opens when either of these sensors is activated.
- The door system can also be turned on/off using a manual switch, **S.** The door will not open unless **S** is on.
- The output from this logic circuit, for whether the door is open or not, is **D**.

Complete the logic circuit diagram for this system:

[3 marks]

F ——

B ——

S ——

—— **D**

Most computer systems have a main memory that consists of both RAM and ROM.

For each of the **two** statements below shade **one** lozenge to indicate if the statement is true or false.

[2 marks]

ROM is volatile memory.

A True ⬭

B False ⬭

In most desktop computers there is more ROM than RAM.

A True ⬭

B False ⬭

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]

Explain the purpose of an operating system.

[4 marks]

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

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

[2 marks]

An SD card is a type of solid state storage.

State **two** advantages of solid state storage compared to magnetic storage.

[2 marks]

Many modern desktop computers have both solid state drives and magnetic hard disk drives.

Give **two** reasons why desktop computers have a magnetic hard disk drive and a solid state drive instead of having just a solid state drive.

[2 marks]

In recent years, there has been a large growth in the use of cloud storage.

Discuss the advantages and disadvantages of using cloud storage.

In your answer you should include an explanation of the reasons for the large growth in recent years and consider any legal, ethical and environmental issues related to the use of cloud storage.

[9 marks]

Many computers use the Von Neumann architecture.

In a computer that uses the Von Neumann architecture bit patterns can be stored in the main memory. Shade the correct lozenge to indicate what these bit patterns could represent. You should only shade **one** lozenge.

A Data ⬭

B Instructions ⬭

C Data and instructions ⬭

D Data or instructions, but not both ⬭

[1 mark]

Five components of a CPU are given below. For each row in **Table 1**, choose the letter **A, B**, **C**, **D** or **E** that best matches the description.

Letters should not be used more than **once**.

A. Bus
B. Arithmetic Logic Unit
C. Control Unit
D. Clock
E. Register

Table 1

Description	Letter
Sends a continuous series of electronic pulses	
Decodes the current instruction	
Completes calculations	

[2 marks]

Fundamentals of Computer Networks

1.

2. What is the internet?
3. What is the world wide web (www)?
4. What are WANs?
5. What is packet switching?
6. What is needed to create a network of computers?
7. What is the purpose of a router?
8. What is WiFi?
9. What is a LAN and identify 3 advantages and disadvantages of using a LAN?
10. State two benefits of networking computers
11. State three disadvantages of using networks
12. What is a network topology?
13. State two ways of keeping network data secure
14. When two computers on a network communicate, they have to use the same protocol. What is a protocol?
15. State which protocol would be the most suitable in each of the following situations:
    1. Making a payment securely when purchasing something over the internet
    2. Transferring a file to another computer on a wide area network
    3. Transferring an email from one server to another server
16. What protocols are on the Application layer?
17. What protocols are on the Transport layer?
18. What protocols are on the Network/Internet layer?
19. What protocols are on the Link layer?
20. Explain what happens in each layer when a message is being sent from a client to a server.

Most schools have a computer network.

Some schools allow teachers to access the school network from their home computers.

Give **one** reason why some schools allow this and **one** reason why some schools do not allow this.

[2 marks]

Reason for: _____

_____

Reason against: _____

_____

PANs and LANs are two different types of network.

Describe **one** difference between a PAN and a LAN.

[1 mark]

_____

_____

Give **one** example of where a PAN could be used.

[1 mark]

_____

_____

"Schools should use a wireless network instead of a wired network".

Discuss this statement.

[6 marks]

When two computers on a network communicate with each other they need to use the same protocol.

Define the term protocol.

[2 marks]

For questions **05.6** to **05.8**, shade **one** lozenge to indicate the most suitable protocol to use in the situation described.

Used to retrieve email stored on a server.

[1 mark]

A	HTTP	⬭
B	HTTPS	⬭
C	FTP	⬭
D	SMTP	⬭
E	IMAP	⬭

Used to make a payment securely when purchasing goods from a website.

[1 mark]

A	HTTP	⬭
B	HTTPS	⬭
C	FTP	⬭
D	SMTP	⬭
E	IMAP	⬭

Used to send an email from a client machine to an email server.

[1 mark]

A	HTTP	⬭
B	HTTPS	⬭
C	FTP	⬭
D	SMTP	⬭
E	IMAP	⬭

TCP/IP is a protocol stack used in networking. There are four layers in the TCP/IP stack.

Complete the table by placing the four layers of the TCP/IP stack into order (1 – 4), where 1 is the top layer and 4 is the bottom layer).

[3 marks]

Layer	**Order (1-4)**
Transport	
Data Link	
Network	
Application	

Describe **three** advantages of using a computer network rather than standalone machines.

[3 marks]

One disadvantage of using a computer network is that there are increased security risks. Describe **three** other disadvantages of using a computer network.

[3 marks]

The application layer and the network layer are two of the layers in the four-layer TCP/IP model. Describe the roles of each of the four layers in the TCP/IP model. In your answer you should also state the names of the other two layers of the TCP/IP model.

[6 marks]

Fundamentals of Cyber Security

1. Why is removable media a threat to the security of a network?
2. Suggest two ways that computer users can leave themselves open to hackers
3. Explain what is meant by ‘blagging’
4. What can a company do to reduce or eliminate incidents of blagging?
5. What is phishing?
6. Describe one way to detect a phishing email
7. What is meant by shouldering
8. Describe one other way in which a criminal may obtain personal information about someone without their consent or knowledge
9. What is penetration testing?
10. Describe two different types of penetration testing
11. Describe a method of identification, and give an example of where it might be used

Organisations often spend a lot of money on cyber security.

Penetration testing is an attack on its own computer system by an organisation to try and identify security weaknesses.

Describe **one** difference between black-box and white-box penetration testing.

[1 mark]

Social engineering is often used to try to gain unauthorised access to a computer system. Phishing is a commonly used social engineering technique where emails are sent that pretend to be from a reputable organisation/company to try and obtain personal details.

Describe another **two** social engineering techniques. You should also explain measures that an organisation can take to try to reduce the security risks from phishing and the two other social engineering techniques you have described.

[6 marks]

Computer viruses, Trojans, adware and spyware are different types of malware.
Describe the similarities and differences between these different types of malware.
Your answer should also describe measures that can be taken to reduce the risks from these malware

[9 marks]

Ethical, legal and environmental impacts of digital technology on wider society, including issues of privacy

1. State three ways technology has changed the way we live and work
2. What are the benefits of driverless cars?
3. What are the drawbacks of driverless cars?
4. What are the **dangers** of social networking sites such as Facebook
5. What are the **benefits** of social networking sites such as Facebook?
6. What factors would you take into consideration when rating an Uber tax driver?
7. Name three jobs that you think could be computerised
8. State five jobs that can't be computerised **easily**