1(a). A supermarket uses a stock control system.
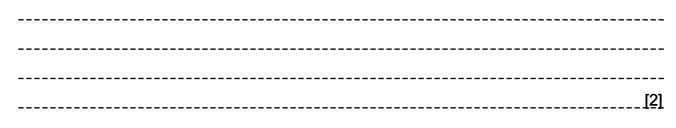
Details of products are stored on a stock database.

The quantity of a particular product in stock is stored as a binary number using two bytes.
There are 312 tins of beans left in stock.

How would this quantity be represented as a binary number in the computer?

-- [2]

(b). The name of a product is stored using characters from the computer's character set.

(i) Explain what is meant by the character set of a computer.

-- [2]

(ii) Explain how codes are used to represent a character set.

-- [3]

2(a). Convert the denary number 43 into an 8 bit binary number.

--[1]

(b). Using binary subtraction, calculate your answer to the following. You must show your working.

01001100 -
00110010

--[2]

(c). Using two's complement convert the denary number −43 into an 8 bit binary number. You must show your working.

--[2]

(d).

(i) Using normalised floating point binary representation using 4 bits for the mantissa and 4 for the exponent, represent the denary value 1.75. You must show your working.

--[2]

(ii) Using normalised floating point binary representation using 4 bits for the mantissa and 4 for the exponent, represent the denary value −**1.75**. You must show your working.

--[2]

3(a). Using the denary number 89 as an example, explain the relationship between binary and hexadecimal representations.

-- [3]

(b).

(i) Change the denary number -89 into a two's complement, 8 bit binary number.

-- [1]

(ii) Change the denary number -72 into a two's complement, 8 bit binary number.

-- [1]

(c).

  (i) Add the two binary answers which you obtained, using 8 bit arithmetic.

     You must show your working.

---**[2]**

  (ii) Explain why your answer to the addition sum is wrong.

---**[2]**

4(a). A Huffman code is a type of binary code where characters are represented by binary numbers of different lengths. A possible Huffman code for a character set of four characters is:

A = 0 B = 11 C = 100 D = 101

For example the word BAD would be represented by 110101.

State how the word CAB would be represented in this code.

_____[1]

The following algorithm takes a message as binary digits, one at a time, from a source and outputs the message that is being transmitted.

```
01    d = ""
02    REPEAT
03      x =  next binary digit from source
04      d = d + x
05      SELECT CASE d
06        CASE "0" :
07          OUTPUT "A"
08          d = ""
09        CASE "11" :
10          OUTPUT "B"
11          d = ""
12        CASE "100" :
13          OUTPUT "C"
14          d = ""
15        CASE "101" :
16          OUTPUT "D"
17          d = ""
18      END SELECT
19    UNTIL end of transmission
```

(b). Explain the purpose of line 01.

_____

_____

_____

_____[2]

(c). State what the operation + does on line 04. State the name of this operation.

_____

_____

_____

_____ [2]

(d).

The source of the message needs a routine to encode messages into the Huffman code. The routine should allow the user to enter a message and output the encoded message.

Write this routine in a high level language you have studied, stating the name of the language you have used. You should use good program writing techniques to ensure that your routine is easy to understand.

You can assume that the message consists only of the characters A, B, C and D.

Name of language _____

Routine

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ [7]

(e). Programming language environments provide several facilities for editing and debugging programs.

Name **two** of these facilities. Describe how each can be used when writing the routine in part **(e)**.

1

2

----

[6]

5(a). Give the number 55 in binary as an 8-bit unsigned integer.

--[2]

(b). Represent the number 55 in normalised floating point binary notation, using 8 bits for the mantissa followed by 8 bits for the exponent, both in two's complement binary.

--[2]

(c). Represent the number 55 in normalised floating point binary notation, with the mantissa and exponent both in two's complement binary, using as few bits as possible.

--[2]

(d). State why a programmer might choose to declare a variable as a floating point number.

--[1]

6. Asim is the head of a chess club. One of his jobs is to send out a monthly newsletter.

For the newsletter, club members send in descriptions of games they play using chess notation, which consist of a sequence of symbols, letters and numbers. It is important that these descriptions are accurate.

One member sends in the description as a plain text file. The text file is saved using Unicode, an extract of which is shown below.

♙e4♟c5

(i) Explain what is meant by the term 'Unicode'.

--**[3]**

When Asim opens this file on the text editor on his computer it looks as below.

☐e4☐c5

(ii) Explain why the text may not be displaying correctly.

--**[2]**

7. Express the denary number –43 in binary using 8-bit two's complement representation.

Show your working.

---[4]

8(a).

Convert the binary number 01101111 to a hexadecimal number.

--[1]

(b). Convert the denary number −19 to an 8-bit number using:

(i) Two's complement representation.

--[1]

(ii) Sign and Magnitude representation.

--[1]

(c). The two values below are stored using unsigned binary. Calculate the subtraction of 01110010 from 11000011. Show your working.

11000011 _
01110010

—————————

[2]

(d). Convert the denary number $1^5/_8$ (i.e. 1.625) to a normalised floating point binary number using 5 bits for the mantissa and 3 bits for the exponent. Show your working.

--**[3]**

9(a).

Convert the denary number 72 to an unsigned 8-bit integer.

_____

_____

_____

_____[1]

(b). Convert the unsigned binary number 10000101 to denary.

_____

_____

_____

_____[1]

(c). Convert the denary number 104 to hexadecimal.

_____

_____

_____

_____[1]

(d). The following floating point binary number is represented using 7 bits for the mantissa and 4 bits for the exponent, both using two's complement.

Mantissa   Exponent
0100101   0100

 Convert the number to denary, showing your working.

-- [3]

(e). Given that computers store everything in binary, explain how they are able to represent text.

-- [2]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		• 0000000100111000	2	1 for correct binary, 1 for 16 digits. **Examiner's Comments** The question did state that a binary number was required, this means that the relatively common answer of using two 8-bit binary numbers that add up to 312 was not an answer to the question as set. It was odd to see so many responses that gave the 16 bit, 2's complement version of −312
	b	i	• Normally equates to the symbols on a keyboard / digits / letters… • …that can be represented / interpreted / understood by a computer • May include control characters	2	Not: Stored on a computer
		ii	• Each symbol has a (binary) code / number… • …which is unique. • Number of bits used for one character = 1 byte • Example code: ASCII / Unicode… • …uses 8 bits /16 bits per character • Use of more bits for extended character set	3	**Examiner's Comments** Many candidates adopted a scatter gun approach to this pair of questions, inserting the facts that they knew about character sets seemingly at random between the two parts. Despite this most scored well here and some candidates gave clear and well-presented responses to both parts.
			Total	7	
2	a		00101011	1	For 1 mark.
	b		00011010	2	For 2 marks. 1 mark for correct answer plus an additional method mark for showing borrowed bits. No method mark for converting numbers to denary performing subtraction and converting back to binary. Allow full marks for converting second number to two's complement and performing addition.
	c		11010101	2	For 2 marks – showing valid method 1 mark.

Question			Answer/Indicative content	Marks	Guidance
	d	i	0111 0001	2	For 2 marks – 1 mark for mantissa 1 mark for exponent.
		ii	1001 0001	2	For 2 marks – 1 mark for mantissa 1 mark for exponent.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
3	a		–Split the binary number in groups of 4 –Change each into a single value/(Hexadecimal) digit –Digits which are between 10 and 15 are given letters A to F –In this example: 0101 = 5 and 1001 = 9/Therefore 89 = 59(hex) (1 per –, max 3)	3	**Examiner's Comments** Candidates who answered this question by demonstration, scored well. Those who tried to describe the process using prose invariably lacked clarity and therefore did not achieve full credit.
	b	i	10100111	1	**Examiner's Comments** Most candidates correctly converted from denary to two's complement.
		ii	10111000	1	**Examiner's Comments** Most candidates correctly converted from denary to two's complement.

	c	i	``` 1 0 1 0 0 1 1 1```
			``` 1 0 1 1 1 0 0 0```
			``` 0 1 0 1 1 1 1 1```
			Carried 1 gets removed --> X̶ 1
			
			(1 for 8 bit correct answer, 1 for showing appropriate correct carries)
				2	Note: follow through from candidate answers to previous part
					
					If ft answer generates no carries – max. 1 mark
					
					Examiner's Comments
					
					For the most part, those candidates with correct answers for the previous question parts produced correct answers for this but some did not gain credit for an 8 bit answer because they did not evidently discard the 9th carry bit.

		ii	–Answer needs 9 bits / Carry / overflow out of 8 bit byte –Two negative numbers have been added and the result is a positive number –Answer is 95 (1 per –, max 2)	2	NOT simply "overflow" **Examiner's Comments** Most candidates gained some credit for identifying the need for 9 bits or the discarded bit producing a positive answer. Few candidates gained maximum credit with some candidates stating that sign and magnitude should be used for binary subtraction.

Question			Answer/Indicative content	Marks	Guidance
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
4	a		• 100011	1	**Examiner's Comments** Almost all candidates achieved this mark
	b		• Initialise the value of d (to the empty string) • Before it gets used in line 04 / as it may already contain a value/ to give it a starting value	2	**Examiner's Comments** Many good answers given, with most candidates gaining at least 1 mark, although some candidates only stated "it sets d to a null value".
	c		• Joins the strings d and x into one string • Concatenation operator	2	Allow append Do not accept 'add' **Examiner's Comments** This was poorly understood by many candidates. Most thinking it was a mathematical addition, and unfortunately not realising that the variables were strings.

Question			Answer/Indicative content	Marks	Guidance

	d		*Example (in pseudocode):*
			
			``
			// get the message
			 INPUT Message
			
			// initialise output string
			Result = ""
			
			// loop through each letter
			FOR pos = 1 to LENGTH(Message)
			
			    // put the code of the letter in result
			    SELECT CASE MID(Message, pos, 1)
			        CASE "A" :
			            Result = Result & "0"
			        CASE "B" :
			            Result = Result & "11"
			        CASE "C" :
			            Result = Result & "100"
			        CASE "D" :
			            Result = Result & "101"
			    END SELECT
			
			END FOR
			
			//return the result
			OUTPUT Result
			``
			Award up to 5 marks for the algorithm:
			
			• INPUT message
			• Uses a loop
			• … to correctly visit each character
			• Replaces "A", "B", "C" and "D" with correct code
			• Outputs the result
			
			Award up to 2 marks for style
			
			• Meaningful identifiers
			• Commenting
			• Indenting
				7	Cannot access bullet points 2, 3 & 5 without a loop
					
					Allow for python's use of "str.replace"
					
					Examiner's Comments
					
					Those that did poorly on this question showed a lack of understanding about the difference between the variable A and the string literal "A". It was a shame that some candidates also missed out on marks for not inputting/passing the "message" in and the indentation of their code. Python seems to be the most common language used but the syntax was not always used correctly.

Question	Answer/Indicative content	Marks	Guidance
e	*eg* • Translator Diagnostics • reports when syntax errors are made and suggests solutions / example from code • Breakpoints • Allows the code to stop at chosen point • To check variables / example from code *Award one mark for each correctly named facility, and up to two marks for the description.*	6	Not dry running / trace tables • Steping • Executes each line in turn • To allow checking of path(s)/values • (Variable) watch • To monitor the status of variables (and objects)… • … as you step through code / as they change **Examiner's Comments** Translator Diagnostics, Breakpoints and watches were generally well known but not always expressed clearly. With breakpoints, for example, most got the point of stopping execution at a statement but then just said "to find the error" rather than checking variable values to see if they matched expected values. In the case stepping it was not always clear if they were describing dry running or stepping.
	Total	18	

Question			Answer/Indicative content	Marks	Guidance
5	a		00110111 (1 mark per nibble)	2	**Examiner's Comments** This question was well answered, with most candidates achieving full marks.
	b		01101110 00000110 (1 mark for mantissa, 1 for exponent)	2	**Examiner's Comments** Few candidates achieved full marks on this question. Many represented a normalised floating point mantissa with two of the same bit at the start.
	c		0110111 0110 (1 mark for mantissa, 1 for exponent)	2	**Examiner's Comments** Few candidates achieved full marks on this question. Many reduced the number of bits by deleting the leading zero's, rendering the result negative.
	d		• The variable may need to store decimal numbers. • To store very large / small values.	1	Max. 1 mark **Examiner's Comments** This question was reasonably well answered, with many candidates achieving the mark.
			Total	7	

Question			Answer/Indicative content	Marks	Guidance
6		i	**Three of:** ☐ Unicode is a character set [1] ☐ Mapping different binary values to characters (on the screen).[1] ☐ Each character is represented by 1-4 bytes. [1] ☐ It supports a very large number of characters [1] ☐ It is backward compatible with ASCII [1]	3	Accept each character is represented by 1byte / 2 bytes / 4bytes (or equivalent value in bits) for BP 3 **Examiner's Comments** Many candidates' explanations lacked clarity. Although most did state that Unicode was a character set.
		ii	☐ Asim's text editor may only support ASCII which doesn't include characters for the chess piece [1] ☐ Cannot recognize / understand the binary values of the two pieces [1] **OR** ☐ Asim may be using a font which doesn't include a representation for the chess pieces… [1] ☐ …and so those characters can't be represented. [1]	2	Question states plain text file so no credit for mention of missing graphics files. **Examiner's Comments** Few candidates referred to the codes that represent the symbols in their explanations, more so referring to the symbols themselves which did not gain credit.
			Total	**5**	

Question			Answer/Indicative content	Marks	Guidance
7			**Method [3 marks]** □ Treat left most bit as negative value (e.g. –128) [1] □ Treat remaining bits as positive values [1] □ Total them the relevant placeholder values. [1] OR □ Work out the positive equivalent in binary [1] □ From the right, working left copy down all the bits up to and including the first 1 [1] □ Flip the remaining bits [1] OR □ Work out the positive equivalent in binary [1] □ Take the one's complement (e.g. flip the bits) [1] □ Add one [1] **Answer [1 mark]** 11010101 [1]	4	**Examiner's Comments** These questions were well answered, with many candidates achieving full marks. However, some candidates lost marks for simple arithmetic errors. Candidates should be reminded to thoroughly check their responses.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
8	a		6F	1 AO2.1	**Examiner's Comment** Very well answered by the majority of candidates.
	b	i	11101101	1 AO2.1	
		ii	10010011	1 AO2.1	**Examiner's Comment** Very well answered by the majority of candidates.
	c		*212* *002* 11000011 01110010 01010001 1 Mark for answer 1 Mark for showing working using appropriate binary method.	2 AO2.1	NB some candidates represent carries with **10** as binary 2 rather than **2** Accept answer with missing leading zero. **Examiner's Comment** Well answered although candidates were required to show their binary working.
	d		$1^5/_8$ is 1.101 in fixed point (1 Mark) *binary point needs moving one place giving* *01101 001* One mark for Mantissa 01101 One mark for exponent 001	3 AO2.1	**Examiner's Comment** Again, this question was generally well answered with most candidates showing clear and logical workings.
			Total	**8**	

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Question			Answer/Indicative content	Marks	Guidance
9	a		01001000	1 AO1.2 (1)	
	b		133	1 AO1.2 (1)	
	c		68	1 AO1.2 (1)	**Examiner's Comments** A significant number of candidates achieved all three available marks across the first three parts of this question.
	d		- Exponent is 4 - Move binary point 4 places to the right - Answer is: 9.25 (1 per -, max 3)	3 AO1.2 (3)	Accept any other method if working is shown **Examiner's Comments** This question was well attempted by most candidates. The methods used were invariably, clearly shown.
	e		- Computers use a character set/ASCII/ UNICODE - To map binary values to characters - Each character is represented by a unique value (1 per -, max 2)	2 AO1.1 (2)	**Examiner's Comments** Most candidates achieved both available marks. With the majority describing ASCII.
			Total	8	