5.4 Binary number system part 1

Name: ________________________

Class: ________________________

Date: ________________________

Time: **431 minutes**

Marks: **320 marks**

Comments:

Q1.

(a) Shade **one** lozenge to indicate which of the unsigned numbers listed in the table has the largest value.

Number base	Number	Largest value (shade one)
Binary	101101001	○
Hexadecimal	30A	○
Decimal	396	○

(1)

(b) This question uses a **normalised** floating point representation with a 7-bit mantissa and a 5-bit exponent, both stored using **two's complement**.

The following is a floating point representation of a number:

Mantissa

0 ●	1	0	1	1	0	0

Exponent

1	1	1	0	1

Calculate the decimal equivalent of the number. You **must** show your working.

____

____

____

Answer ____

(2)

(Total 3 marks)

Q2.

This question uses a **normalised** floating point representation with a 7-bit mantissa and a 5-bit exponent, both stored using **two's complement**.

Write the normalised floating point representation of the decimal value -608 in the boxes below. You **must** show your working.

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____

Answer

●							

Mantissa

Exponent

(Total 3 marks)

Q3.

A particular computer uses a **normalised** floating point representation with an 8-bit mantissa and a 4-bit exponent, both stored using **two's complement**.

Four bit patterns that are stored in this computer's memory are listed in **Figure 1** and are labelled **A**, **B**, **C** and **D**. Some of the bit patterns are valid normalised floating point numbers.

Figure 1

	Mantissa									Exponent			
A	0 ●	0	0	0	0	0	0	1		0	0	0	0
B	0 ●	1	0	0	0	0	0	0		1	0	0	0
C	1 ●	0	0	0	0	0	0	0		0	0	1	0
D	1 ●	1	0	0	1	1	1	0		1	0	0	0

(a) Shade **one** lozenge to indicate which bit pattern (**A–D**) in **Figure 1** represents a negative normalised value.

A ○ **B** ○ **C** ○ **D** ○

(1)

(b) Shade **one** lozenge to indicate which bit pattern (**A–D**) in **Figure 1** represents the smallest positive normalised value.

A ○ **B** ○ **C** ○ **D** ○

(1)

(c) The following is a floating point representation of a number:

Mantissa									Exponent			
1 ●	0	1	1	0	0	0	0		0	0	1	1

Calculate the decimal equivalent of the number. You **must** show your working.

Answer ______________________________

(2)

(d) Write the normalised floating point representation of the decimal value 58.5 in the boxes below. You **must** show your working.

Answer

Mantissa

•							

Exponent

(3)

There can be a loss of precision when a decimal number is stored when using a floating point system.

The closest possible representation of the decimal number 13.8 is shown below.

Mantissa

0 •	1	1	0	1	1	1	0

Exponent

0	1	0	0

By converting this bit pattern back into denary it can be seen that the actual number stored is 13.75, not 13.8.

(e) Calculate the absolute error that has occurred.

Answer ______________________________

(1)

(f) Calculate the relative error that has occurred. Express your answer as a percentage to two decimal places.

Answer ____

(1)

(Total 9 marks)

Q4.

The table below is a partially complete representation of the rules for adding together two bit values. The first two columns represent the two bit values to add. The first row has been completed and represents the binary addition rule 0 + 0 = 0. Carry occurs when the answer cannot be stored in one bit.

		Answer	**Carry**
0	0	0	0
0	1		
1	0		
1	1		

Complete the table to show the **Answer** and **Carry** values for the given binary addition rules by filling in the unshaded cells.

(Total 3 marks)

Q5.

A particular computer uses a **normalised** floating point representation with a 7-bit mantissa and a 5-bit exponent, both stored using **two's complement**.

(a) Four bit patterns that are stored in this computer's memory are listed in the figure below and are labelled with the letters **A** to **D**. Three of the bit patterns are valid floating point numbers and one is not.

	Mantissa	Exponent
A	1 . 0 1 0 1 0 0	0 0 0 1 1
B	0 . 0 1 0 0 0 1	1 0 1 1 0
C	0 . 1 0 0 1 0 0	0 1 0 0 0
D	0 . 1 1 1 1 0 0	0 0 0 1 1

Complete the table below. In the **Correct letter (A–D)** column write the appropriate letter from **A** to **D** to indicate which bit pattern in the figure above matches the description in the **Value description** column.

Do **not** use the same letter more than once.

Value description	Correct letter (A–D)
A normalised negative value.	
The largest positive normalised number of the four values.	
A value that is not valid in the representation because it is not normalised.	

(3)

(b) This is a floating point representation of a number:

Mantissa

0.	1	0	1	1	0	1

Exponent

0	0	1	0	0

Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working ____

____

____

(1)

Answer ____

(1)

(c) This is a floating point representation of a number:

Mantissa

0.	1	0	1	0	1	0

Exponent

1	1	1	0	1

Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working ____

____

____

(1)

Answer ____

(1)

(d) Write the normalised floating point representation of the denary value 3008 in the boxes below. Show how you have arrived at your answer.

Working ____

____

(2)

Answer

	•					

Mantissa

Exponent

(1)

There can be a loss of precision when a denary number is stored using this floating point system.

The closest possible representation of the denary number 12.83 is shown below:

0	• 1	1	0	0	1	1

Mantissa

0	0	1	0	0

Exponent

By converting this bit pattern back into denary it can be seen that the actual number stored is 12.75, not 12.83.

(e) Calculate the absolute error that has occurred.

(1)

(f) Calculate the relative error that has occurred.

You must show your working or express your answer as a percentage to four decimal places.

(1)

(g) In the context of floating point, explain what overflow is and give an example of a situation which might cause overflow to occur.

(3)

(Total 15 marks)

Q6.

A particular computer uses a **normalised** floating point representation with a 7-bit mantissa and a 5-bit exponent, both stored using **two's complement**.

(a) In the boxes below, write the most negative value that can be stored using this representation:

Mantissa

	•					

Exponent

(2)

(b) This is a floating point representation of a number:

Mantissa

1 •	0	1	0	1	1	0

Exponent

0	1	0	1	1

Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working ____

____

____

Answer ____

(2)

(c) Write the normalised floating point representation of the denary value 12 ¾ in the boxes below. Show how you have arrived at your answer.

Working ____

____

____

____

Answer

Mantissa

	•					

Exponent

(3)

(d) Floating point numbers are usually stored in normalised form.

(i) State **two** advantages of using a normalised representation.

Advantage 1 ____

____

____

Advantage 2 ____

____

____

(2)

(ii) When a number is stored in normalised form it is always the case that the bits either side of the binary point are different from each other, i.e. if the bit before the binary point is 0, the bit after it will be 1 and if the bit before it is 1, the bit after it will be 0.

Using this information, explain how the 12 bits used to store a floating point number in this question could be used more efficiently, to increase the precision of the numbers which could be represented, without reducing the available range.

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(2)

(Total 11 marks)

Q7.

(a) What is the decimal equivalent of the hexadecimal number $D6_{16}$? Show your working.

____

____

____

____

(2)

(b) Represent the decimal value 9.375_{10} as an unsigned binary fixed point number, with 4 bits before and 4 bits after the binary point.

____

(2)

(c) Represent the decimal value -67_{10} as an **8-bit two's complement binary integer.**

(2)

(d) A computer represents numbers using 8-bit two's complement binary.

Using this representation perform the calculation:

01001000_2
01100011_2 +

Answer:

(1)

(e) What problem has resulted from performing the calculation using 8-bit two's complement binary?

(1)
(Total 8 marks)

Q8.

A particular computer uses a **normalised** floating point representation with an 8-bit mantissa and a 4-bit exponent, both stored using **two's complement**.

Four bit patterns that are stored in this computer's memory are listed in the figure below and are labelled **A, B, C, D**. Three of the bit patterns are valid floating point numbers and one is not.

	Mantissa								Exponent			
A	0 ● 1	0	1	1	1	0	0		1	0	1	0
B	0 ● 0	0	1	1	0	1	0		0	1	0	1
C	1 ● 0	0	0	0	0	0	0		0	1	1	1
D	1 ● 0	1	1	1	1	1	1		1	0	0	0

(a) Complete the table below. In the Correct letter (**A-D**) column shade the appropriate lozenge **A, B, C or D** to indicate which bit pattern from above is an example of the type of value described in the Value description column.

Do **not** use the same letter more than once.

Value description	**Correct letter (A-D)**
A positive normalised value	A ○ B ○ C ○ D ○
The most negative value that can be represented	A ○ B ○ C ○ D ○
A value that is not valid in the representation because it is not normalised	A ○ B ○ C ○ D ○

(3)

(b) The following is a floating point representation of a number:

Mantissa								Exponent			
0 ● 1	0	1	1	0	0	0		0	1	0	1

Calculate the decimal equivalent of the number. Show how you have arrived at your answer.

Answer ______________________________

(2)

(c) Write the normalised floating point representation of the negative decimal value -6.75 in the boxes below. Show how you have arrived at your answer.

Answer:

Mantissa Exponent

(3)

(d) An alternative two's complement format representation is proposed. In the alternative representation 6 bits will be used to store the mantissa and 6 bits will be used to store the exponent.

Existing Representation (8-bit mantissa, 4-bit exponent):

Mantissa Exponent

Proposed Alternative Representation (6-bit mantissa, 6-bit exponent):

Mantissa Exponent

Explain the effects of using the proposed alternative representation instead of the existing representation.

Q9.

A particular computer uses a **normalised** floating point representation with a 7-bit mantissa and a 5-bit exponent, both stored using **two's complement.**

(a) Four bit patterns that are stored in this computer's memory are listed below and are labelled with the letters **A** to **D**. Three of the bit patterns are valid floating point numbers and one is not.

A

Mantissa							Exponent				
0 •	0	1	0	1	0	0	0	0	0	1	1

B

Mantissa							Exponent				
0 •	1	0	0	0	0	1	0	1	1	1	0

C

Mantissa							Exponent				
1 •	0	1	0	1	0	0	0	0	0	1	1

D

Mantissa							Exponent				
0 •	1	1	1	1	0	0	1	1	1	1	0

Complete the table below. In the **Correct letter (A-D)** column write the appropriate letter from A to D to indicate which bit pattern matches the description in the **Value description** column.

Do **not** use the same letter more than once.

Value description	**Correct letter (A-D)**
A negative value	
The largest positive number of the four values	
A value that is not valid in the representation because it is not normalised	

(3)

(b) This is a floating point representation of a number:

Mantissa								Exponent				
0 •	1	1	0	1	0	1		0	0	1	0	0

Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working ____

____

____

(1)

Answer ____

(1)

(c) This is a floating point representation of a number:

Mantissa								Exponent				
0 •	1	0	0	1	1	0		1	1	1	0	1

Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working ____

____

____

(1)

Answer ____

(1)

(d) Write the normalised floating point representation of the denary value 2944 in the boxes below. Show how you have arrived at your answer.

Working ____

____

____

(2)

Answer ____

Mantissa								Exponent				
•												

(1)

(e) There can be a loss of precision when a denary number is stored using this floating point system.

The closest possible representation of the denary number 12.87 is shown below:

Mantissa

0	• 1	1	0	0	1	1

Exponent

0	0	1	0	0

By converting this bit pattern back into denary, it can be seen that the actual number stored is 12.75, not 12.87.

(i) Calculate the absolute error that has occurred.

____

____

(1)

(ii) Calculate the relative error that has occurred. Express your answer as a percentage to four decimal places.

____

____

(1)

(iii) Sometimes a floating point calculation can produce a result that is so close to zero that the result's closest possible representation is zero.

What is the name given to this specific type of error?

____

(1)

(Total 13 marks)

Q10.

The image below shows an 8-bit bit pattern.

1	0	1	1	0	1	1	0

(a) If the bit pattern above is an **unsigned binary integer**, what is the denary equivalent of this bit pattern?

____

____

(1)

(b) If the bit pattern above is a **two's complement binary integer**, what is the denary equivalent of this bit pattern?

____

(2)

(c) What is the range of **denary** numbers that can be represented using **8-bit two's complement binary integers**?

(2)

(d) If the bit pattern above is an **unsigned binary fixed point** number with 3 bits before and 5 bits after the binary point, what is the denary equivalent of this bit pattern?

(2)

(e) What is the **hexadecimal** equivalent of the bit pattern above?

(2)

(f) Why are bit patterns often displayed using hexadecimal instead of binary?

(1)

(g) Describe a method that can, without the use of binary addition, multiply any **unsigned binary integer** by the binary number 10 (the denary number 2).

____

(2)

(Total 12 marks)

Q11.

A normalised floating point representation uses an 8-bit mantissa and a 4-bit exponent, both stored using **two's complement format**.

(a) In binary, write the largest positive number that can be represented using this normalised floating point system in the boxes below:

Mantissa									Exponent			
	•											

(2)

(b) This is a floating point representation of a number:

Mantissa									Exponent			
0	•	1	0	1	1	0	0	0	0	0	1	1

Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working ____

____

____

(1)

Answer ____

(1)

(c) This is a floating point representation of a number:

Mantissa									Exponent			
1	•	0	1	1	0	0	0	0	1	1	0	0

Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working ____

____

____

(1)

Answer ____

(1)

(d) Write the normalised floating point representation of the **negative** denary value -108 in the boxes below. Show how you have arrived at your answer.

Working ____

____

____

____

(2)

Answer

	•											

Mantissa Exponent

(1)

(e) (i) In the context of floating point representation, explain what overflow is.

____

____

____

____

(2)

(ii) The table below contains descriptions of operations which may or may not cause an overflow error when they are carried out with a floating point representation.

Place **one** tick next to the operation that may cause overflow.

Operation	**May cause overflow? (Tick one box)**
Subtracting a very small number from a large number.	
Dividing a large number by a very small number.	
Multiplying a large number by a very small number.	

(1)

(Total 12 marks)

Q12.

(a) What is the denary equivalent of the hexadecimal number A7?

You may use the space below for rough working. You may get some marks for your working, even if your answer is incorrect.

Answer ____________________

(2)

(b) Represent the denary value 7.625 as an **unsigned binary fixed point** number, with 4 bits before and 4 bits after the binary point.

Use the space below for rough working.

Answer ____________________

(2)

(c) Represent the denary value -18 as an **8-bit two's complement binary integer**.

Use the space below for rough working.

Answer ____________________

(2)

(d) What is the **largest positive denary value** that can be represented using **8-bit two's complement binary**?

Use the space below for rough working.

Answer ____________________

(1)

(e) Describe how **8-bit two's complement binary** can be used to subtract one number from another number. In your answer you must show how the calculation 23 – 48 would be completed using the method that you have described.

You may use the space below for rough working.

Answer ____________________

(4)

Figure 1 shows a state transition diagram for a finite state machine (FSM).

Table 1 shows the outputs produced by the finite state machine in **Figure 1** for some possible input strings. Some of the outputs are missing from the table below. Input strings are processed starting with the right-most bit.

Figure 1

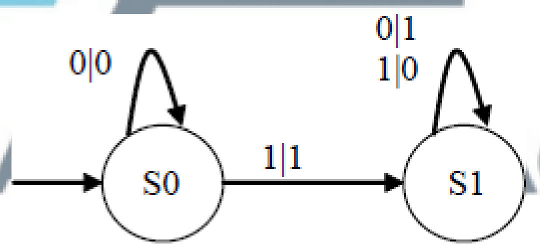


Table 1

Input string	Output string
00010011	11101101
00010010	**(a)**
00010100	11101100
00010101	**(b)**

(f) What output string should be in position **(a)** in the table?

____

(1)

(g) What output string should be in position **(b)** in the table?

(1)

(h) What is the purpose of the finite state machine shown in **Figure 1**?

(1)

(i) A finite state machine can be represented as a state transition diagram or as a state transition table. **Table 2** is an incomplete state transition table for **Figure 1**.

Complete the **unshaded** cells in the table below.

Table 2

Input	Original state	Output	New state
0	S0	0	S0
1		1	S1
0	S1		S1

(3)

(Total 17 marks)

Q13.

A particular computer uses a **normalised** floating point representation with an 8-bit mantissa and a 4-bit exponent, both stored using **two's complement**.

(a) Four bit patterns that are stored in this computer's memory are listed in **Figure 1** and are labelled with the letters **A** to **D**. Three of the bit patterns are valid floating point numbers and one is not.

Figure 1

	Mantissa								Exponent			
A	0	• 1	0	0	0	0	0	0	1	0	0	0

Mantissa Exponent

B

0 •	1	0	0	0	0	0	0

1	1	1	1

Mantissa Exponent

C

0 •	0	1	0	1	0	0	0

0	1	1	0

Mantissa Exponent

D

1 •	0	1	0	1	0	0	0

0	1	0	1

Mantissa Exponent

Complete **Table 1** below. In the **Correct letter (A–D)** column write the appropriate letter from **A** to **D** to indicate which bit pattern in **Figure 1** is an example of the type of value described in the **Value description** column.

Do **not** use the same letter more than once.

Table 1

Value description	**Correct letter (A-D)**
A negative value.	
The smallest positive value that can be represented.	
A value that is not valid in the representation because it is not normalised.	

(3)

(b) This is a floating point representation of a number.

0 •	1	0	1	0	0	0	0

0	1	1	0

Mantissa Exponent

Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working: ____

(1)

Answer: ____

(1)

(c) Write the normalised floating point representation of the negative denary value –7.75 in the boxes below. Show how you have arrived at your answer.

Working: ____

(2)

Answer: ____

Mantissa

•							

Exponent

(1)

(d) There can be a loss of precision when a denary number is stored using this floating point system.

The closest possible representation of the denary number 6.9 is shown below.

Mantissa

0 •	1	1	0	1	1	1	0

Exponent

0	0	1	1

By converting this bit pattern back into denary it can be seen that the actual number stored is 6.875, not 6.9.

(i) Calculate the absolute error that has occurred.

____

(1)

(ii) Calculate the relative error that has occurred.

____

(1)

(iii) Explain how the floating point system used could be modified to allow a more accurate representation of 6.9.

____

____

____

(2)

(Total 12 marks)

Q14.

The table below is a partially complete representation of the rules for adding together two bit values. The first two columns represent the two bit values to add. The first row has been completed and represents the binary addition rule `0 + 0 = 0`. Carry occurs when the answer cannot be stored in 1 bit.

		Answer	**Carry**
0	0	0	0
0	1		
1	0		
1	1		

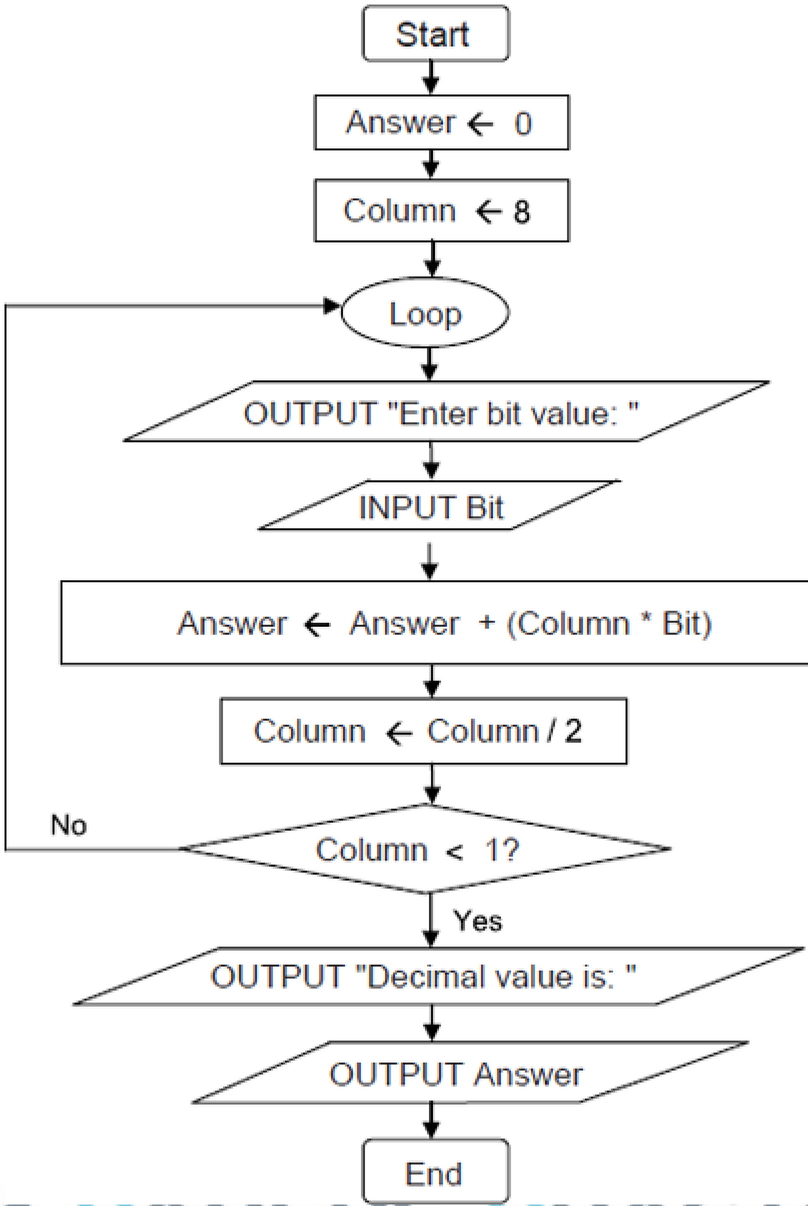
Complete the table above to show the **Answer** and **Carry** values for the given binary addition rules.

(Total 3 marks)

Q15.

Create a folder/directory for your new program.

The algorithm, represented as a flowchart below, and the variable table, describe the converting of a 4-bit binary value into denary.



Identifier	Data type	Purpose
`Column`	`Integer`	Stores the place value (column heading)
`Answer`	`Integer`	Stores the denary value equivalent to the bit pattern entered by the user
`Bit`	`Integer`	Stores a `0` or `1` entered by the user

What you need to do

Write a program for the above algorithm.

Test the program by showing the result of entering the values `1, 1, 0, 1 (in that order).`

Save the program in your new folder/directory.

Evidence that you need to provide

(a) Your PROGRAM SOURCE CODE.

(11)

(b) SCREEN CAPTURE(S) for the test described above.

(3)

(c) What is the largest denary number that could be output by the algorithm represented by the flowchart in the diagram above?

(1)

(d) The algorithm represented by the flowchart above can convert sixteen different bit patterns into denary.

If the symbol $\boxed{\text{Column} \longleftarrow 8}$ is changed to $\boxed{\text{Column} \longleftarrow 16}$ how many **more** bit patterns could be converted into denary?

(1)

(e) When developing a new system the stages of the systems development life cycle could be followed.

At which stage of the systems development life cycle would the flowchart above have been created?

(1)

(f) At which stage of the systems development life cycle would the algorithm represented by the flowchart above be automated using a programming language?

(1)
(Total 18 marks)

Q16.

A normalised floating point representation uses a 7-bit mantissa and a 5-bit exponent, both stored using **two's complement format**.

(a) In binary, write the most **negative** number that can be represented using this normalised floating point system in the boxes below:

	•					

Mantissa

Exponent

(2)

(b) This is a floating point representation of a number:

1	• 0	1	0	1	0	0		0	0	1	1	0

Mantissa Exponent

Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working: ____

____

____

(1)

Answer:____

(1)

(c) Write the normalised floating point representation of the denary value 416 in the boxes below. Show how you have arrived at your answer.

Working:____

____

____

(1)

Answer:

	•											

Mantissa Exponent

(1)

(d) Write the normalised floating point representation of the negative denary value –12.5 in the boxes below. Show how you have arrived at your answer.

Working: ____

____

____

____

(2)

Answer:

	•											

Mantissa Exponent

(1)

(e) The table below lists three different calculations that might cause an error to occur in a floating point system.

Complete the table below by stating the name of the type of error that may occur for each calculation. You should **not** give the same answer more than once.

Calculation	Type of error
Multiplying two very large numbers together.	
Dividing a number by a very large number.	
Adding together two numbers of very different sizes eg a tiny number to a very big number.	

(3)

(Total 12 marks)

Q17.

(a) Represent the denary number 123 in binary using 8 bits.

Answer ____

(1)

(b) How many different denary numbers can be represented using 8-bit binary?

Answer ____

(1)

(c) What is the hexadecimal equivalent of the denary number 123?

Answer ____

(2)

(d) Why are bit patterns often displayed using hexadecimal instead of binary?

____

____

(1)

(Total 5 marks)

Q18.

The table below shows the values output by a 3-bit Gray Code (GC) counter.

Some of the GC values are missing.

GC	Decimal equivalent
000	0
001	1
(a)	2
(b)	3
(c)	4
111	5
101	6
100	7

(a) What value should be in position **(a)** in the table?

____

(1)

(b) What value should be in position **(b)** in the table?

____

(1)

(c) What value should be in position **(c)** in the table?

(1)

(d) State **one** advantage of GC counters compared with pure binary counters.

(1)

(Total 4 marks)

Q19.

A normalised floating point representation uses an 8-bit mantissa and a 4-bit exponent, both stored using **two's complement format.**

(a) In binary, write in the boxes below, the smallest positive number that can be represented using this normalised floating point system.

	•											

Mantissa Exponent

(2)

(b) This is a floating point representation of a number:

1	•	0	1	1	0	0	0	0	0	0	1	0

Mantissa Exponent

Calculate the denary equivalent of the number. Show your working.

Working:

(1)

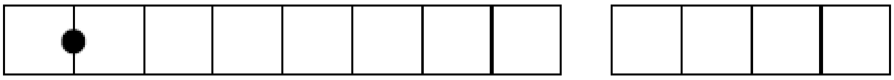
Answer:

(1)

(c) Write the normalised floating point representation of the denary value 12.75 in the boxes below. Space has been provided for you to do rough work, if required.

Rough Work:

Answer:



Mantissa Exponent

(2)

(d) Floating point numbers are usually stored in normalised form.

State **two** advantages of using a normalised representation.

Advantage 1: ____

____

____

Advantage 2: ____

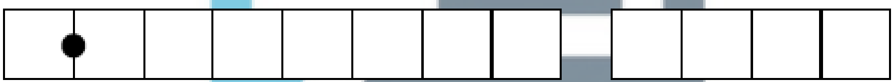
____

____

(2)

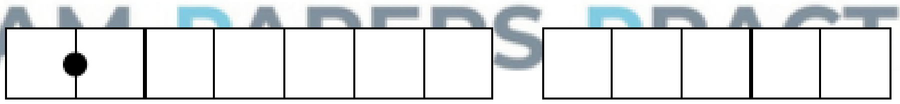
(e) An alternative **two's complement format** representation is proposed. In the alternative representation **7 bits** will be used to store the mantissa and **5** bits will be used to store the exponent.

Existing Representation (8-bit mantissa, 4-bit exponent):



Mantissa Exponent

Proposed Alternative Representation (7-bit mantissa, 5-bit exponent):



Mantissa Exponent

Explain the effects of using the proposed alternative representation instead of the existing representation.

____

____

____

____

____

(2)

(Total 10 marks)

Q20.

The diagram below shows the contents of a memory location.

1	0	1	0	0	1	1	1

(a) What is the denary equivalent of the contents of this memory location if it represents an **unsigned binary integer**?

Use the space below for rough working.

Answer ______________________________________

(1)

(b) What is the denary equivalent of the contents of this memory location if it represents an **unsigned binary fixed point number**, with 4 bits before and 4 bits after the binary point?

Use the space below for rough working.

Answer ______________________________________

(2)

(c) What is the denary equivalent of the contents of this memory location if it represents a **two's complement binary integer**?

Use the space below for rough working.

Answer ______________________________________

(2)

(d) What is the **hexadecimal** equivalent of the binary pattern shown in diagram above?

Use the space below for rough working.

Answer ____

(1)

(Total 6 marks)

Q21.

A normalised floating point representation uses an 8-bit mantissa and a 4-bit exponent, both stored using **two's complement format.**

(a) In binary, write the largest positive number that can be represented using this normalised floating point system in the boxes below.

Mantissa:

●							

Exponent:

(1)

(b) This is a floating point representation of a number.

Mantissa:

1 ●	0	1	0	1	0	0	0

Exponent:

0	0	1	1

Calculate the denary equivalent of the number, showing how you have arrived at your answer.

Working: ____

____

____

Answer: ____

(2)

(c) Write the normalised floating point representation of the denary value 13.625 in the boxes below. Space has been provided for you to do rough work.

Rough Work: ____

____

____

Answer:

Mantissa:

●							

Exponent:

(2)

(d) Write the normalised floating point representation of the denary value 0.34375 in the boxes below. Space has been provided for you to do rough work.

Rough Work: ____

____

____

Answer:

•							

Mantissa

Exponent

(2)

(e) Explain what overflow is and give an example of a situation which might cause overflow to occur.

____

____

____

____

____

(3)

(Total 10 marks)

Q22.

(a) Bitmapped graphic images are composed of **pixels**.

State what is meant by a pixel.

____

____

____

____

(2)

(b) Any black and white image will require only a single bit to encode each pixel.

Figure 1 shows a black and white bitmapped image.
Figure 2 shows the memory locations where the image is stored.
The first byte used for the pixel data is at location 187.
The pixel data are stored row-by-row, starting with row 1:

- black pixels are encoded with the bit set to 1
- white pixels are encoded with the bit set to 0 .

Figure 1

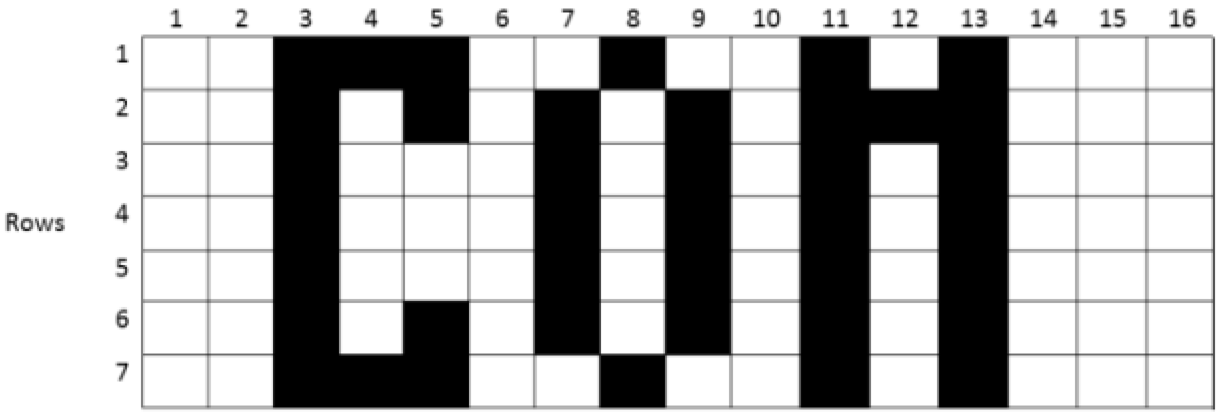


Figure 2

Location	Contents
187	0011 1001
188	0010 1000
189	
190	
:	
:	
:	
200	0010 1000

(i) What will be the contents of location 189 in **binary**?

Use the grid for rough working.

(1)

(ii) What will be the contents of location 190 in **denary**?

____

____

(1)

(c) Colour images can also be encoded as bitmaps.

(i) Explain how the colour of each pixel is encoded.

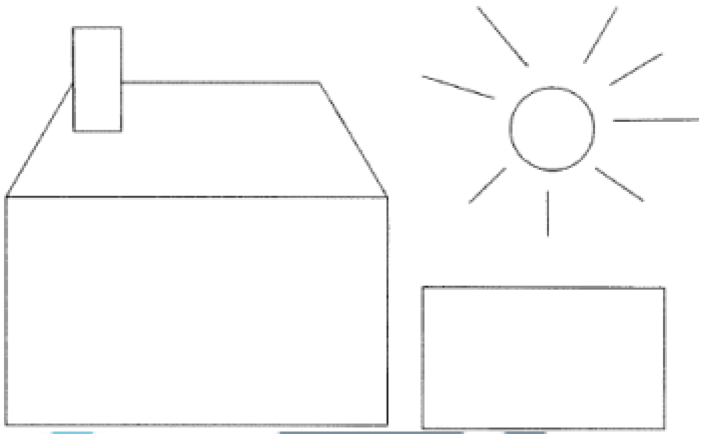
(1)

(ii) How many bits are required to store each pixel for a 256-colour image?

(1)

(d) The image in **Figure 3** was created with a vector graphics program.

Figure 3



(i) Describe how a vector graphics program stores the data about the image.

(2)

(ii) Name **three** properties that would be stored for a circle object.

(3)

(Total 11 marks)

Q23.

Computer programs process and store numeric data.

A computer game stores the following data:

- **level of difficulty** as an integer in the range 1 to 15
- **player rating** as an integer in the range -120 to +120
- **fuel level** as a number with a fractional part.
  This number is in the range 0 to 100.

(a) The level of difficulty is stored as an **unsigned binary number** using a single byte.
For a particular game, the level of difficulty was set at 11.

Calculate its binary value.

(2)

(b) A player rating value is stored as a **two's complement integer** using a single byte.

(i) Convert the player rating value of 119 into binary.

(1)

(ii) Convert the player rating value of -13 into binary.

(2)

(c) A fuel level value is stored as an **unsigned fixed point number** using **two bytes** with **four bits** after the binary point.
Convert the fuel level value of 25.75 into binary.

											●				

(3)
(Total 8 marks)

Q24.

(a) (i) Explain what is meant by a pixel.

____

____

(1)

(ii) How are pixels encoded to form a bitmapped image?

____

____

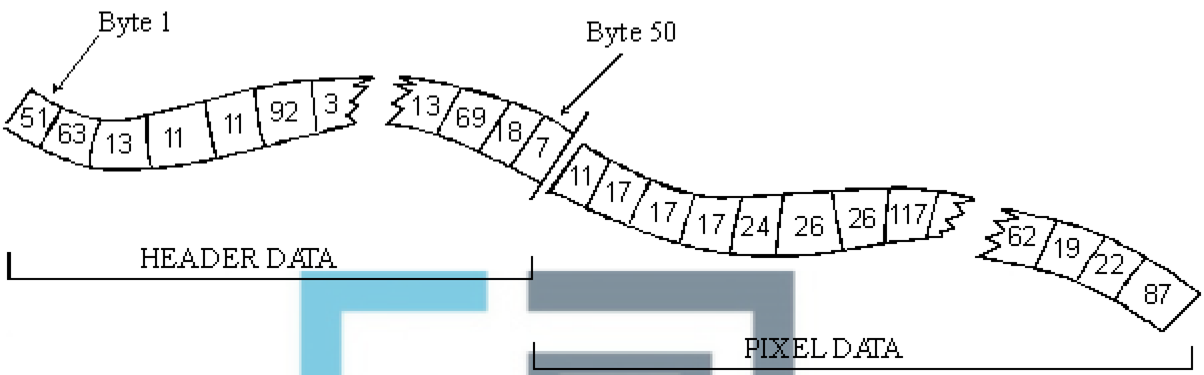
(1)

(b) Images can be saved in a bitmapped image file as a **'256 colour bitmap'**.

How many bytes are used to store each pixel? ______________________________

(1)

(c) The first 50 bytes of these bitmapped files are used for **header data**. See **Figure 1**.



Name **two** items of data which should be included and stored in the file header.

1. ____

2. ____

(2)

(d) A high level programming language has a function `ReadImageByte` which is used to read the contents of a bitmapped image file.

It is defined in the help files as follows:

Function `ReadImageByte : Byte` The function `ReadImageByte` returns the next byte of data from a bitmapped image.

The pseudo-code that describes the process of reading the contents of the file header data is shown below.

```
Procedure ReadHeaderData
   For Position ← 1 To 50 Do
     CurrentHeader [Position] ← ReadImageByte
   EndFor
EndProcedure
```

(i) Complete the identifier information in the table below for this pseudo-code.

Variable Identifier	Data Type	Description
`Position`	Integer	
`Current Header`		Stores theheader data

(2)

The first four bytes of the header data are:

First	Second	Third	Fourth
51	63	13	11

(ii) What **binary value** will be assigned to variable `CurrentHeader[3]`?

____

(1)

(e) The width and height of the bitmapped image are stored by variables `ThisWidth` and `ThisHeight`.

A procedure `ReadPixelData` is to read the remaining contents of a bitmap image i.e. the byteswhich represent the individual pixels and to organise these as an image grid as shown in Figure 2.

Byte 51 Byte 58

Byte 59

11	17	17	17	24	26	26	117
19	50	25	96	96	24	24	113
18	114	22	87	13	29	31	45
81	96	28	87	29	49	45	45
39	101	28	28	62	19	22	87

Byte 98

(i) Complete the gaps in the pseudo-code below.

```
Procedure ReadPixelData
  For X ← 1 To ThisHeight Do
    For Y ← 1 To ______________ Do
      ThisByte ← ReadImageByte
      ByteData [ ______________,  Y] ← ThisByte
    EndFor
  EndFor
EndProcedure
```

(2)

(ii) What data structure has the programmer used for variable `ByteData`?

____

(1)

(f) A graphics studio has produced all the graphic images for a new computing textbook.

The images all need to be ‘tidied up’ and, rather than edit every one with graphics software, it is suggested that the task be given to a computer programmer who will, for each image:

- remove the top row of pixels, and
- remove all the pixels in the first two columns - see **Figure 3**.

Byte 51 Byte 58

Byte 59

255	255	255	255	255	255	255	255
255	25	25	96	96	24	24	113
255	114	22	87	13	29	31	45
255	96	28	87	29	49	45	45
255	101	28	28	27	71	23	23

Byte 98

The `ReadPixelData` procedure is to be refined so that not all pixels will be retained. **The enclosed pixels in Figure 3 are those to be retained** and these bytes will be written to an array `Final`. These pixels, together with the header data bytes, will form the amended bitmapped file.

The test pixel data shown in **Figure 3** are to be used to trace the amended `ReadPixelData` procedure.


```
ThisWidth = 8
ThisHeight = 5
Call ReadPixelData

Procedure ReadPixelData
  Counter ← 0
  For X ← 1 to ThisHeight Do
    For Y ← 1 to ThisWidth Do
      ThisByte ← ReadImageByte
      If(X>1 AND Y>2)Then
        Final [Counter] ← ThisByte
        Counter ← Counter + 1
      EndIf
    EndFor
  EndFor
EndProcedure
```

Trace the execution of the pseudo-code **for two iterations only** of the outer loop (the loop controlled by variable X) by completing **Figure 4**.

ThisWidth	ThisHeight	Counter	X	Y	This Byte		Final
8	5					[0]	
						[1]	
						[2]	
						[3]	
						[4]	
						[5]	
						[6]	
						[7]	
						[8]	
						[9]	
						[10]	
						[11]	
						[12]	
						[13]	
						[14]	
						[15]	

(6)

(g) In this question identifier names have been used in the design for variables and procedure and function names.

(i) Name **one** other program element for which the programmer would allocate an identifier name.

____

(1)

(ii) Programming languages impose restrictions about the choice of identifier names; for example a <Space> character cannot be included.

State **two** other restrictions in a programming language with which you are familiar.

____

____

(2)

(Total 20 marks)

Q25.

The binary pattern 1001 1000 0100 can be interpreted in a number of different ways.

(a) Convert the binary pattern to hexadecimal.

____

(1)

(b) What is the decimal value if this binary pattern represents BCD?

____

(1)

(c) The above binary pattern represents a normalised two's complement floating point number with an **eight** bit mantissa followed by a **four** bit exponent.

(i) State its value in **denary**.

____

____

____

(3)

(ii) Give **one** reason for storing floating point numbers in normalised form.

____

____

(1)

(iii) How does the above binary pattern indicate that the floating point number is normalised?

____

(1)

(iv) What is the largest positive denary number that can be stored using this representation?

____

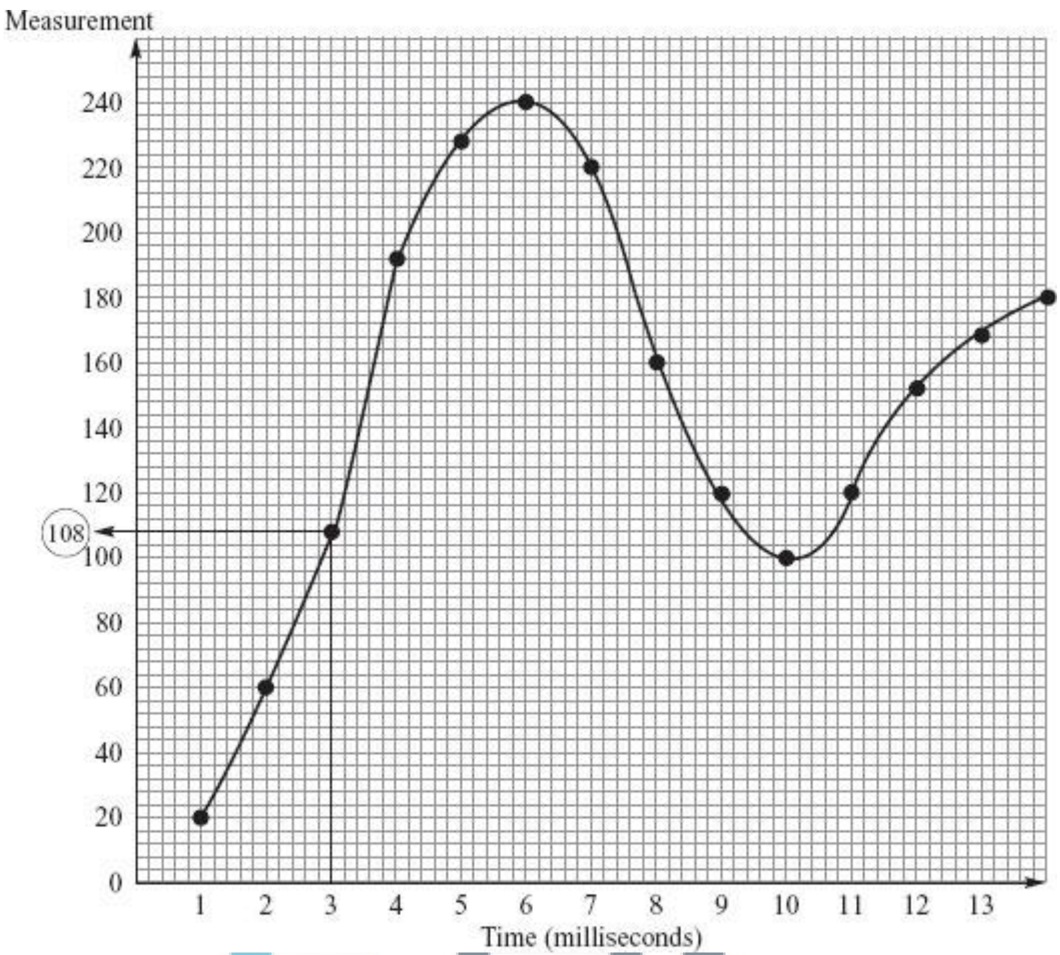
____

(2)

(Total 9 marks)

Q26.

The figure below shows a very small part of a sound wave recorded through a microphone connected to a computer.



The dots each represent a recorded measurement of the sound wave. The recorded measurements are stored in main memory shown in the table below, with the first measurement stored in main memory location 700.

Memory Address	Measurement
700	0001 0100
701	0011 1100
702	(e)
703	1011 1101
704	1110 0011
705	1111 0000
706	1101 1100
707	1010 0000
708	0111 0111
709	0110 0100

(a) Name **two** items of essential software which **must** be in the main memory at the time this recording process takes place.

1. ____

2. ____

(2)

(b) (i) Explain what is meant by the **sampling rate**.

____

(1)

(ii) Study the figure above and state what the sampling rate is for this recording.

(1000 milliseconds = 1 second).

____

(1)

(c) Study the table above. How many bits are allocated to each sample?

____

(1)

(d) (i) State **one** advantage of increasing the number of bits allocated to each sample.

____

(1)

(ii) State **one** disadvantage of increasing the number of bits allocated to each sample.

____

(1)

(e) Study the figure above. What will be the binary value stored at location 702 shown in the table?

____

(1)

(f) In the table each of the binary values represents part of a sound file. Give **three** other possible interpretations of one or more bytes held in main memory when the computer is being used for any application (excluding part of a picture or other media file).

1. ____

2. ____

3. ____

(3)

(Total 11 marks)

Q27.

The decimal number 57 is entered on a keyboard in the form of two ASCII characters ‘5’ and ‘7’. These are stored in the computer’s memory as

0	0	1	1	0	1	0	1
0	0	1	1	0	1	1	1

(a) Express these binary values in hexadecimal.

____

(1)

(b) Express these binary values in denary.

____

(1)

(c) By completing the table below, show how the decimal value 57 could be stored as a signed integer using two’s complement in 8 bits.

(2)

(d) By completing **Table 2**, show how the decimal value 57.0 could be stored in normalised floating point form as an 8 bit mantissa followed by an 8 bit exponent. Both mantissa and exponent are to be stored as signed values using two’s complement.

Table 2

(2)

(e) Give **two** advantages of normalised floating point format over fixed point format.

1. ____

____

2. ____

____

(2)

(Total 8 marks)

Q28.

The table below shows the contents of three memory locations.

Address	Memory contents
56	0011 0111
57	1000 1001
58	1100 0000

If the binary codes each represent a pure binary integer, what are the denary numbers stored at locations 56 and 57?

Address	Memory contents	Denary
56	0011 0111	
57	1000 1001	

(Total 2 marks)

Q29.

Figure 1 below shows an area of main memory storing a text file which is about to be sent to a printer.

Address	Contents
0	
1	
...	
...	
150	0100 0101
151	0101 1000
152	0100 0001
153	0100 1101

Table 1

ASCII Code Table

Character	Decimal	Character	Decimal	Character	Decimal
<Space>	32	I	73	R	82
A	65	J	74	S	83

B	66	K	75	T	84
C	67	L	76	U	85
D	68	M	77	V	86
E	69	N	78	W	87
F	70	O	79	X	88
G	71	P	80	Y	89
H	72	Q	81	Z	90

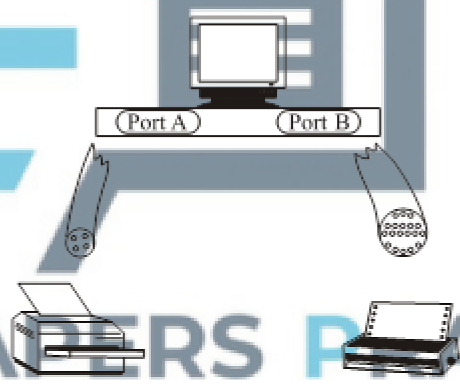
(a) Assuming the first character to be printed is held at address 150, show the **first four** characters to be printed on the page. Use **Table 1.**

____

(3)

(b) **Figure 2** shows there are two printers available on the PC and they are connected to the computer. One is connected to port A, the other to port B.

Figure 2



The cable which connects to port A has 4 wires and connects to a USB printer.

The cable which connects to port B has 25 wires of which eight are used for sending data bits.

(i) What does USB stand for?

____

(1)

(ii) What type of data transmission occurs using Port B?

____

(1)

(iii) The computer communicates with the printer connected to port B using a **handshaking protocol.** Explain this term.

____

(2)

(iv) The port B cable uses 8 wires for data bits. Using a handshaking protocol, the other wires are used to send various signals. Name **one** signal.

(1)

(v) **Figure 1** shows the first four bytes of the text file to be printed. Name **two** necessary items of software resident in main memory at the time the printout is produced.

1.

2.

(2)

(Total 10 marks)

Q30.

The binary pattern 0100 0000 1110 can be interpreted in a number of different ways.

(a) State its hexadecimal representation.

(1)

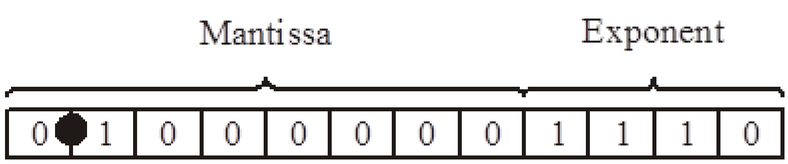
(b) State its value as a decimal number if it represents a signed binary integer using two's complement representation.

(1)

(c) State its value as a decimal number if it represents an unsigned fixed point number with four bits after the binary point.

(2)

(d) (i) State its value as a decimal number if it represents a two's complement floating point number with an eight bit mantissa followed by a four bit exponent.



(3)

(ii) This floating point number is said to be *normalised*
How does the bit pattern indicate that this number is normalised?

____

____

(1)

(iii) What is the largest positive value that can be stored in this floating point representation?

____

(2)
(Total 10 marks)

Q31.

(a) Convert the denary values 27 and –19 into 8-bit binary integers using two's complement format.

27									
–19									

(3)

(b) Add together your **two** 8-bit binary values.

27										
–19										
Result										

(2)

(c) The result has an additional bit.

(i) Give the name of this bit ___________________________________

(1)

(ii) How can it be used? ____

____

(1)

(d) State your binary values for 27 and –19 in Hexadecimal.

27____

–19____

(2)
(Total 9 marks)

Q32.

The figure below shows the main memory and processor of a computer system. Data moves between these **two** components along the data bus which uses parallel data transmission.

(a) (i) Show the binary representation for the denary value 59.

____

(1)

(ii) Add to the diagram in the figure an 8-bit data bus connecting the components showing the value 59 in its binary form being transferred from the main memory to the processor.

(2)

(b) Give **three** possible interpretations of the byte being read in part (a) (ii).

1. ____

2. ____

3. ____

(3)

(Total 6 marks)

Q33.

The binary pattern 1001 0111 0100 can represent different numbers.

(a) State its hexadecimal representation.

____

(1)

(b) State its value in denary if it represents an unsigned fixed point number with four bits after the binary point.

____

(2)

(c) State its value in denary if it represents a two’s complement fixed point number with four bits after the binary point.

____

____

(2)

(d) (i) State its value in denary if it represents a normalised two's complement floating point number with an eight bit mantissa followed by a four bit exponent.

(3)

(ii) Give a reason for storing floating point numbers in normalised form.

(1)

(Total 9 marks)

Q34.

(a) The ASCII code for the character '0' (zero) is 00110000. By completing the boxes show how 27 would be represented in a 16 bit word:

(i) as ASCII characters;

(1)

(ii) in pure binary (unsigned binary).

(1)

(b) Unicode is another coding system for characters. Why is it **not** possible to code 27 into the 16 bit word using Unicode?

(1)

(c) What is the largest value that can be stored in a 16 bit word when the following coding systems are used?

Pure binary (unsigned binary)

(1)

(Total 4 marks)

Q35.

The binary pattern 1000 1100 0100 can be interpreted in a number of different ways.

(a) State its value in **denary** if it represents an unsigned fixed point number with four bits after the binary point.

____

(2)

(b) (i) State its value in **denary** if it represents a two's complement floating point number with an eight bit mantissa followed by a four bit exponent.

____

(3)

(ii) The floating point number 1000 1100 0100 is said to be normalised.

How does the bit pattern indicate that this number is normalised?

____

____

(1)

(iii) Why should floating point numbers be stored in normalised form?

____

____

(1)

(Total 7 marks)