AQA Computer Science A-Level

4.5.4 Binary number system

Past Paper Questions

Additional Specimen AS Paper 2

0 2 . 4 A computer represents numbers using 8-bit two's complement binary.

Using this representation perform the calculation showing all your working:

[2 marks]

$$00001001_2$$
$$00000011_2 \times$$

_____

Answer:

A number is to be represented in binary using 6 bits and twos complement.

0 2 . 5 What is the largest possible positive number that can be represented using this representation.

[1 mark]

_____

_____

Additional Specimen Paper 2

0 2 . 1 A computer represents numbers using **8-bit two's complement** binary.

Using this representation, perform the decimal calculation $78_{10} - 23_{10}$.

Show all of your working.

[3 marks]

| 0 | 2 |.| 2 | Perform the binary calculation $1011_2 * 101_2$.

Show all of your working.

[2 marks]

| 0 | 3 | The following value is stored in a byte:

| 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |

| 0 | 3 |.| 1 | If the byte represents **an unsigned binary integer**, what is its value in **decimal**?

[1 mark]

| 0 | 3 |.| 2 | If the byte represents **a two's complement binary integer**, what is its value in **decimal**?
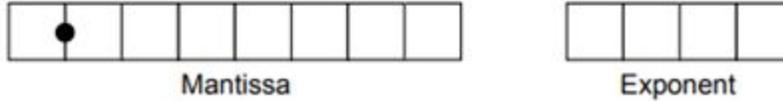
[1 mark]

| 0 | 3 |.| 3 | If the byte represents an **unsigned fixed point binary number** with five bits to the left of the decimal point and three bits to the right of it, what is its value in **decimal?**
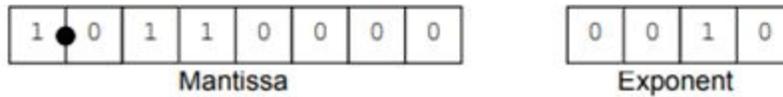
[1 mark]

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

3 (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 marks)

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

| 1 | ● 0 | 1 | 1 | 0 | 0 | 0 | 0 |

Mantissa

| 0 | 0 | 1 | 0 |

Exponent

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

Working: ....

....

....

(1 mark)

Answer: ....
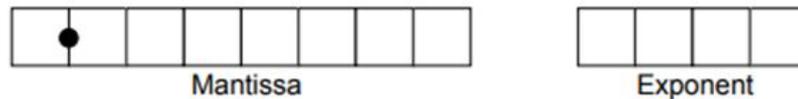
(1 mark)

3 (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.
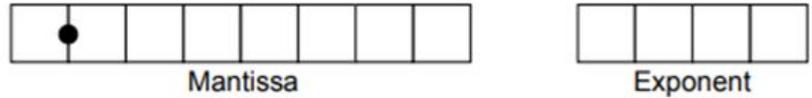
Rough Work: ....

....

....

Answer:

| ● | | | | | | | |

Mantissa

| | | | |

Exponent

(2 marks)

3 (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):
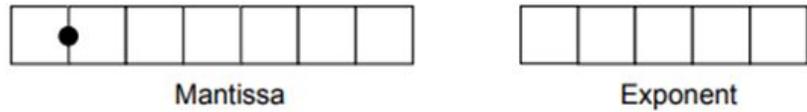
Mantissa   Exponent

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

....

....

....

....

....

(2 marks)

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

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

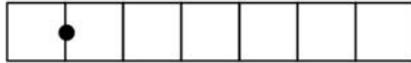Advantage 1: ....

....

Advantage 2: ....

....

(2 marks)

June 2012 Comp 3

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

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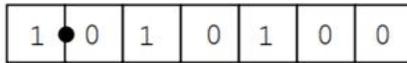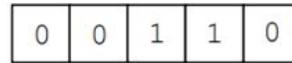
	•						

Mantissa   Exponent

(2 marks)

6 (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 mark)

Answer:...

(1 mark)

6 (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 mark)

Answer:

•						

Mantissa

Exponent

(1 mark)

6 (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 marks)

Answer:

•						

Mantissa

Exponent

(1 mark)

6 (e) **Table 4** lists three different calculations that might cause an error to occur in a floating point system.

Complete **Table 4** 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.

Table 4

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.	Cancellation *Not in new specification

June 2016 AS Paper 2

0 2 **Figure 1** contains a bit pattern.

Figure 1

0	0	1	1	1	0	0	1

0 2 . 3 What is the decimal equivalent of the bit pattern shown in **Figure 1** if it represents an **unsigned fixed-point binary** value with four bits before the binary point and four bits after the binary point?

[2 marks]

_____

_____

_____

_____

_____

| 0 | 2 | . | 4 | What is the decimal equivalent of the bit pattern shown in **Figure 1** if it represents a **two's complement binary integer**?

[1 mark]

_____

_____

_____

June 2017 AS Paper 2

| 0 | 2 | **Figure 1a** and **Figure 1b** show two bit patterns.

Figure 1a

| 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |

Figure 1b

| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |

| 0 | 2 | . | 1 | Explain how unsigned binary integers can be converted to hexadecimal.

You should illustrate in your explanation how the bit pattern in **Figure 1a** would be converted.

[2 marks]

_____

_____

_____

_____

_____

0 2 . 2 If **Figure 1a** and **Figure 1b** both represent unsigned binary integers, what is the **binary result** of adding the two numbers together?

[1 mark]

_____

_____

_____

Answer: _____

0 2 . 3 If **Figure 1a** and **Figure 1b** both represent unsigned binary integers, what is the **binary result** of multiplying the two numbers?

You **must** show your working.

[2 marks]

_____

_____

_____

_____

_____

Answer: _____

0 2 . 4 Indicate clearly on **Figure 2** where the binary point must be placed so that the value 19.375 is represented.

[1 mark]

Figure 2

1	0	0	1	1	0	1	1

1 1

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 8** and are labelled **A**, **B**, **C** and **D**. Some of the bit patterns are valid normalised floating point numbers.

Figure 8

A

0 • 0	0	0	0	0	0	1

Mantissa

0	0	0	0

Exponent

B

0 • 1	0	0	0	0	0	0

Mantissa

1	0	0	0

Exponent

C

1 • 0	0	0	0	0	0	0

Mantissa

0	0	1	0

Exponent

D

1 • 1	0	0	1	1	1	0

Mantissa

1	0	0	0

Exponent
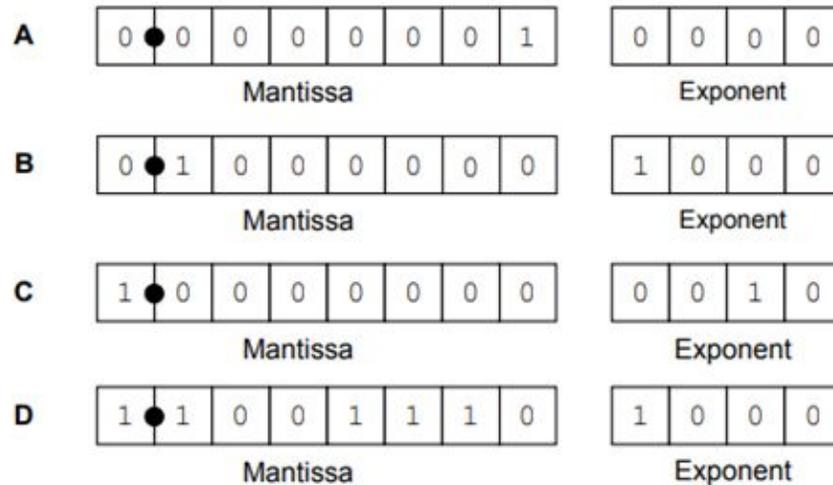
1 1 . 1

Shade **one** lozenge to indicate which bit pattern (**A–D**) in **Figure 8** represents a negative normalised value.

[1 mark]

A ◯   B ◯   C ◯   D ◯

1 1 . 2

Shade **one** lozenge to indicate which bit pattern (**A–D**) in **Figure 8** represents the smallest positive normalised value.
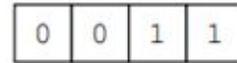
[1 mark]

A ◯   B ◯   C ◯   D ◯

1 1 . 3 The following is a floating point representation of a number:

1 • 0	1	1	0	0	0	0

Mantissa

0	0	1	1

Exponent

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

[2 marks]

_____

_____

_____

_____

Answer _____

1 1 . 4 Write the normalised floating point representation of the decimal value 58.5 in the boxes below. You **must** show your working.

[3 marks]

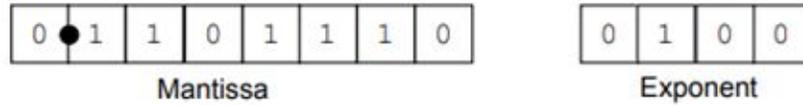_____

_____

_____

_____

Answer

•							

Mantissa

Exponent

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.

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

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

1 1 . 5 Calculate the absolute error that has occurred.

[1 mark]

_____

_____

Answer _____

1 1 . 6 Calculate the relative error that has occurred. Express your answer as a percentage to two decimal places.

[1 mark]

_____

_____

Answer _____

June 2011 Comp 1

0 2 How many different denary numbers can be represented using 8-bit binary?

Use the space below for rough working, then copy the answer to your Electronic Answer Document.

(1 mark)

June 2012 Comp 1

Table 1 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.

Table 1

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

0 1 Complete **Table 1** to show the **Answer** and **Carry** values for the given binary addition rules.

*Copy the cells in **Table 1** that contain your answer into the Electronic Answer Document.*
(3 marks)

June 2013 Comp 1

0 2 Represent the denary value 7.625 as an **unsigned binary fixed point** number, with 4 bits before and 4 bits after the binary point.   *(2 marks)*

0 3 Represent the denary value -18 as an **8-bit two's complement binary integer**.

0 4 What is the **largest positive denary value** that can be represented using **8-bit two's complement binary**?
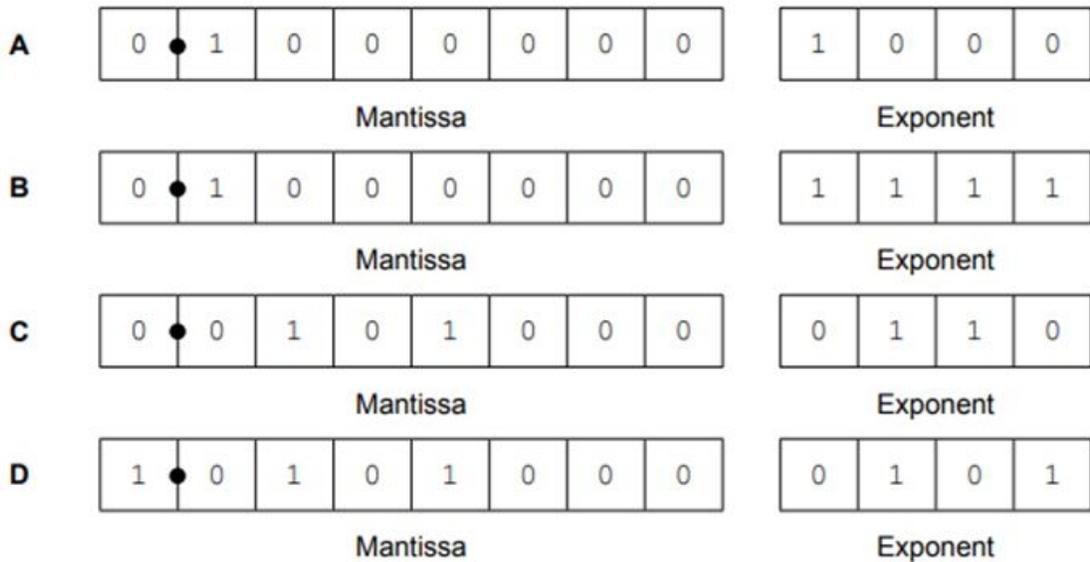
0 5 Describe how **8-bit two's complement binary** can be used to subtract one number from another number. In your answer you must show how the calculation 23 – 48 would be completed using the method that you have described.

2   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**.

2 (a)   Four bit patterns that are stored in this computer's memory are listed in **Figure 3** and are labelled with the letters **A** to **D**. Three of the bit patterns are valid floating point numbers and one is not.

Figure 3

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

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 3** is an example of the type of value described in the **Value description** column.
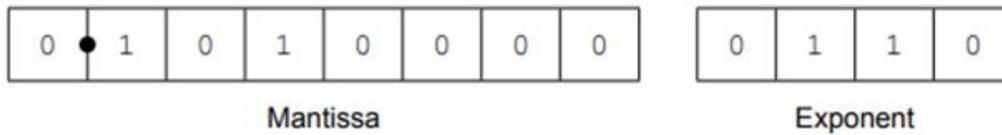
Do **not** use the same letter more than once.

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 marks)

2 (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 mark)

Answer: ....

(1 mark)

2 (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 marks)

Answer:

	•												

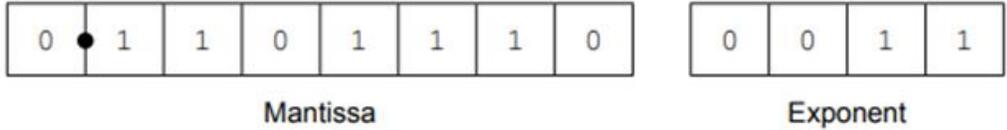   Mantissa   Exponent

(1 mark)

2 (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.

0 • 1	1	0	1	1	1	0		0	0	1	1

Mantissa   Exponent

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

2 (d) (i)   Calculate the absolute error that has occurred.

....

....

(1 mark)

2 (d) (ii)   Calculate the relative error that has occurred.

....

....

(1 mark)

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

....

....

....

(2 marks)

Specimen AS Paper 2

0 2 . 2 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 marks]

_____

_____

_____

_____

0 2 . 3 Represent the decimal value -67_{10} as an **8-bit two's complement binary integer**.

[2 marks]

_____

_____

_____

_____

0 2 . 4 A computer represents numbers using 8-bit two's complement binary.

Using this representation perform the calculation:

[1 mark]

01001000_2
$01100011_2 +$

Answer:

_____

0 2 . 5 What problem has resulted from performing the calculation using 8-bit two's complement binary?

[1 mark]

_____

_____

| 0 | 8 |

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 6** and are labelled **A, B, C, D**. Three of the bit patterns are valid floating point numbers and one is not.

Figure 6

A

0 • 1	0	1	1	1	0	0

Mantissa

1	0	1	0

Exponent

B

0 • 0	0	1	1	0	1	0

Mantissa

0	1	0	1

Exponent

C

1 • 0	0	0	0	0	0	0

Mantissa

0	1	1	1

Exponent

D

1 • 0	1	1	1	1	1	1

Mantissa

1	0	0	0

Exponent
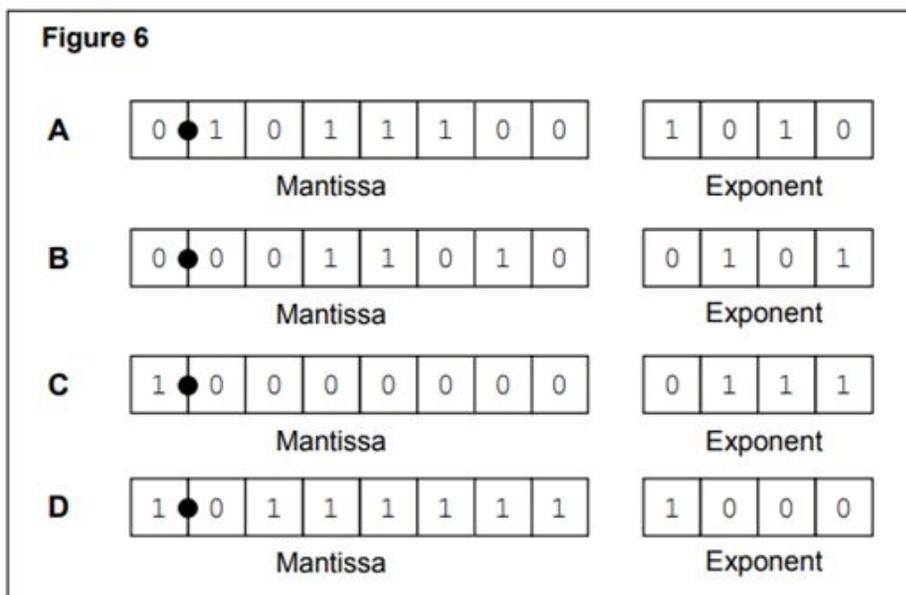
| 0 | 8 | . | 1 |

Complete **Table 3**. In the Correct letter (**A-D**) column shade the appropriate lozenge **A, B, C** or **D** to indicate which bit pattern in **Figure 6** is an example of the type of value described in the Value description column.

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

[3 marks]

Table 3

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 ○

0 8 . 2 The following is a floating point representation of a number:

| 0 • 1 | 0 | 1 | 1 | 0 | 0 | 0 |

Mantissa

| 0 | 1 | 0 | 1 |

Exponent
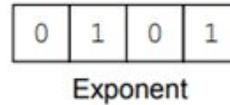
Calculate the decimal equivalent of the number. Show how you have arrived at your answer.
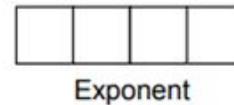
[2 marks]

_____

_____

Answer: _____

0 8 . 3 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.
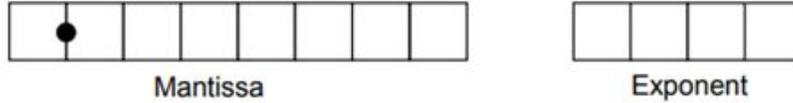
[3 marks]

_____

_____

_____

_____

Answer:

| • | | | | | | | |

Mantissa

| | | | |

Exponent

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

0 8 . 4 Explain the effects of using the proposed alternative representation instead of the existing representation.

[2 marks]

_____

_____

_____

_____