

QUESTION 1.



1 In a particular computer system, real numbers are stored using floating-point representation.

- 8 bits for the mantissa, followed by
- 8 bits for the exponent

Two's complement form is used for both mantissa and exponent.

(a) (i) A real number is stored as the following two bytes:

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

Calculate the denary value of this number. Show your working.

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.....[3]

(ii) Explain why the floating-point number in **part (a)(i)** is not normalised.

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.....[2]

(iii) Normalise the floating-point number in **part (a)(i)**.

Mantissa								Exponent							

[2]



(b) (i) Write the largest positive number that can be written as a normalised floating-point number in this format.

Mantissa	Exponent																
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[2]																	

(ii) Write the smallest positive number that can be written as a normalised floating-point number in this format.

Mantissa	Exponent																
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[2]																	

(iii) If a positive number is added to the number in **part (b)(i)** explain what will happen.

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.....[2]

(c) A student writes a program to output numbers using the following code:

```

X ← 0.0
FOR i ← 0 TO 1000
  X ← X + 0.1
  OUTPUT X
ENDFOR
    
```

The student is surprised to see that the program outputs the following sequence:

0.0 0.1 0.2 0.2999999 0.3999999

Explain why this output has occurred.

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.....[3]

QUESTION 2.

4

1 In a particular computer system, real numbers are stored using floating-point representation.

- 8 bits for the mantissa, followed by
- 4 bits for the exponent



Two's complement form is used for both mantissa and exponent.

(a) (i) A real number is stored as the following 12-bit binary pattern:

0	1	1	0	1	0	0	0	0	0	1	1
---	---	---	---	---	---	---	---	---	---	---	---

Calculate the denary value of this number. Show your working.

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.....[3]

(ii) Give the normalised binary pattern for +3.5. Show your working.

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.....[3]

(iii) Give the normalised binary pattern for –3.5. Show your working.

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.....[3]



The number of bits available to represent a real number is increased to 16.

- (b) (i) If the system were to use the extra 4 bits for the mantissa, state what the effect would be on the numbers that can be represented.

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.....[1]

- (ii) If the system were to use the extra 4 bits for the exponent instead, state what the effect would be on the numbers that can be represented.

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.....[1]

- (c) A student enters the following expression into an interpreter:

OUTPUT (0.1 + 0.2)

The student is surprised to see the following output:

0.30000000000000001

Explain why this output has occurred.

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.....[3]

QUESTION 3.



1 In a particular computer system, real numbers are stored using floating-point representation.

- 12 bits for the mantissa
- 4 bits for the exponent
- two's complement form for both mantissa and exponent

(a) Calculate the floating-point representation of +2.5 in this system. Show your working.

Mantissa											Exponent			
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..... [3]

(b) Calculate the floating-point representation of -2.5 in this system. Show your working.

Mantissa											Exponent			
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..... [3]



(c) Find the denary value for the following binary floating-point number. Show your work.

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

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..... [3]

(d) (i) State whether the floating-point number given in **part (c)** is normalised or not normalised.
 [1]

(ii) Justify your answer given in **part (d)(i)**.

 [1]

(e) The system changes so that it now allocates 8 bits to both the mantissa and the exponent.
 State **two** effects this has on the numbers that can be represented.

1

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2

..... [2]

QUESTION 4.



1 In a particular computer system, real numbers are stored using floating-point representation.

- 8 bits for the mantissa
- 8 bits for the exponent
- two's complement form for both mantissa and exponent

(a) Calculate the floating point representation of +3.5 in this system. Show your working.

Mantissa							Exponent								
●															

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..... [3]

(b) Calculate the floating-point representation of -3.5 in this system. Show your working.

Mantissa							Exponent							
●														

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..... [3]



(c) Find the denary value for the following binary floating-point number. Show your work.

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

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..... [3]

(d) (i) State whether the floating-point number given in **part (c)** is normalised or not normalised.

..... [1]

(ii) Justify your answer given in **part (d)(i)**.

.....

..... [1]

(e) Give the binary two's complement pattern for the negative number with the largest magnitude.

Mantissa								Exponent									
●																	

[2]

QUESTION 5.



2 (a) A computer system stores real numbers using floating-point representation. The numbers have:

- eight bits for the mantissa
- four bits for the exponent.

The mantissa and exponent are both in two's complement form.

(i) Calculate the denary value of the following floating-point number.

Mantissa	Exponent												
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">0</td> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">0</td> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">1</td> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">1</td> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">1</td> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">0</td> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">0</td> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">0</td> </tr> </table>	0	0	1	1	1	0	0	0	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">0</td> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">1</td> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">1</td> <td style="border: 1px solid black; width: 20px; height: 20px; text-align: center;">1</td> </tr> </table>	0	1	1	1
0	0	1	1	1	0	0	0						
0	1	1	1										

Show your working.

Working

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Answer [3]

(ii) State how you know the floating-point number in **part (a)(i)** is not normalised.

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..... [1]

(iii) Normalise the floating-point number in **part (a)(i)**.

Mantissa	Exponent												
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> </tr> </table>									<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> </tr> </table>				

[2]

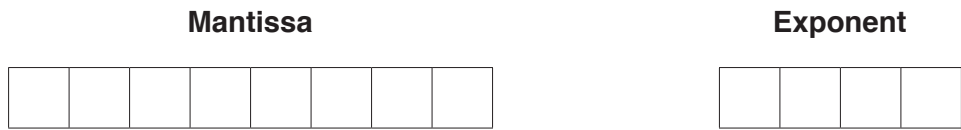
(b) (i) Write the largest positive number that this system can represent as a normalised floating-point number in this format.

Mantissa	Exponent												
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> </tr> </table>									<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> </tr> </table>				

[2]



- (ii) Write the smallest positive number that can be stored as a normalised number in this format.



[2]

- (c) The number of bits available to represent a real number is increased to 16.

State the effect this has on the numbers that can be represented, if the additional four bits are used in the:

(i) mantissa
[1]

(ii) exponent
[1]

- (d) A student enters the following code into an interpreter.

```
X = 0.1
Y = 0.2
Z = 0.3
OUTPUT (X + Y + Z)
```

The student is surprised to see the output:

0.6000000000000001

Explain why this is output.

.....

[3]

QUESTION 6.



1 (a) A computer system uses floating-point representation to store real numbers. The numbers have:

- 8 bits for the mantissa
- 8 bits for the exponent

The mantissa and exponent are both in two's complement form.

(i) Calculate the denary value of the following floating-point number. It is **not** in normalised form.

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

Show your working.

Working

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Answer [3]

(ii) Convert the denary number +7.5 into a normalised floating-point number.

Show your working.

Mantissa								Exponent							

Working

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[3]



(iii) Convert the denary number -7.5 into a normalised floating-point number.
Show your working.

Mantissa

Exponent

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Working

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[3]

(b) A normalised floating-point number is shown.

Mantissa

Exponent

0	1	1	1	1	1	1	1
---	---	---	---	---	---	---	---

0	1	1	1	1	1	1	1
---	---	---	---	---	---	---	---

(i) State the significance of this binary number.

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.....[1]

(ii) State what will happen if a positive number is added to this number.

.....

.....[1]

QUESTION 7.



1 In a computer system, real numbers are stored using normalised floating-point with:

- twelve bits for the mantissa
- four bits for the exponent.

The mantissa and exponent are both in two's complement form.

(a) Calculate the denary value for the following binary floating-point number.

Show your working.

Mantissa

1	0	0	1	0	1	1	1	0	0	1	1
---	---	---	---	---	---	---	---	---	---	---	---

Exponent

0	1	1	1
---	---	---	---

Working

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Answer [3]

(b) Calculate the normalised floating-point representation of +1.5625 in this system.

Show your working.

Working

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.....

.....

.....

Mantissa

--	--	--	--	--	--	--	--	--	--	--	--

Exponent

--	--	--	--

[3]



(c) (i) Write the largest positive number that can be stored as a normalised floating-point number using this format.

Mantissa

Exponent

--	--	--	--	--	--	--	--	--	--	--	--

--	--	--	--

[2]

(ii) Write the smallest non-zero positive number that can be stored as a normalised floating-point number using this format.

Mantissa

Exponent

--	--	--	--	--	--	--	--	--	--	--	--

--	--	--	--

[2]

(d) The developer of a new programming language decides that all real numbers will now be stored using 20-bit normalised floating-point representation. She must decide how many bits to use for the mantissa and how many bits for the exponent.

Explain the trade-off between using either a large number of bits for the mantissa, or a large number of bits for the exponent.

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..... [3]

QUESTION 8.



1 (a) A computer stores real numbers using floating-point representation. The numbers have:

- eight bits for the mantissa
- four bits for the exponent.

The mantissa and exponent are both stored in two's complement format.

(i) Calculate the denary value of the following floating-point number.

Show your working.

Mantissa

0	0	1	1	0	1	1	1
---	---	---	---	---	---	---	---

Exponent

0	1	0	1
---	---	---	---

Working

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Answer

[3]

(ii) State why the floating-point number in **part (a)(i)** is **not** normalised.

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..... [1]

(iii) Give the floating-point number in **part (a)(i)** in normalised two's complement format.

Mantissa

--	--	--	--	--	--	--	--

Exponent

--	--	--	--

[2]



- (b) (i) Convert the denary number +11.625 into a normalised floating-point number.

Show your working.

Working

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Mantissa

--	--	--	--	--	--	--	--

Exponent

--	--	--	--

[3]

- (ii) Convert the denary number –11.625 into a normalised floating-point number.

Show your working.

Working

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.....

Mantissa

--	--	--	--	--	--	--	--

Exponent

--	--	--	--

[3]



(c) A student enters the following into an interpreter:

```
OUTPUT (0.2 * 0.4)
```

The student is surprised to see that the interpreter outputs the following:

```
0.080000000000000002
```

Explain why the interpreter outputs this value.

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QUESTION 9.



1 Real numbers are stored using floating-point representation in a computer system.

This representation uses:

- 8 bits for the mantissa, followed by
- 4 bits for the exponent.

Two's complement form is used for both the mantissa and the exponent.

(a) (i) A real number is stored as a 12-bit normalised binary number as follows:

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

Calculate the denary value for this binary number. Show your working.

Working

.....

.....

Denary value [3]

(ii) Calculate the normalised binary number for -3.75 . Show your working.

Mantissa	Exponent

Working

.....

.....

.....

[3]

(b) The number of bits available to represent a real number is increased to 16.

State the effect of increasing the size of the exponent by 4 bits.

.....

..... [1]



(c) State why some binary representations can lead to rounding errors.

.....
.....

(d) Complete the following descriptions by inserting the **two** missing terms.

..... can occur in the exponent of a floating-point number, when the exponent has become too large to be represented using the number of bits available.

A calculation results in a number so small that it cannot be represented by the number of bits available. This is called

[2]

QUESTION 10.



8 (a) The following 16-bit binary pattern represents a floating-point number in two's complement form. The twelve most significant bits are used for the mantissa and the four least significant bits are used for the exponent.

Most significant bit
↓

significant
↓

0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

(i) Identify the binary value of the exponent.

..... [1]

(ii) Identify the binary value of the mantissa.

..... [1]

(iii) State whether the number stored is positive or negative. Justify your choice.

Positive or negative

Justification

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[2]

(iv) Convert the binary floating-point number in **part (a)** into denary. Show your working.

Working

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Denary value

[3]



- (b) The number of bits used for the exponent is increased to eight, and the number of bits used for the mantissa is decreased to eight.

State the effects of this change.

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..... [2]



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