QUESTION 1.

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

- 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

0	0	1	0	1	0	0	0

+ve

Exponent 4 2 1

+ve

0	0	0	0	0	0	1	1

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

Exponent = 3

Mantissa = 00101000

$= 0.0101000 \times 2^3$

8 4 2 1 0.5 0.25

$= 0010.1000$

$= 2.5$ [3]

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

It is +ve no, so it must start with 0.1 to be normalized but the given no starts with 0.0 [2]

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

Mantissa

0 · 1	0	1	0	0	0	0	

Exponent

0	0	0	0	0	0	1	0

[2]

Qn is $0.0101000 \times 2^3 = 0.101000 \times 2^2$

0 here

(b) **(i)** Write the largest positive number that can be written as a normalis
number in this format.

+ve exp

largest

Mantissa							
0	1	1	1	1	1	1	1

Exponent							
0	1	1	1	1	1	1	1

[2]

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

0.1...

-ve exp & highest -ve

Mantissa							
0	1	0	0	0	0	0	0

Exponent							
1	0	0	0	0	0	0	0

0.1... for +ve

[2]

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

If +ve no is added overflow occur as there is no way to represent higher value. If we neglect overflow bit, it will go to smaller number.

[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.

Computer can't exactly represent every float values so, rep^n of 0.1 is approximate the given program adds this approx so, error accumulates resulting in noticable error in later terms.

[3]

QUESTION 2.

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

- 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.

....[3]

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

3.5

= 11.1

= 0.111×2^2

Using 8 bit for mantissa & 4 bit for exponent as above

⇒

Mantissa = 01110000

Exponent = 0010

[3]

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

3.5 = 11.1

lets use 8 bits for mantissa

3.5 = 011.10000 ⇒ flip +1

-3.5 = 100.10000

= 1.001000×2^2

mantissa = 1001000

[3]

exponent = 0010

more bits in exp ⇒ range↑
more bits in mantissa ⇒ precision↑

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.

precision increases

....[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.

range increases

....[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.

....

....

....

....

....

....[3]

QUESTION 3.

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

- 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**

	•										

[3]

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

Mantissa **Exponent**

	•										

[3]

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

Mantissa

0 ●	0	1	1	0	0	0	0	0	0	0	0

Exponent

0	0	1	1

....

....

....

....

....

.... [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 ....

....

2 ....

.... [2]

QUESTION 4.

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

- 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

[3]

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

Mantissa

•							

Exponent

[3]

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

Mantissa

0	● 1	1	1	0	0	0	0

Exponent

0	0	0	0	0	1	0	0

....

....

....

....

....

.... [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.
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

0	0	1	1	1	0	0	0

Exponent

0	1	1	1

Show your working.

Working ....

....

....

....

....

Answer .... [3]

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

....

....[1]

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

Mantissa

Exponent

[2]

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

Mantissa

Exponent

[2]

(ii) Write the smallest positive number that can be stored as a normalis[ed floating-point] number in this format.

Mantissa									**Exponent**			

[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. 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

0	0	1	0	1	0	1	0

Exponent

0	0	0	0	0	1	0	1

Show your working.

Working ....

....

....

....

....

Answer ....

[3]

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

Show your working.

Mantissa

Exponent

Working ....

....

....

....

....

[3]

(iii) Convert the denary number –7.5 into a normalised floating-point numbe

Show your working.

Mantissa

Exponent

Working ....

....

....

....

....
[3]

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

Mantissa

0	1	1	1	1	1	1	1

Exponent

0	1	1	1	1	1	1	1

(i) State the significance of this binary number.

....

....[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-poi
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 ....

....

....

....

....

Answer .... [3]

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

Show your working.

Working ....

....

....

....

....

....

Mantissa

Exponent

[3]

(c) **(i)** Write the largest positive number that can be stored as a normalis
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.

....

....

....

....

....

.... [3]

QUESTION 8.

1 **(a)** A computer stores real numbers using floating-point representation. T
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 ....

....

....

....

....

Answer ....

[3]

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

....

.... [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 nu

Show your working.

Working ....

....

....

....

....

....

Mantissa

Exponent

[3]

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

Show your working.

Working ....

....

....

....

....

....

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:

```
0.08000000000000002
```

Explain why the interpreter outputs this value.

....

....

....

....

....

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

0	1	0	1	0	0	1	0

Exponent

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 complement form. The twelve most significant bits are used for the mantissa least significant bits are used for the exponent.

Most significant bit ↓ | **significant** ↓

0	1	1	1	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 ....

....

....
[2]

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

Working ....

....

....

....

....

Denary value ....
[3]

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

State the effects of this change.

....

....

....

.... [2]

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