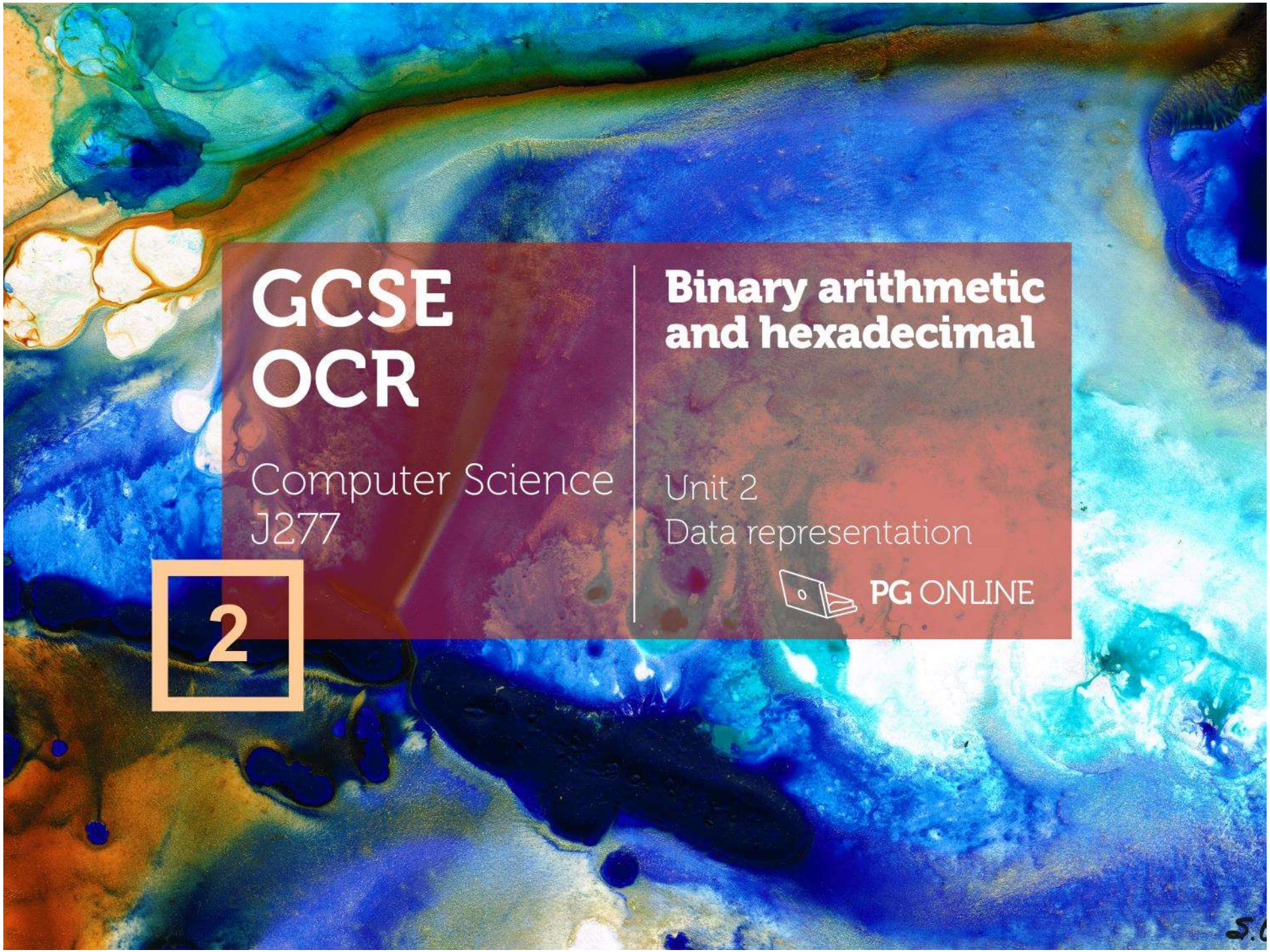
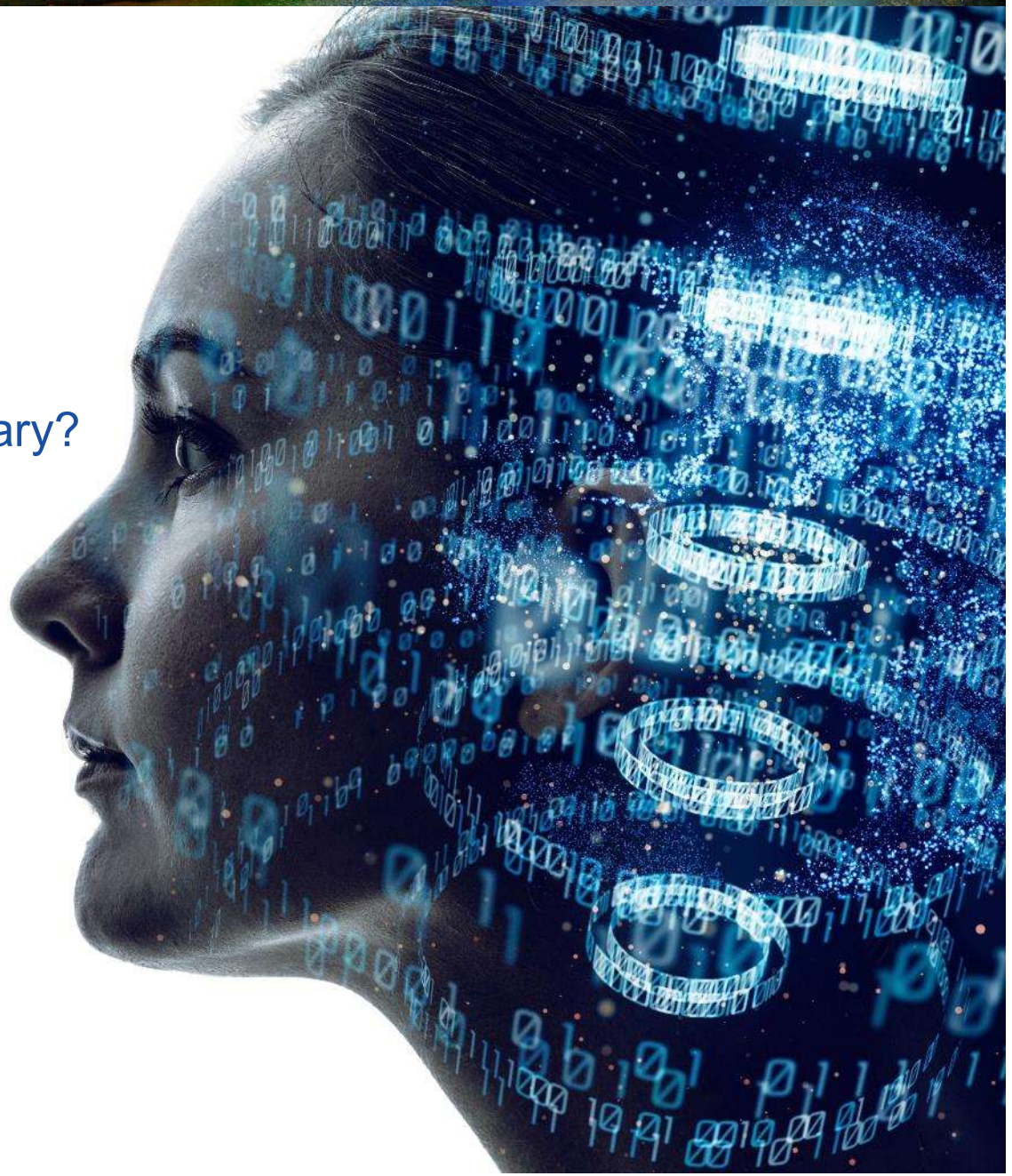

GCSE
OCR
Computer Science
J277
2
Binary arithmetic and hexadecimal
Unit 2
Data representation
PG ONLINE

Objectives

- Convert positive denary whole numbers (0-255) into 2-digit hexadecimal numbers and vice versa
- Convert between binary, denary and hexadecimal equivalents of the same number
- Add two 8-bit binary integers and explain overflow errors which may occur
- Understand the use of binary shifts

Starter

- Review:
  - What is 7 in binary?
  - What is 1001 in denary?
- What is:
  1001 + 110 ?



Starter

Answers

- What is 7 in binary?
  - 111
- What is 1001 in denary?
  - 9
- What is 1001 + 110?
  - Binary Denary
    1001+ 9+
    110 6
    1111 =15

Binary to denary conversion

- Practise converting binary to denary and back again
  - Convert each of the following to binary or denary

128	64	32	16	8	4	2	1
0	1	0	1	1	0	0	1
1	1	0	0	0	0	1	0

14

105

How can you quickly tell which is odd and even in any binary number?

Binary to denary conversion

Answers

- 0101 1001 = 89
- 1100 0010 = 194
- 14 = 1110
- 105 = 110 1001
- Even binary numbers will have a 0 at the end
- Odd binary numbers will have a 1 at the end

Hexadecimal

- Hexadecimal (or hex) is a number system which uses base 16
- As we only have 10 digits, it uses 0-9 and then the letters A to F

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**A**	**B**	**C**	**D**	**E**	**F**

- What is **F** in denary?
- What is **10** in hex?

Hex to denary conversion

- You will only need to translate one- or two-digit hexadecimal numbers

16s	Units
2	**A**

2x16 + 10 = 42 in denary

- Multiply the left-hand digit by 16, then add the units
- What is hex **27** in denary?

Denary to hex conversion

- Divide the denary number by 16 to get the number of 16s (the left-hand hex digit)
- The remainder gives you the units

  Denary **18** becomes:

  18 / 16 = 1 remained 2 so
  the hex value for **18** is **12**

  (*Spoken, 'One Two', not 'Twelve'*)

- What is denary **27** in hex?
- What is denary **44** in hex?

Hex to denary conversions

Answers

- What is hex 27 in denary?
  - 2 x 16 + 7 = 39
- What is denary 27 in hex?
  - **1** x 16 remainder 11 (11 is **B** in hex) = 1B
- What is denary 44 in hex?
  - **2** x 16 remainder 12 (12 is **C** in hex) = 2C

Worksheet 2

- Complete **Task 1a** on **Worksheet 2**

Binary to hex conversion

- Take a binary word of 8 bits

  1 1 1 0 0 1 0 1

- Divide into two nibbles of 4 bits

  1 1 1 0 0 1 0 1

- Convert each nibble into its hex value and rejoin

  1 1 1 0 = 14 = E in Hex + 0 1 0 1 = 5 in Hex

  So 1 1 1 0 0 1 0 1 = E5 in Hex

Hex to binary conversion

- What is **3B** in hex?

  Split the two hex characters

  3 = 0011 in binary and **B = 1011**

  So **3B = 0011 1011** in binary

  What is hex **21** in binary?

  What is hex **A5** in binary?

Hex to binary conversion

Answers

- What is hex 21 in binary?
  - 2 = 0010, 1 = 0001
  - 21 in hex = 0010 0001 in binary
- What is hex A5 in binary?
  - A = 10 = 1010, 5 = 0101
  - A5 in hex = 1010 0101 in binary

Worksheet 2

- Complete **Task 1b** on **Worksheet 2**

Why use hex?

- There are advantages for programmers and Computer Scientists in using hex rather than binary
  - It is much simpler to remember a hex value than a binary value
  - It is quicker to write or type since a hex digit only takes up one digit rather than 4 bits
  - People are less likely to make an error with fewer digits
  - It is easy to convert between hex and binary

Binary addition

- Use binary to add two numbers together

1 + 1 = 10?

Simple denary addition

Work right to left :

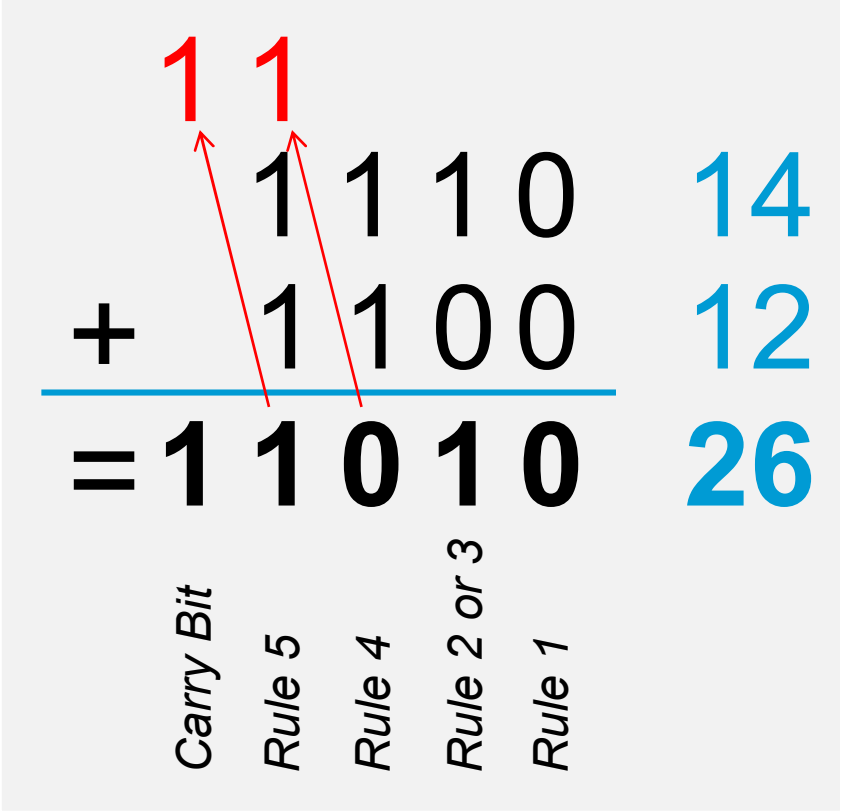
1. **Add the Units**
2. **If Over 9, *Carry* Tens**
3. **Add Tens**

```
    1
  1 4
+ 1 7
= 3 1
```

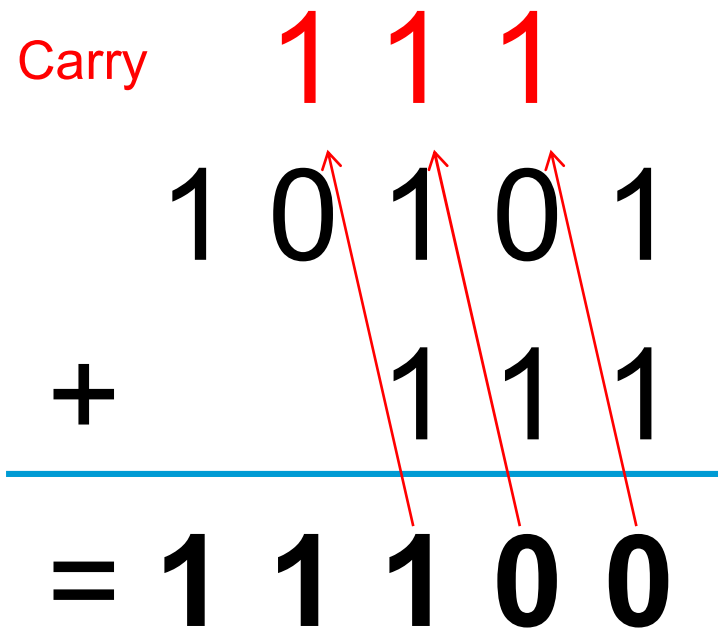
The rules of binary addition

Work right to left and apply these simple rules:

1. 0 + 0 = 0
2. 0 + 1 = 1
3. 1 + 0 = 1
4. 1 + 1 = 0 *Carry 1*
5. 1 + 1 + 1 = 1 *Carry 1*



Adding binary values



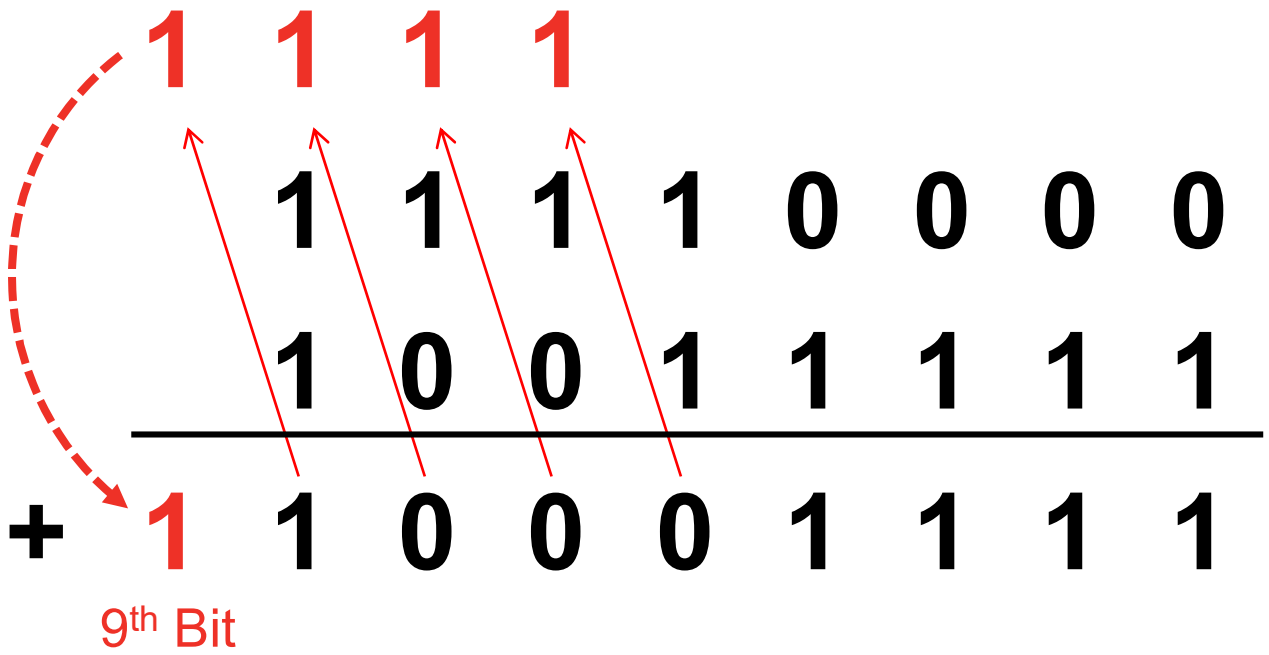
Adding numbers

- Computers work with a fixed number of bits at a time
  - This can cause problems
  - What problem will arise when adding the following bytes and storing the result in one byte?

```
  1 1 1 1 0 0 0 0
+ 1 0 0 1 1 1 1 1
```

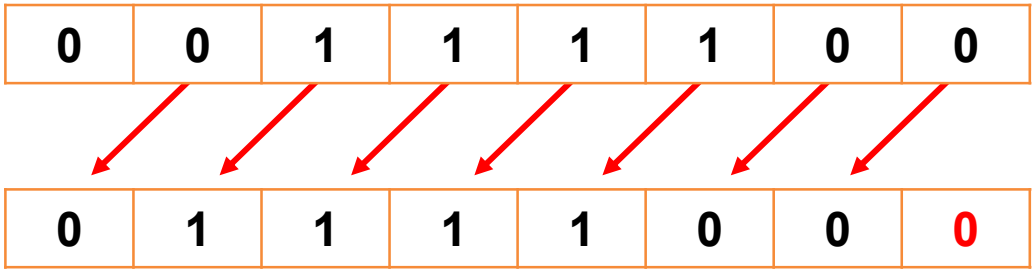
Overflow error

- When the result of an addition is too large for the number of bits the computer works with there will be an **overflow error**



Logical binary shift operations

- A binary shift left of one bit moves all the bits one place to the left
  - The vacant bit spaces are filled with zeros



- Looking at the table above, what effect does a shift left of one place have on the binary value?
  - What effect would a shift right of two places have?

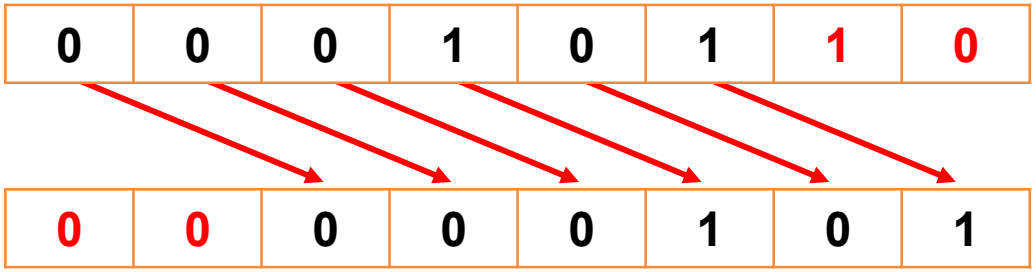
Shift operations

Answers

- A binary shift left of one bit doubles the number
  - E.g. 1000=8
    Shift left once, 10000=16
- A binary shift right of two places results in halving the number and rounding down each time
  - Example 1: 1000=8
    Right shift once, 100 = 4
    Right shift again, 10 = 2
  - Example 2: 1001 = 9
    Right shift once, 100 = 4
    Right shift again, 10 = 2

Effects of shifts

- Logical shifts can very quickly multiply or divide a binary number by a factor of two
  - Left shifts multiply
  - Right shifts divide
- A loss of accuracy can occur if 1 bits are removed:
  - 22 / 4 is not exactly 5



Worksheet 2

- Complete **Task 2**

Plenary

- Work out the answers to each of the following then compare your answers with a partner
  - Convert C in hexadecimal to denary
  - Convert 2B in hexadecimal to binary
  - Convert 1010 0011 in binary to hexadecimal
  - Calculate
    1001 0101 +
    0010 0110
  - Calculate the left shift of 0110 1011
  - Explain the effect of a left shift

Plenary

Answers

- C in hexadecimal = 12 in denary
- 2B in hexadecimal = 16*2 + 1*B = 32 + 11 = 43
- 1010 0011 in binary = A3 in hexadecimal
- 1001 0101 + 0010 0110 = 1011 1011 in binary
- Left shift 0110 1011 (107) = 1101 0110 (214)
- The left shift doubles the number

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