**Worksheet 4: Binary addition**

# Use the rules a – e of binary addition below as a guide to work out the answers to the questions

1. **0 + 0 = 0**
2. **0 + 1 = 1**
3. **1 + 0 = 1**
4. **1 + 1 = 0 *carry 1 = 10***
5. **1 + 1 + 1 = 1 *carry 1 = 11***

1. Start with this simple sum. (You can use rules (a) and (b) to help you if necessary.) Calculate the decimal equivalent and check that it is correct.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **8** | **4** | **2** | **1** |  |  | **Decimal** |
|  | 0 | 0 | 1 | 1 | = |  | 3 |
| + | 1 | 0 | 0 | 0 | = | + |  |
| = |  |  |  |  | = | = |  |

2. Use the same techniques as you did in the last question to find the binary result.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 1 | 0 | 0 | 1 |
| + | 0 | 1 | 0 | 0 |
| = |  |  |  |  |

3, Use the carry row at the top for the carried 1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  | 1 | 0 | 1 | 1 |
| + | 0 | 0 | 1 | 0 |
| = |  |  |  |  |

4. Now use rule (d) to help with this problem. Remember that like in decimal addition, the last carry just makes the number bigger and is added on to the left of the number.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
|  |  | 1 | 0 | 1 | 1 |
| + |  | 1 | 0 | 1 | 0 |
| = |  |  |  |  |  |

5. Use rule (e) in this question. Use the carry row again and remember: 1+1+1 = 1 carry 1.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
|  |  | 1 | 1 | 1 | 1 |
| + |  | 1 | 0 | 1 | 1 |
| = |  |  |  |  |  |

6. Increase the size of the numbers using a 6-bit pattern. Apply the same rules as before.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
|  | 1 | 0 | 0 | 0 | 1 | 1 |
| + | 0 | 1 | 1 | 0 | 1 | 0 |
| = |  |  |  |  |  |  |

7. Now try a full 8-bit binary pattern.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |
|  | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| + | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| = |  |  |  |  |  |  |  |  |

8. Now try without the help of the grid or rules (a) to (e) to refer to.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |
|  | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| + | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| = |  |  |  |  |  |  |  |  |

An 8-bit binary pattern can hold 256 different numbers – 0–255. When the result of the addition is greater than 255, an overflow error occurs!

9. Try and work out the answer here using all the normal rules and see if you get an overflow error.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |
|  | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| + | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
|  |  |  |  |  |  |  |  |  |

10. How do computers hold numbers greater than 255?