

Binary Addition

You need to be able to add up 3 binary numbers

This works just like adding decimal (normal) numbers, but can only use binary numbers - so you can only use 0s and 1s

Binary Addition

The rules:

$$0 + 0 + 0 = 0$$

$$1 + 0 + 0 = 1$$

$$0 + 1 + 0 = 1$$

$$1 + 1 + 0 = 10 \quad (1 + 1 = 2; 2 \text{ in binary is } 10)$$

$$1 + 1 + 1 = 11 \quad (1 + 1 + 1 = 3; 3 \text{ in binary is } 11)$$

Binary Addition

$$\begin{array}{r} 01001001 \\ 01010100 \\ + 01001000 \\ \hline \end{array}$$

Binary Addition

Start by adding as normal:

- $1 + 0 + 0 = 1$
- $0 + 0 + 0 = 0$

	0	1	0	0	1	0	0	1
	0	1	0	1	0	1	0	0
+	0	1	0	0	1	0	0	0
<hr/>								
						1	0	1

Binary Addition

Then carry any added digits:

- $1 + 0 + 1 = 2$ - which is 10 in binary
- so put the 0 in the column and **carry the 1**

$$\begin{array}{rcccccccc} & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 \\ & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 \\ + & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\ \hline & & & & & 0 & 1 & 0 & 1 \\ & & & & & & & & & 1 \end{array}$$

Binary Addition

Continue to carry 10 as needed...

$$\begin{array}{r} 01001001 \\ 01010100 \\ + 01001000 \\ \hline 10010101 \\ 11 \end{array}$$

Binary Addition

- $1 + 1 + 1 = 3$; 3 is 11 in binary
- So put the 1 in the column and carry the 1 across

$$\begin{array}{rcccccccc} & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 \\ & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 \\ + & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\ \hline & & \mathbf{1} & \mathbf{1} & \mathbf{0} & \mathbf{0} & \mathbf{1} & \mathbf{0} & \mathbf{1} \\ & \mathbf{1} & & \mathbf{1} & \mathbf{1} & & & & \end{array}$$

Binary Addition

Double check your answer - it's easy to make a silly mistake

Make sure you **carry across carefully**

$$\begin{array}{r} 01001001 \\ 01010100 \\ + 01001000 \\ \hline 11100101 \\ \text{1} \quad \quad \text{1} \quad \quad \text{1} \end{array}$$

Binary Addition

2 to try for yourself

$$\begin{array}{r} 00100001 \\ 01100001 \\ + 00110100 \\ \hline \end{array}$$

$$\begin{array}{r} 10001100 \\ 01010100 \\ + 00010010 \\ \hline \end{array}$$

Answers on the next slide... (no peeking!)

Binary Addition

How did you do? Did you **carry across carefully**?

$$\begin{array}{r} 00100001 \\ 01100001 \\ + 00110100 \\ \hline 10110110 \\ \text{1 1} \qquad \qquad \qquad \text{1} \end{array}$$

$$\begin{array}{r} 10001100 \\ 01010100 \\ + 00010010 \\ \hline 11110010 \\ \qquad \qquad \qquad \text{1 1 1} \end{array}$$

1 mark is given for the left 4 numbers and a second mark for the right 4 numbers

Binary Addition - what if...

You'll probably never get given this, but what if...

$$\begin{array}{rcccccccc} & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \\ + & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 \\ \hline & & & & & & & \mathbf{1} & \mathbf{1} & \mathbf{0} \\ & & & & & & & 1 & 1 & 1 \end{array}$$

Binary Addition - what if...

$1+1+1+1 = 4$; 4 in binary is 100.

So carry the 1 and 0 - but in **their own columns...**

	1	0	0	0	1	0	1	1
	0	0	0	1	1	1	1	0
+	0	0	0	0	1	1	0	1
<hr/>								
					0	1	1	0
			1	0	1	1	1	

Binary Addition - what if...

I've never seen this done in an exam, but it is possible you'll get it...

$$\begin{array}{rcccccccc} & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \\ + & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 \\ \hline & \mathbf{1} & \mathbf{0} & \mathbf{1} & \mathbf{1} & \mathbf{0} & \mathbf{1} & \mathbf{1} & \mathbf{0} \\ & & & & 1 & 0 & 1 & 1 & 1 \end{array}$$

Binary Addition

Summary:

- only use binary numbers (0s and 1s)
- add up as normal
- $1 + 1 = 10$ - so put 0 and carry the 1 to the left
- $1 + 1 + 1 = 11$ - so put 1 and carry the 1
- double check your answer
- there are always 2 marks available

Binary Addition

You will **never** be given a question that does this

If you end up adding a bit to the left then you've done something wrong!

	1	0	0	0	1	0	1	1
	1	0	0	1	1	1	1	0
+	0	0	0	0	1	1	0	1
<hr/>								
1	0	0	1	1	0	1	1	0
1			1	0	1	1	1	