

1.4 DATA TYPES & STRUCTURES · 1.4.3

Adders & flip-flops — Mark scheme

30 marks · spec 1.4.3(e)

AO key: AO1 = knowledge · AO2 = application. Accept any valid notation. Do not award the same point twice.

Q	ANSWER	AO	MARKS
1(a)	$S = A \oplus B$. (1)	AO1	1
1(b)	$C = A \cdot B$. (1)	AO1	1
1(c)	A and B into an XOR gate giving S (1); the same A and B into an AND gate giving C (1). (2)	AO2	2
1(d)	It cannot accept a carry-in from a previous column (only adds two bits). (1)	AO1	1
1(e)	$S = 0, C = 1$. (1)	AO2	1

Q	ANSWER	AO	MARKS																																													
2(a)	3 (A, B and the carry-in). (1)	AO1	1																																													
2(b)	<table><tr><th>A</th><th>B</th><th>CIN</th><th>S</th><th>COUT</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr></table> S column correct (2); Cout column correct (2) (1 each if mostly correct). (4)	A	B	CIN	S	COUT	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	1	1	0	1	1	0	0	1	0	1	0	1	0	1	1	1	0	0	1	1	1	1	1	1	AO2	4
A	B	CIN	S	COUT																																												
0	0	0	0	0																																												
0	0	1	1	0																																												
0	1	0	1	0																																												
0	1	1	0	1																																												
1	0	0	1	0																																												
1	0	1	0	1																																												
1	1	0	0	1																																												
1	1	1	1	1																																												
2(c)	One full adder per bit/column, with the carry-out of each fed into the carry-in of the next (chained). (1)	AO1	1																																													

Q	ANSWER	AO	MARKS
3(a)	It stores one bit of data (1); synchronised to a clock (1). (2)	AO1	2
3(b)	Inputs: a data input D and a clock (1); outputs: Q and $\neg Q$ (1). (2)	AO1	2
3(c)	On the clock edge/pulse it captures the value on D (1); and holds it on Q until the next clock edge (even if D changes) (1). (2)	AO1	2

Q	ANSWER	AO	MARKS
4(a)	$S = A \oplus B \oplus \text{Cin}$. (1)	AO1	1
4(b)	$\text{Cout} = (A \cdot B) + (\text{Cin} \cdot (A \oplus B))$. Correct expression (2) (1 if a valid equivalent with a slip). (2)	AO2	2
4(c)	Registers / memory. (1)	AO1	1
4(d)	The shared clock makes all the flip-flops capture/change at the same time (1); keeping them synchronised / in step across the processor (1). (2)	AO1	2

Q	ANSWER	AO	MARKS
5(a)	$S = 1$ (1); $\text{Cout} = 1$ (1). (2)	AO2	2
5(b)	$1 + 1 + 1 = 3$, which is binary 11 (1); the sum bit is 1 and the carry-out is 1, matching $S=1$, $\text{Cout}=1$ (1). (2)	AO2	2
5(c)	8 (one per bit). (1)	AO2	1
5(d)	An XOR gate. (1)	AO1	1

Total for paper: 30 marks