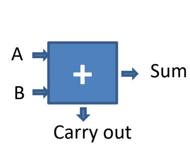
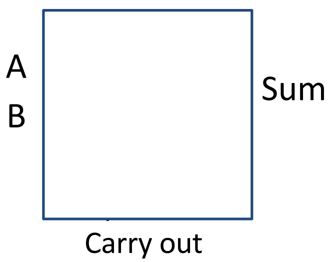
Addition: 1-bit *half* adder

ex

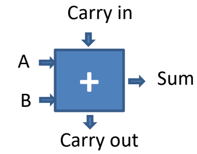


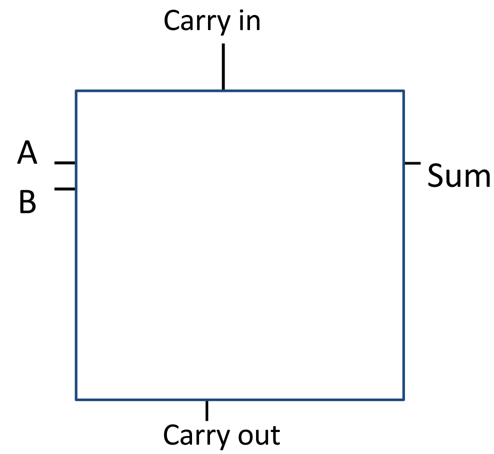
A	B	Carry out	Sum
0	0		
0	1		
1	0		
1	1		



Addition: 1-bit *full* adder

ex



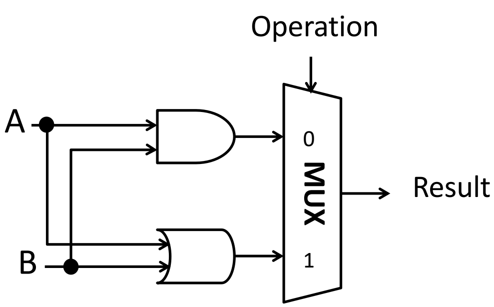


Carry in	A	B	Carry out	Sum
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

1-bit ALU for bitwise operations

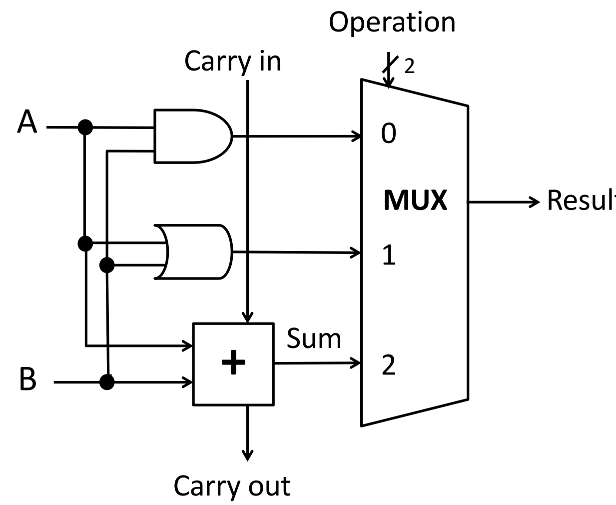
ex

Build an n-bit ALU from n 1-bit ALUs.
Each bit *i* in the result is computed from the corresponding bit *i* in the two inputs.



Op	A	B	Result
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

1-bit ALU



ALU conditions

Extra ALU outputs
describing properties of result.

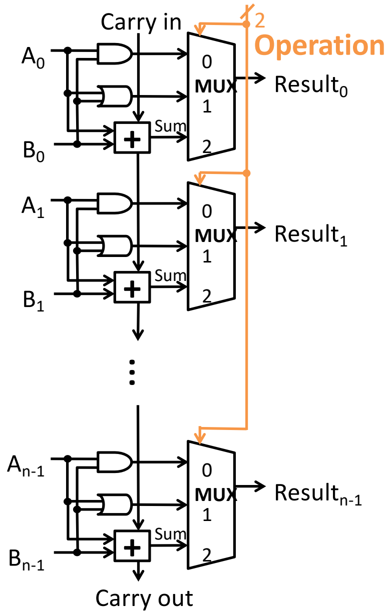
Zero Flag: ex
1 if result is 00...0 else 0

Sign Flag: ex
1 if result is negative else 0

Carry Flag:
1 if carry out else 0

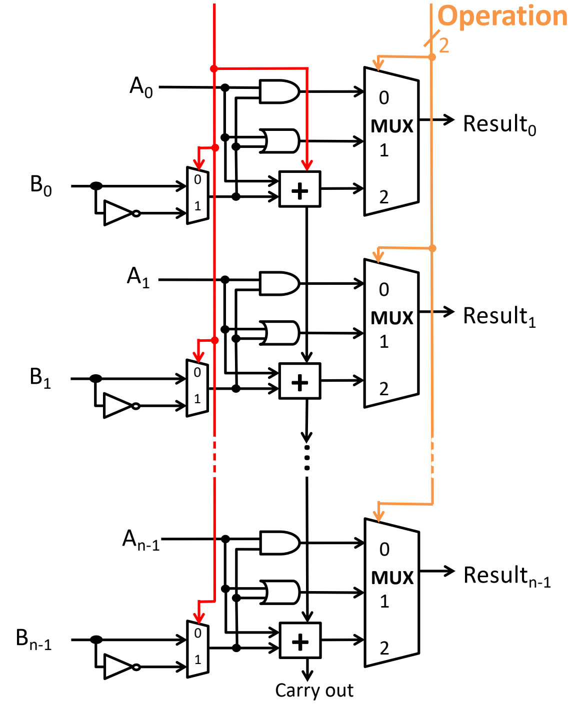
(Signed) **Overflow Flag:**
1 if signed overflow else 0

Implement these.



Add subtraction

How can we control ALU inputs
or add minimal new logic
to compute **A-B**?



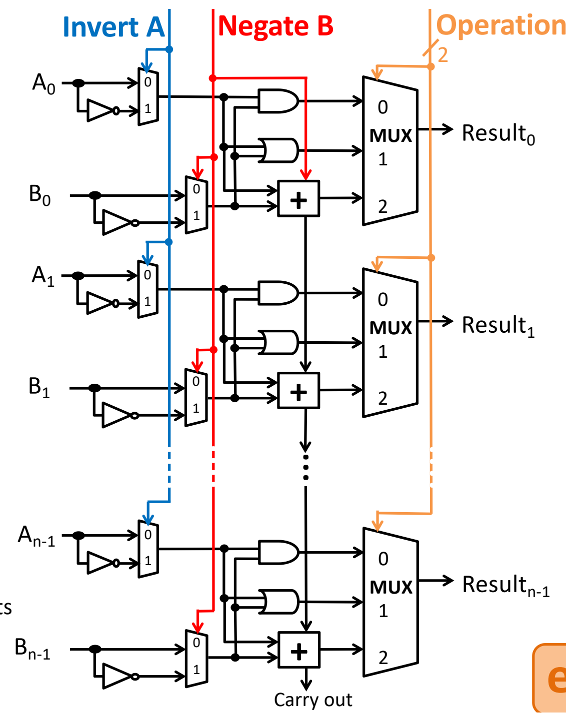
A NAND B

A NOR B

A<B

A==B

How can we control ALU inputs
or add minimal new logic
to compute each?



ex