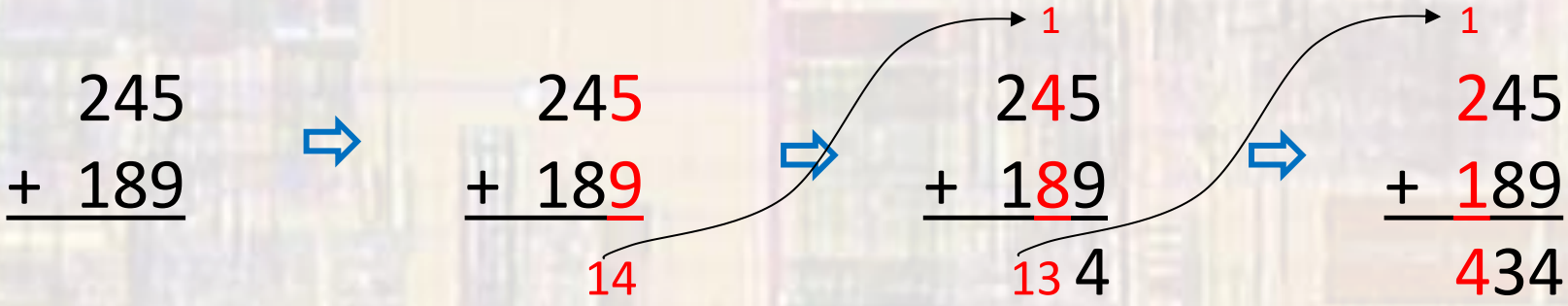
Signed Binary Addition

Last updated 10/3/24

These slides introduce signed binary addition

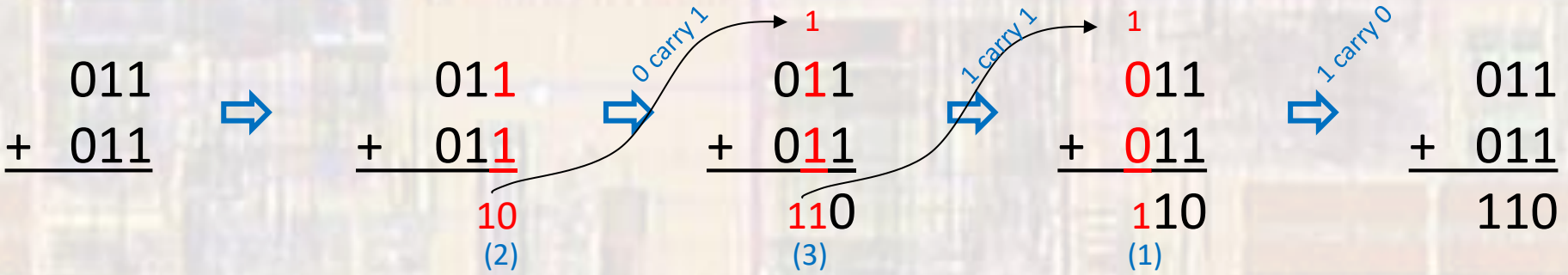
Signed Binary Addition

- Decimal Addition - Elementary school concepts
  - Add columns of numbers and keep track of the carry over to the next column
  - We normally use the decimal number system
    - Digits: 0-9
    - Carry over is in sets of 10



Signed Binary Addition

- Signed Binary Addition - Extend elementary school concepts
  - Add columns of numbers and keep track of the carry over to the next column
  - Use the binary number system
    - Digits: 0-1
    - Carry over is in sets of 2



Signed Binary Addition

- Signed Binary Addition - Examples

```
    1                  1 1 1 1
  100101               101111
+ 011001             + 001001
  111110               111000
```

```
  1 1 1 1 1
  101111
+ 011001
  1001000
```

Depending on the situation – this may or may not be a problem

Signed Binary Addition

- Overflow
  - In elementary school we did not care how many digits the answer required

```
  745
+ 589
 1334
```

  - In signed binary addition – we are generally representing something that ultimately is to be executed in hardware
    - Our hardware cannot change the number of bits (wires) it can hold
    - We must establish a maximum number size (# of bits) and create an error when the result of the addition does not fit in this size
    - Due to the unique nature of signed binary numbers, the mathematical addition of an extra bit may or may not indicate a problem (note: we can not physically add a bit)

Signed Binary Addition

- Overflow – cont'd
  - The process of determining overflow in a signed binary addition is:
    - Compare the carry-in of the MSB to the carry-out of the MSB
      - If they are the same – no overflow
      - If they are different - overflow

```
  1 1 1 1 1
  101111   -17
+ 011001    25
 1001000     8
```

Carry-in to MSB (1)
=
Carry-out of MSB (1)
→ No overflow
→ Result is correct

```
  0 1 1 1 1
  101111   -17
+ 101001   -23
 1011000    24
```

Carry-in to MSB (0)
≠
Carry-out of MSB (1)
→ overflow
→ Result is wrong

Signed Binary Addition

- Overflow – Interpretation

6 bit signed binary

```
  0 1 1 1 1
    101111   -17
+   101001   -23
  ---------
  1011000    24
```

Overflow

MSB Carry-out ≠ carry-in

Result in 6 bits is 24

6 bit
Signed Binary
Number Line