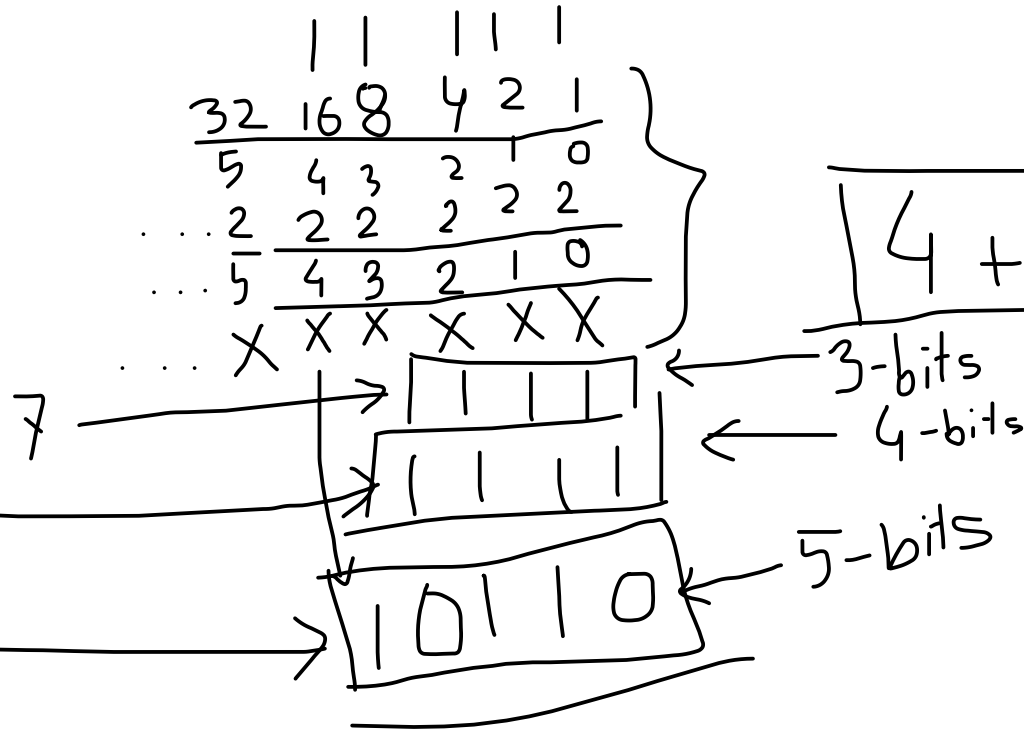


# Decimal to Binary (smaller numbers)

- $(7)_{10} = (?)_2$
- $(15)_{10} = (?)_2$
- $(22)_{10} = (?)_2$

15

22



$$4 + 2 + 1 = 7$$

$$8 + 4 + 2 + 1 = 15$$

$$16 + 4 + 2 = 22$$

# Decimal to Binary (Large number)

- $(2345)_{10} = (?)_2$

$$\begin{array}{rcl} 2345 / 2 & = & 1 \\ \hline 1172 / 2 & = & 0 \\ \hline 586 / 2 & = & 0 \\ \hline 293 / 2 & = & 1 \\ \hline 146 / 2 & = & 0 \\ \hline 73 / 2 & = & 1 \\ \hline 36 / 2 & = & 0 \end{array}$$

$$\begin{array}{rcl} 18 / 2 & = & 0 \\ \hline 9 / 2 & = & 1 \\ \hline 4 / 2 & = & 0 \\ \hline 2 / 2 & = & 0 \\ \hline 1 / 2 & = & 1 \end{array}$$

$$(100100101001)_2$$

What is the largest number that you can represent using  $n$  bits?

Answer:  $2^n - 1$

- $$\begin{array}{l|l} \begin{array}{l} \nearrow 2^1 = 2 \\ \nearrow 2^2 = 4 \\ \nearrow 2^3 = 8 \end{array} & \begin{array}{l} 0, 1 \\ 00, 01, 10, 11 \\ 000, 001, 010, 011, 100, 101, 110, 111 \end{array} \end{array}$$

$\begin{array}{cccccccc} 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \end{array}$

- $$2^4 = 16 \quad 0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111,$$
- $$1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111$$



- Find the 9's complement and 10's complement of 45670?
- Answer:  $10^5 - 1 - 45670 = 99999 - 45670 = 54329$  <- 9's complement
- $54329 + 1 = 54330$  <- 10's complement
  
- Find the 1's complement and 2's complement of 10011?
- Answer: 1's complement:  $2^5 - 1 - 10011 = 32 - 1 - 10011 = 100000 - 1 - 10011 = 11111 - 10011 = 1100$
- 2's complement = 1101

- Find the 10's complement of 45670?
- Answer: 54330 (left the LSB 0 unchanged, then the next immediate digit is subtracted from 10, and finally the remaining digits are subtracted from 9).
- Find the 2's complement of 10011?
- Answer: 01101 (left the first 1 unchanged and then the replacing 1's with 0's and 0's with 1's in all other higher significant digits)

# Summary

- Bits and bytes
- A way to get a binary from a smaller decimal number
- Identifying LSB and MSB
- Complements
  - $r$ 's (decimal and binary)
  - $(r-1)$ 's (decimal and binary)
- Next class will do subtraction using complements