

2. Number Systems & Encoding

COMP2121 • KC Notes

2.1 Number representation

- **Base r to base 10**
 - Decimal: $(3597)_{10} = 3 \times 10^3 + 5 \times 10^2 + 9 \times 10 + 7$
 - Binary: $(1011)_2 = 1 \times 2^3 + 0 \times 2^2 + 1 \times 2 + 1$
 - Hexadecimal: $(F24B)_{16} = 15 \times 16^3 + 2 \times 16^2 + 4 \times 16 + 11$
- **Base 10 to base r**
 - Divide repeatedly by powers of r, e.g. $11.25 = 8 + 2 + 1 + \frac{1}{2^2} = 1011.01$
- **Negative numbers**
 - Two's complement – flip the bits and add one
 - Subtraction is done by adding a negative number
 - **Overflow** when adding two positive or two negative numbers
- **Floating point numbers: IEEE 754 FP standard**
 - Bit 31: S=1 for negative numbers, S=0 for positive numbers
 - Bit 23-30: Real exponent E-127
 - Bit 0-22: Significand

S EEEEEEEEE FFFFFFFFFFFFFFFFFFFFFFFF

- Example: $15.25 = (1111.01)_2 = 1.11101 \times 2^3$
 - Bit 31: 0
 - Bit 23-30: $127 + 3 = 130 = 1000\ 0010$
 - Bit 0-22: 1110 1000 0000 0000 0000 000
- Example: 0 1000 0011 1111 1101 0000 0000 0000 000
 - Bit 31: 0 +
 - Bit 23-30: 1000 0011 = $131 - 127 = 2^4$
 - Bit 0-22: 1111 1101 = 0.98828125
 - $+1.98828125 \times 2^4 = 31.8125$