CS-150 Worksheet 2
Data Representation

This worksheet is about getting familiar with representation of different number types, including negative numbers, real numbers, and calculations on them. Show your working for all tasks.

☐ Task 2.1 – Convert to Two's Complement binary

i. Convert the following decimal numbers to 8-bit Two's Complement binary:

- 34
- -50

ii. Convert the following numbers from 8-bit Two's Complement binary to decimal:

- 10111011
- 00100101

☐ Task 2.2 – Two's Complement binary arithmetic

i. Perform the following additions with 8-bit Two's Complement binary representation:

- 00010101 + 00101110
- 10010110 + 00010111

ii. Perform the following subtractions with 8-bit Two's Complement binary representation:

- 00110111 - 00001101
- 01011010 - 11101111

☐ Task 2.3 – Convert Real Numbers from base x to base y

i. Convert the following from decimal to binary

- 10.125
- 223.25

ii. Convert the following real numbers from binary to hexadecimal:

- 10010111100.0111
- 1100.0010101

☐ Task 2.4 – The `sign` × `mantissa` × `base`$^{\texttt{exp}}$ scheme

i. Convert the following decimal real numbers, identifying `sign`, `mantissa`, `base` and `exp`, **your representation should only use a mantissa of 5 digits**, e.g. 3.141592 becomes Sign: +1, Mantissa: 31415, Base: 10, Exponent: -4. **Note:** we drop the "92", and rounding does not occur as we haven't defined as such in this representation scheme.

- 23.451
- 0.123141

ii. Convert each of the following to their real number form, in decimal.

- Sign: -1, Mantissa: 57231, Base: 10, Exponent: 5
- Sign: +1, Mantissa: 13123, Base: 10, Exponent: -7

☐ Task 2.5 – Scientific Notation

Convert the following decimal real numbers into Scientific Notation, **however this time we can only store 5 significant digits**. For example: 111029 would be 1.1103E5. Note that Scientific Notation **does** define what happens with regards to rounding.

- 5240.82
- 249236.23
- 0.0014210

☐ Task 2.6 – Keyword Encoding

i. Apply Keyword Encoding to the following nursery rhyme:

> Three blind mice. Three blind mice. See how they run. See how they run. They all ran after the farmer's wife, Who cut off their tails with a carving knife, Did you ever see such a sight in your life, As three blind mice?

ii. Calculate the compression ratio of the new compressed message.

☐ Task 2.7 – Run-Length Encoding

i. Apply Run-Length encoding to the following:

- AAAAAAAAAAaaaAAAABBCCCCDDDdAAAAaEEEEEE
- 10111011011100000001010111111010000011111001000001

ii. Calculate the compression ratio of the new compressed messages above.

☐ Challenge Task

Construct a Huffman Tree and encode the following message:

- the cat in the hat sat on the mat

Calculate the compression ratio of the new compressed message above.

☐ Challenge Task

Write a program, in either Java or Python, which takes in a decimal floating point number and converts it to a fixed length $\texttt{sign} \times \texttt{mantissa} \times \texttt{base}^{\texttt{exp}}$ representation. Print out the different components of this representation. i.e:

```
Prompts and inputs:
    Enter floating point decimal number: 3.14159265359
    Enter length of mantissa: 5

Outputs:
    Sign: Positive
    Mantissa: 31415
    Base: 10
    Exponent: -4
```