CS270 Practice Sheet
"Number Crunching"

These problems are similar to the one in Recitation 2 and Homework 1.
Answers can be checked on the websites shown at the bottom of the assignment.

Goals

To understand data representation in a computer, including boolean, integer, floating point, and character values, and the associated logical and arithmetic operations.

Question 1 (10 points): What is the minimum number of bits required to represent all of the 52 cards in a deck ? If you use the minimum number of bits, how many bit patterns are unused?

Minimum number of bits: **6, since $2^6 = 64$, 5 bits is not enough, since $2^5 = 32$, 7 bits is too much**

Number of unused bit patterns: **12, since 64 – 52 = 12**

Question 2 (10 points): What are the binary, hexadecimal, and base 6 representations of the decimal value 5678?

Hexadecimal: **5678 / 16 = 354, 5678 % 16 = 14 = 0xE (digit 0)**
354 / 16 = 22, 354 % 16 = 2 = 0x2 (digit 1)
22 / 16 = 1, 22 % 16 = 6 = 0x6 (digit 2)
1 / 16 = 0, 1 % 16 = 1 = 0x1 (digit 3)
Answer: $5678_{10} = 162E_{16}$
Confirmation: $1 * 16^3 + 6 * 16^2 + 2 * 16 + 14 = 4096 + 1536 + 32 + 14 = 5678_{10}$

Binary: **Answer $5678_{10} = 0001\ 0110\ 0010\ 1110_2$, this is very simple!**
Confirmation: $2^{12} + 2^{10} + 2^9 + 2^5 + 2^3 + 2^2 + 2 = 5678_{10}$

Base 6: **5678 / 6 = 946, 5678 % 6 = 2 (digit 0)**
946 / 6 = 157, 946 % 6 = 4 (digit 1)
157 / 6 = 26, 157 % 6 = 1 (digit 2)
26 / 6 = 4, 26 % 6 = 2 (digit 3)
4 / 6 = 0, 4 % 6 = 4 (digit 4)
Asnwer: $5678_{10} = 42142_6$
Confirmation: $4 * 6^4 * 2 * 6^3 + 1 * 6^2 + 4 * 6 + 2 = 5184 + 432 + 36 + 24 + 2 = 5678$

Question 3 (10 points): What is the range of unsigned integers that can be stored using 4 bits? What is the range for signed integers represented in 1's and 2's complement, with the same number of bits?

Range of unsigned integers: **0** to **15**

Range of signed integers: **-7** to **7** (1's complement)

Range of signed integers: **-8** to **7** (2's complement)

Question 4 (10 points): Show the 2's complement addition of -8 plus +5, with both numbers in binary using 6 bits. Hint: make sure that the resulting binary number corresponds to the correct answer.

111000 (-8) + **000101** (5) = **111101** (-3)

Question 6 (10 points): Show the results of the following bitwise operations (using the same number of bits as shown in each problem):

NOT(1011) = **0100**
1001 OR 1100 = **1101**
1001 AND 1100 = **1000**
1001 XOR 1100 = **0101**

Question 7 (10 points): Show the results of the following bitwise operations:

~(0x45 | 0x23) = ~(01000101 | 00100011) = ~(01100111) = 10011000 = **0x98**

Question 8 (10 points): Find the decimal floating-point number corresponding to the hex value shown below (assuming IEEE 32-bit floating-point representation):

0x40840000 = sign: 0, exponent: 10000001, mantissa: 000 0100 0000 0000 0000 0000
Exponent = 129 – 127 = 2, mantissa = **1**.00001
Binary method: 1.00001 * 2^2 = 100.001 = 4.125
Decimal method: 1.03125 * 2^2 = 4.125
Answer: **4.125**

Question 9 (10 points): Find the binary and hexadecimal numbers for the following floating-point value (assuming IEEE 32-bit floating-point representation):

5.75f = 101.11 in binary, left of decimal 4 + 1 = 5, right of decimal 0.5 + 0.25 = 0.75
Must normalize 101.11 by shifting right 2 bits to **1**.0111, so exponent is 2
Sign = 0 (positive), exponent = 2 + 127 bias = 129 = 10000001, mantissa = 0111
Put it together 0 10000001 01110000000000000000000 = 0100 0000 1011 1000 0000 0000 0000 0000
Answer: **0x40B80000**

Question 10 (10 points): Translate the following strings from characters into ASCII hexadecimal values and vice versa:

"What" = **0x57686174**

Website for ASCII conversion: www.branah.com/ascii-converter
Website for IEEE floating-point conversion: www.h-schmidt.net/FloatConverter
Website for two's complement math: www.planetcalc.com/747