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CS 219-1002: Computer Organization
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CS 219 – Assignment #2

Purpose: Become familiar with the MIPS architecture floating point data representation and instructions
Due: Monday (2/01)
Points: 75

Reading/References:

Chapters 2, section 2.4, 2.9, Chapter 3, section 3.5 (initial part)

Assignment:

Answer the following questions:

1) Answer the following questions:

a) Convert 19_{10} to 32-bit two's compliment number. Show result in binary and hex. [1 pts]
Example answer:

decimal: 19_{10}
binary: $0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0001\ 0011_2$
hex: 13_{16}

Binary: $0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0001\ 0011_2$

Hex: 13_{16}

b) Convert -25_{10} to 32-bit two's compliment number. Show result in binary and hex. [3 pts]

Binary: $1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1110\ 0111_2$

Hex: $FFFFFF27_{16}$

c) Convert 22_{10} to 32-bit two's compliment number. Show result in binary and hex. [3 pts]

Binary: $0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0001\ 0110_2$

Hex: 16_{16}

d) Convert 2048_{10} to 32-bit two's compliment number. Show result in binary and hex. [3 pts]

Binary: $0000\ 0000\ 0000\ 0000\ 0000\ 1000\ 0000\ 0000_2$

Hex: 800_{16}

e) Convert -2048_{10} to 32-bit two's compliment number. Show result in binary and hex. [3 pts]

Binary: $1111\ 1111\ 1111\ 1111\ 1111\ 1000\ 0000\ 0000_2$

Hex: $FFFFF800_{16}$

f) Convert $0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000_2$ to a decimal number. [3 pts]

Decimal: 0_{10}

g) Convert $1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 0000\ 0110_2$ to a decimal number. [3 pts]

Decimal: -6_{10}

h) Convert $1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1110\ 1111_2$ to a decimal number. [3 pts]

Decimal: -15_{10}

2) Show the format for the IEEE 754 32-bit floating point representation. [2 pts]

32 bits → sign (1 bit), biased exponent (8 bits), significant (23 bits)

$(-1)^s * (1.\text{fraction}) * 2^{(\text{exp} - 127)}$

Exponent: 1 - 254, fraction: any, value = ±floating point number

3) What is the range of the IEEE 754 32-bit floating point representation. [3 pts]

The range of single precision numbers is then from as small as

$\pm 1.00000000000000000000000_2 * 2^{-126}$

to as large as

$\pm 1.11111111111111111111111_2 * 2^{+127}$

4) Show the format for the IEEE 754 64-bit floating point representation. [2 pts]

64 bits → sign (1 bit), biased exponent (11 bits), significant (52 bits)

$(-1)^s * (1.\text{fraction}) * 2^{(\text{exp}-1023)}$

Exponent: 1 - 2064, fraction: any, value = ±floating point number

5) What is the range of the IEEE 754 64-bit floating point representation. [3 pts]

The range of double precision numbers is then from as small as

$\pm 1.0000000000000000000000_2 * 2^{-1022}$

to as large as

$\pm 1.1111111111111111111111_2 * 2^{+1041}$

6) The bias for the IEEE 754 32-bit representation is 127. What is the ***bias*** for IEEE 754 64-bit representation? [3 pts]

1023

7) What is the decimal representation of the following hex values? Assume IEEE 754 32-bit floating point representation. Must show work for full credit. [5 pts each]

a) $C0200000_{16}$
→ (binary) $1 \mid 100\ 0000\ 0 \mid 010\ 0000\ 0000\ 0000\ 0000\ 0000_2$
Sign bit: 1
Biased exponent: 100 0000 0 → 128 - 127 = 1
$-1.01 * 2^1 \rightarrow -10.1_2 \rightarrow -2.5_{10}$

b) $C1120000_{16}$
→ (binary) $1 \mid 100\ 0001\ 0 \mid 001\ 0010\ 0000\ 0000\ 0000\ 0000_2$
Sign bit: 1
Biased exponent: 100 0001 0 → 130 - 127 = 3
$-1.001001 * 2^3 \rightarrow -1001.001_2 \rightarrow -9.125_{10}$

c) $C1440000_{16}$
→ (binary) $1 \mid 100\ 0001\ 0 \mid 100\ 0100\ 0000\ 0000\ 0000\ 0000_2$
Sign bit: 1
Biased exponent: 130 - 127 = 3
$-1.10001 * 2^3 \rightarrow -1100.01_2 \rightarrow -12.25_{10}$

d) $C1AA0000_{16}$
$\rightarrow$ (binary) 1 | 100 0001 1 | 010 1010 0000 0000 0000 0000_2
Sign bit: 1
Biased exponent: 131 - 127 = 4
$-1.010101 * 2^4 \rightarrow -10101.01_2 \rightarrow -21.25_{10}$

8) What is the IEEE 754 32-bit floating point representation of the following decimal numbers. Must show work for full credit. [5 pts each]

a) 2.0
$2.0_{10} \rightarrow 10.0_2 \rightarrow 1.00 * 2^1$
Biased Exponent: 1 = 127 + 1 = 128 $\rightarrow$ 1000 0000_2
Sign bit: 0
IEEE 754 32-bit floating point representation:
0 | 100 0000 0 | 000 0000 0000 0000 0000 0000

b) 7.25
$7.25_{10} \rightarrow 111.01_2 \rightarrow 1.1101 * 2^2$
Biased Exponent: 2 = 127 + 2 = 129 $\rightarrow$ 1000 0001_2
Sign bit: 0
IEEE 754 32-bit floating point representation:
0 | 100 0000 1 | 110 1000 0000 0000 0000 0000

c) -23.125
$-23.125_{10} \rightarrow -10111.001_2 \rightarrow 1.0111001 * 2^4$
Biased Exponent: 4 = 127 + 4 = 131 $\rightarrow$ 1000 0011_2
Sign bit: 1
IEEE 754 32-bit floating point representation:
1 | 100 0001 1 | 000 0000 0000 0000 0000 0000

d) -17.625
$-17.625_{10} \rightarrow -10001.101_2 \rightarrow -1.0001101 * 2^4$
Biased Exponent: 4 = 127 + 4 = 131 $\rightarrow$ 1000 0011_2
Sign bit: 1
IEEE 754 32-bit floating point representation:
1 | 100 0001 1 | 000 1101 0000 0000 0000 0000