Name:

SSN(6):

CMSC 311 Computer Organization

Jolly Numbers Worksheet with Answers
–draft–
–NO CALCULATORS–

Fall, 1999
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1. Write the decimal number, (108_{10}), as an unsigned binary number. Express your answer in hexadecimal and octal as well.
   Answer: 1101100_2, $6C_{16}$, 154_8

2. Write the hexadecimal number, (108_{16}), as a decimal number.
   Answer: 264_{10}

3. What is the largest integer (in decimal) that can be expressed as a 32-bit unsigned binary number? Note: as always, you may express your answer in terms of powers of two if you like.
   Answer: $2^{32} - 1 = 4,294,967,295_{10}$

4. Write the decimal number (-2100_{10}) as a 16-bit sign magnitude number. Express your answer in hexadecimal as well.
   $1000\ 1000\ 0011\ 0100_2$, 8834_{16}

5. Express the hexadecimal number $(7A0F_{16})$ as a base 10 number, assuming that the original hexadecimal number is in **sign magnitude** form. Repeat assuming unsigned binary form.
   Answer:
   Sign magnitude: $7A0F_{16} = 0111\ 1010\ 0000\ 1111_2 = 31,247_{10}$
   Unsigned Binary: $7A0F_{16} = 0111\ 1010\ 0000\ 1111_2 = 31,247_{10}$

6. Express the hexadecimal number $(F401_{16})$ as a base 10 number, assuming that the original hexadecimal number is in **sign magnitude** form. Repeat assuming unsigned binary form.
   Sign magnitude: $F401_{16} = 1111\ 0100\ 0000\ 0001_2 = -(2^{14} + 2^{13} + 2^{12} + 2^{10} + 2^0) = -29,697_{10}$
   Unsigned Binary: $F401_{16} = 1111\ 0100\ 0000\ 0001_2 = 2^{15} + 2^{14} + 2^{13} + 2^{12} + 2^{10} + 2^0 = 95,233_{10}$

7. Convert the following "decimal fractions" to 32-bit fixed point equivalents, where the "binary fraction" is the lower 16 bits, and the "binary integer" part is the upper 16 bits. The "binary integer" part is stored as a sign magnitude number. You may give your answer in hexadecimal for convenience. Also indicate which representations are exact, and which are approximations because of truncations. Is underflow present anywhere?

   (a) 125.25
   $125.25_{10} = 007D.4000_{16}$

   (b) -456.089
   $-456.089_{10} = -(01C8.16C8_{16} + (0.704 \times 2^{-32})_{10}) \approx 81C8.16C8_{16}$

   (c) 512.0000000025
   $512.0000000025_{10} = 0200.000A_{16} + (0.737418 \times 2^{-32})_{10} \approx 0200.000A_{16}$

   (d) 104.11111
   $104.11111_{10} = 0068.1C71_{16} + (0.7049 \times 2^{-32})_{10} \approx 0068.1C71_{16}$

   (e) -116.8888
   $-116.8888_{10} = -(0074.E388_{16} + (0.3968 \times 2^{-32})_{10}) \approx 8074.E388_{16}$

8. Express the fixed-point numbers above using 32-bit IEEE floating-point notation.

   (a) 125.25
   $125.25_{10} = 007D.4000_{16} = 42FC\ \ 8000_{IEEE}$

   (b) −456.089
   $-456.089_{10} \approx -01C8.16C8_{16} = C3E4\ \ 0B64_{IEEE}$

   (c) 512.0000000025
   $512.0000000025_{10} \approx 0200.000A_{16} \approx 4400\ \ 0003_{IEEE}$ (with rounding)

   (d) 104.11111
   $104.11111_{10} \approx 0068.1C71_{16} = 42D0\ \ 38E3_{IEEE}$

   (e) −116.8888
   $-116.8888_{10} \approx -0074.E388_{16} = C2E9\ \ C710_{IEEE}$

9. Express both operands in signed 2's complement, and perform the indicated operations. (Note: don't forget to sign-extend the numbers so that all arithmetic is performed between numbers of the same size.)

   (a) $46 - 120$
   $46:\ 2E_{16} \qquad 120:\ 78_{16} \qquad 46 - 120:\ B6_{16}$

   (b) $-(-1654 + 2098)$
   $-1654:\ 98A_{16} \qquad 2098:\ 832_{16} \qquad -(-1654 + 2098):\ E44_{16}$

   (c) $25246 + 21670$
   $25246:\ 0629E_{16} \qquad 21670:\ 054A6_{16} \qquad 25246 + 21670:\ 0B744_{16}$

   (d) $(-256 - 1248)$
   $-256:\ F00_{16} \qquad 1248:\ 4E0_{16} \qquad (-256 - 1248):\ A20_{16}$

   (e) $116 - (-76)$
   $116:\ 074_{16} \qquad -76:\ FB4_{16} \qquad 116 - (-76):\ 0C0_{16}$

10. Which of the operations in the previous problem, if any, can be performed correctly using 16-bit signed 2's complement arithmetic.

   (a) $46 - 120$
   Yes

   (b) $-(-1654 + 2098)$
   Yes

   (c) $25246 + 21670$
   No

   (d) $(-256 - 1248)$
   Yes

   (e) $116 - (-76)$
   Yes