(1) (3 points) Do the following 8-bit one's complement addition. Indicate if overflow occurs.

```
  11110000
+ 01000110
----------
```

(2) (6 points, 3 each) Do the following 8-bit two's complement subtraction. Indicate if overflow occurs.

```
  11110000                      00000001
- 01000110                    - 10000000
----------                    ----------
```

(3) (8 points, 2 each) Give the bit pattern in Z after each of the following SAL instructions.

```
 .data
X:  .word  0x55
Y:  .word  0xda
Z:  .word  0
```

a. `and Z, X, Y` Z = ____________________________

b. `add Z, X, Y` Z = ____________________________

c. `sra Z, Y, 3` Z = ____________________________

d. `xor Z, X, Y` Z = ____________________________

(4) (6 points) Add the following IEEE single precision floating point numbers. Show the manipulations of the bit patterns to get the IEEE single precision floating point result.

```
   0 10000011   011 0111 0000 0000 0000 0000  (22.875)
 + 1 10000010   001 1010 0000 0000 0000 0000  (-9.625)
---------------------------------------------
```

(5) (8 points) Same problem as (4), but multiply (not add).

```
  0 10000011   011 0111 0000 0000 0000 0000  (22.875)
x 1 10000010   001 1010 0000 0000 0000 0000  (-9.625)
---------------------------------------------
```

(6) (4 points) Some computers have a single instruction to perform the floating point operation

```
( A * B ) + C
```

In some cases, this instruction obtains a slightly different answer than when the same computer is programmed to perform two conventional instructions, a multiplication followed by an addition. Offer a (brief) possible explanation for this difference.

(7) (3 points, 1 each) -5.25 is to be rounded to an integer. What value will it be rounded to in the following rounding schemes?

a) Round toward nearest

b) Round toward negative infinity

c) Round toward zero

(8) (6 points) What is the base address of a 2-dimensional array where element [4,5] of a 12 by 7 array of integers is located at the decimal address 408? Assume that the array is stored in row major order, and that the element at the base address is element [0,0].

(9) (6 points) A 3 by 5 array of words is declared in SAL as

```
ar2D:  .word  0:15  #space for 3 x 5 = 15 words
```

The array is stored in row major order. Write a SAL code fragment which, given a value from 0 to 2 in variable `row`, and a value from 0 to 4 in variable `col`, copies ar2D[row, col] into variable `result`.

(10) (4 points) Briefly explain the difference between the MAL instruction

```
    lw  $9, label
```

and the MAL instruction

```
    la  $9, label
```

(11) (5 points) What value is in register $12 after the following MAL code fragment is executed? Give your answer in hexadecimal.

```
 .data
aa:   .word  8
bb:   .word  12
cc:   .space 4
dd:   .byte  2:4
 .text
  .
  .
  .
      la   $14, aa
      lw   $12, 12($14)
```

(12) (6 points) The `lbu` instruction differs from `lb` in that `lbu` zero fills the three most significant bytes of the register, while `lb` sign extends. Give a MAL instruction sequence no longer than three instructions which has the same effect as `lb` but uses only `lbu` and shift instructions.

(13) (6 points) Consider evaluating the statement

X := A * ((B * C) - D)

This could be evaluated using a stack with the following sequence:

```
push(A)
push(B)
push(C)
*
push(D)
-
*
pop(X)
```

Consider evaluating this expression using MAL. The use of a stack can be avoided completely by allocating registers for each of the intermediate operands. Finish the MAL code to complete this instruction sequence.

```
lw    $8, A
lw    $9, B
lw    $10, C
mult  $9, $9, $10
```

(14) (10 points, 2 each) Suppose that a computer's memory and registers contain the following values:

location	contents
$5	0x000013a0
$6	0x00000014
0x0000139c	0x00000015
0x000013a0	0x000013a8
0x000013a4	0x000013b0
0x000013a8	0x00000000

Suppose that a load word instruction is located at address 0x00001390. Give the value loaded if the instruction is executed with the addressing mode of the source

a. immediate, with value 0x000013a4

b. register direct, with register $5

c. direct, with address 0x0000139c

d. indirect, with address 0x000013a0

e. base displacement, with register $5 and displacement 0x10