Homework #3

**Due Date:** End of class on Wednesday, November 13, 2019

Name: ...........................................
1. (15 points)

Write a C function that is equivalent to the following Pep/9 subroutine.

```
Q1:  subsp 2,i
     ldwa 0,i
     stwa 0,s
     ldwx 7,s
loop: subx 1,i
     brlt exit
     ldba 5,sfx
     cpba 4,s
     brne loop
     ldwa 0,s
     adda 1,i
     stwa 0,s
     br loop
exit: ldwa 0,s
     stwa 9,s
     addsp 2,i
     ret
```
2. (32 points)

Pep/9 array S1 is 30 bytes long and contains only lower case letters. Array S2 is also 30 bytes long and contains only lower case letters.

(a) (6 points) briefly describe how you would determine if the contents of S2 is a permutation of the contents of S1. Your algorithm is allowed to change the contents of the arrays.

(b) (26 points) Implement your solution to (a) in Pep/9 assembly code.
3. (15 points)

The Pep/9 subroutine below is a translation of the following C function

```c
int CM (int N)
{
    if (N==1) return 0;
    else if (N%2==1) return 1 + CM(3*N+1);
    else return 1 + CM(N/2);
}
```

(a) Add appropriate comments to the three highlighted sections.

```
CM:  ldwa 2,s
    cpwa 1,i
    breq ret0
    anda 1,i
    breq case3
case2: subsp 4,i
    ldwa 6,s
    asla
    adda 6,s
    adda 1,i
    stwa 0,s
    call CM
    ldwa 2,s
    adda 1,i
    stwa 8,s
    addsp 4,i
    ret
case3: subsp 4,i
    ldwa 6,s
    asra
    stwa 0,s
    call CM
    ldwa 2,s
    adda 1,i
    stwa 8,s
    addsp 4,i
    ret
ret0: ldwa 0,i
    stwa 4,s
    ret
```
4. (20 points)

Array $T$ is declared \[ \text{int } T[3][10][5] \] and a typical access is \[ T[i][j][k] \]
Each int requires 2 bytes.

(a) (4 points) How much space is needed for the array $T$ if it stored in row-major order?

(b) (4 points) If the array $T$ is stored in column-major order, how much space is needed?

(c) (6 points) If we store $T$ using Iliffe vectors, additional space is needed for arrays of pointers. Making an assumption about the order in which dimensions are accessed, determine how much additional space is needed. Assume an address requires 2 bytes. Show your calculations.

(d) (6 points) Give an implementation different from your answer to (c) that uses either more or less storage.
5. (18 points)

The Pep/9 subroutine below is a translation of a C function that has the following prototype

\[ \text{void Q5 (int[], int[], int, int*)} \]

Q5 returns via the 4\textsuperscript{th} (reference) parameter the number of times corresponding integers in the two arrays are not both even. The third parameter gives the number of elements in each of the arrays.

Some of the instructions in the subroutine have the wrong addressing mode. Correct them.

```
Q5:  subsp 2,i
     ldwa 0,s
     stwa 0,i
     ldwx 8,s
     subx 1,i
     aslx
     loop: ldwa 2, sf
     ora 6, sf
     anda 1, i
     breq skip
     ldwa 0, s
     adda 1, s
     stwa 0, s
     skip: subx 2, i
     brge loop
     ldwa 0, s
     stwa 10, s
    addsp 2, i
     ret
```