CS 137: Assignment #2

Due on Friday, Sep 26, 2025, at 11:59 PM

Submit all programs using the Marmoset Submission and Testing Server located at
https://marmoset.student.cs.uwaterloo.ca/

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Notes:

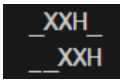
- Use the examples to guide your formatting for your output. Remember to terminate your output with a newline character.
- You can use only syntax/language features we have covered so far up to the end of M4.
- You must NOT use the MATH Library
- Use only `int` type of variables.

Problem 1

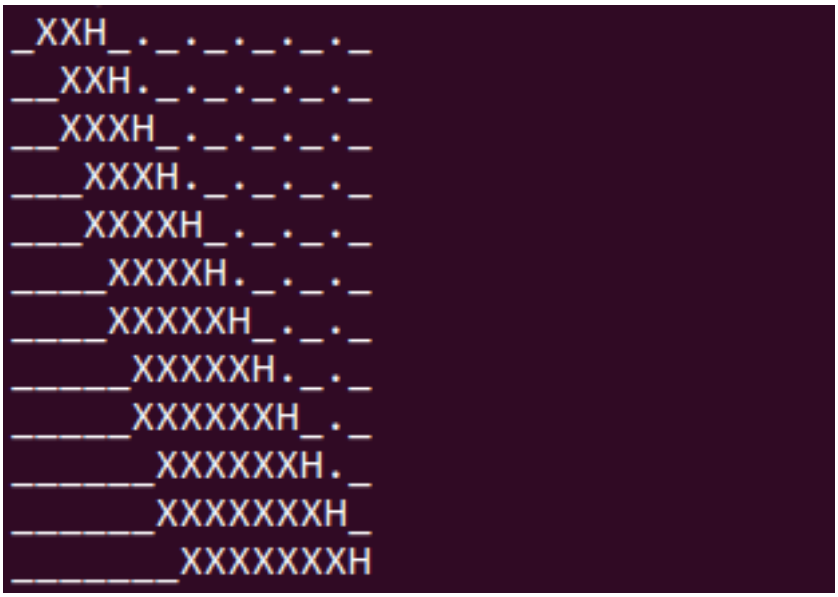
This is a straightforward version of the classic game "Snake". A snake moves only from left to right, growing itself whenever it eats the bait. The snake is on a line of n discrete spaces. At each time point, the snake moves one space.

Write a C program `snake.c` that reads a natural number `n` (Assume that it is at least 5) and prints the line the snake is on as it moves. Assume the snake has an initial body length of `2` and its head is at position `3` (indices start from `0`). The line has `n` spaces, and there are baits on every odd space that the snake hasn't visited yet. Print the subsequent states in new lines; the game ends when the snake's head reaches the end of the line. Denote snake's head by "H", body by "X", bait by ".", and empty space character by "_".

For n==5, the output will look like the following (each line ends with a `\n` character):



For n==15, the output will look like the following (each line ends with a `\n` character):



Problem 2

a) Create the file `functions.h`, which contains the following declarations:

I) `void square(int w);`

II) `void spiral(int w);`

III) `void rotation(int w);`

b) Implement all the functions above (as explained below) in the file `functions.c`

Note: You are to submit this file (along with `functions.h` file) containing only your implemented functions. **You must keep the required included libraries.**

c) Submit `functions.zip`, **which contains** the files `functions.c`, and `functions.h`

Here are the objectives of the three functions:

Assume `w>1`.

`I) void square(int w);` prints the numbers `1,2,….,w`^{2} in a square shape (of size `wxw`) on w lines of output

Examples:

`void square(2)` prints:

```
1 2
3 4
```

`void square(5)` prints:

```
1 2 3 4 5
6 7 8 9 10
11 12 13 14 15
16 17 18 19 20
21 22 23 24 25
```

`void square(6)` prints:

```
1 2 3 4 5 6
7 8 9 10 11 12
13 14 15 16 17 18
19 20 21 22 23 24
25 26 27 28 29 30
31 32 33 34 35 36
```

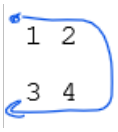
II) `void spiral(int w);` prints the numbers `1,2,….,w`^{2} in a "spiral" order (compared with the square shape from part `I` above) on one line.

Examples:

`void spiral(2)` prints:

```
1 2 4 3
```

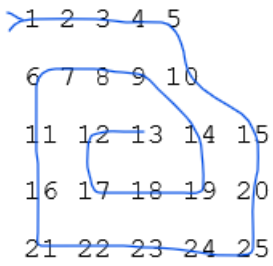
Because



`void spiral(5)` prints:

```
1 2 3 4 5 10 15 20 25 24 23 22 21 16 11 6 7 8 9 14 19 18 17 12 13
```

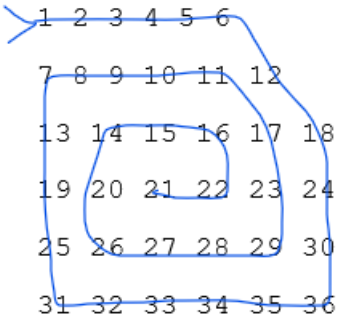
Because:



`void spiral(6)` prints:

```
1 2 3 4 5 6 12 18 24 30 36 35 34 33 32 31 25 19 13 7 8 9 10 11 17 23
29 28 27 26 20 14 15 16 22 21
```

Because:



III) `void rotation(int w);` prints the numbers $1, 2, \ldots, w^2$ in a "rotation" order on one line (compared with the square shape). Each rotation is 90 degrees for some incremental offsets.

Examples:

`void rotation(2)` prints:

```
1 2 4 3
```

`void rotation(5)` prints:

```
1 5 25 21 2 10 24 16 3 15 23 11 4 20 22 6 7 9 19 17 8 14 18 12 13
```

`void rotation(6)` prints:

```
1 6 36 31 2 12 35 25 3 18 34 19 4 24 33 13 5 30 32 7 8 11 29 26 9 17
28 20 10 23 27 14 15 16 22 21
```

Explore the pattern before you start coding

Notes:

Each number printed is followed by a space (including the last number in each line).

Each line ends with a `\n` character.

Problem 3

For any given positive integer, the function `void zigzag(int w)` prints numbers in a zigzag across rows, as illustrated in the following examples (not that the function prints `w` lines, and the last line starts and ends with the value w. w=1 is a special case to consider:

`zigzag(1)` prints:

```
1
```

`zigzag(6)` prints:

```
1          11
  2      10
    3 9
    8 4
  7      5
6          6
```

`zigzag(11)` prints:

```
1                    21
  2                20
    3            19
      4        18
        5    17
          6
        15   7
      14       8
    13           9
  12               10
11                   11
```

Note: no space at the start of the first line and the start of the last line.

Note: You are to submit the file `funzigzag.c` containing only your implemented functions (that is, you must delete the test cases portion and the `main` function). However, **you must keep the required included libraries.**

Problem 4

a) Create the file `fun.h`, which contains the following declarations:

I) `int isSophieGermainPrime(int p);`

II) `int base2nat(int bs, int num);`

III) `int nat2base(int bs, int num);`

b) Implement all the functions above (explained below) in the file `fun.c`

Note: You are to submit this file (along with fun.h file) containing only your implemented functions.

You should keep the required included libraries.

c) Submit `fun.zip` **which contains** the files `fun.c`, and `fun.h`

I)

Definition: *A Sophie Germain[1] prime* is a [positive] prime number p such that 2p + 1 is also a prime number. For example, 2 is a Sophie Germain prime since 2 and 2(2) + 1 = 5 are prime numbers.

Task: Create the function

`int isSophieGermainPrime(int n)`

which determines if an integer `n` is a Sophie Germain prime. The function should return `1` if `n` is a Sophie Germain prime and `0` otherwise.

Fast Facts: Sophie Germain

Known For: French mathematician, physicist, and philosopher specializing in elasticity theory and number theory.

Also Known As: Marie-Sophie Germain

Born: April 1, 1776, in Rue Saint-Denis, Paris, France

Died: June 27, 1831, in Paris, France

Education: École Polytechnique

Awards and Honors: Number theory named after her, such as Sophie Germain prime, Germain curvature, and Sophie Germain's identity. The Sophie Germain Prize is awarded annually by the *Foundation Sophie Germain*.

1

II)

When you see a number such as 734, it is generally assumed that you are using the base 10 number system (also known as the decimal system). That is:

$734 = 7*10^2 + 3*10^1 + 4*10^0$

It is, however, possible to use any number as a base. For example, assuming we are in a base 5 number system, the notation 2301 would generate the decimal number 326:

$2*5^3 + 3*5^2 + 0*5^1 + 1*5^0 = 326$ (this equation is in decimal)

Note that when using base 10 we have precisely 10 unique digits for each position, that is 0,1,2,3,4,5,6,7,8,9. Similarly, base 5 only allows for 5 digits 0,1,2,3,4 (To represent the "normal" (i.e. decimal) value 5 in base 5 we would write 10; 6 would be represented as 11, 7 would be 12 etc. To see this, consider 12 (in base 5), which means we compute $1*5^1 + 2*5^0$ to get 7).

Task: Create the function

// pre: 1<bs<10 and num>0 a valid integer in base bs

`int base2nat(int bs, int num)`

which returns a positive integer representing the decimal value of `num` (`num` is in base `bs`).

III)

// pre: 1<bs<10 and num>0

`int nat2base(int bs, int num);`

It takes a base (`bs`) and a non-negative integer (num) in decimals and returns the value in base `bs`.

The following code will help you with testing

```
1. #include <stdio.h>
2. #include <assert.h>
3. #include "fun.h "
4.
5. int main(void){
6.          assert(isSophieGermainPrime(11));
7.          assert(isSophieGermainPrime(41));
8.          assert(base2nat(5,23114)==1659);
9.          assert(base2nat(7,1)==1);
10.         assert(base2nat(3,1211012)==1328);
11.         assert(base2nat(8,715)==461);
12.         assert(nat2base(5,1659)==23114);
13.         assert(nat2base(9,1331)==1738);
14.  }
```