PROGRAMMING PROJECT 1
Due: 31 / 03 / 2024 – 22:00PM (No late submission)

In this project, you are required to implement some procedures in MIPS assembly language. You will use a MIPS simulator (QTSPIM or MARS) to develop and test your code. There will be four questions in the project which are unrelated.

Question 1. *(12 points)*
A special sequence of numbers is defined using the following equation,
$f(x) = a* f(x-1) + b * f(x-2) – 2$, where a and b are coefficients.
As an example, if a = 6, b = 1 and the first two numbers of the sequence are 0 and 1 ($x_0 = 0$, $x_1 = 1$), then the sequence is "0, 1, 4, 23, 140, 861 …"

Write a MIPS procedure that calculates nth number of this sequence. The program requires five integers as input: a, b, x0, x1 and n. Then, it calculates the sequence using the given equation until finds the nth element. Finally, the program prints the result to the screen. Note that n must be greater than 1; if the value of n is smaller than 1, the program asks the user to enter a number that is greater than 1.

Example Run:
Please enter the coefficients: 2 1
Please enter first two numbers of the sequence: 1 2
Enter the number you want to calculate (it must be greater than 1): 4
Output: 4th element of the sequence is 6.

Question 2. *(13 points)*
Write a MIPS procedure that switch the elements of an integer array. The procedure takes an integer array as input, examines if adjacent elements are *coprime* to each other. Two integers are coprime, if the only positive integer that is a divisor of both of them is 1. If the adjacent number is coprime, procedure move to the next pair for examination. Otherwise, the two number is removed from the array and their least common factor is included to the array. Your MIPS code must print the updated array.
Example Run 1:
Input: "6 4 3 2 7 13"
Output: "The new array is: 12 7 13"
Explanation for the example (Note that the following line summarizes the steps of the execution; it is not the output).
6 4 3 2 7 13 -> **12 3** 2 7 13 -> **12 2** 7 13 -> **12 7** 13 -> 12 **7 13**

Example Run 2:
Input: "25 2 3 9 6 4 5"
Output: "The new array is: 25 36 5"
Explanation for the example:
25 2 3 9 6 4 5-> 25 **2 3** 9 6 4 5-> 25 2 **3 9** 6 4 5-> 25 2 **9 6** 4 5->25 **2 18** 4 5->25 **18 4** 5->25 **36 5**

Question 3. *(15 points)*

Write a MIPS procedure that recursively shuffles the given string. The program takes two inputs: a string array to be shuffled and an integer that represents how many times the shuffle operation is performed. Initially, the string is divided into two substrings and their positions are swapped. The division and swapping operation are performed recursively to substrings. The program finished its execution when it reaches the level n provided by user. Finally, the shuffled string is printed to the screen. Assume that the number of the characters in the input are power of two; there is no need to implement additional error checking.

Example Run:
Input: "Computer"
3
Output: "retupmoC"

Explanation of the example: Note that the following line summarizes the steps of the execution; it is not the output.
Computer
uterComp
erutmpCo
retupmoC

Question 4. *(20 points)*

In a matrix containing only 1s and 0s, the island pattern is defined as a connected set of 1s where the set of 1s are surrounded by either edge of the matrix or 0s. *The cells are considered connected if they are horizontally or vertically adjacent.Diagonal case is not considered.*

Write a MIPS program to determine *the largest island of the matrix stored in the memory.* In your program, it will read the memory from the .data segment, where the first two integers represent the number of rows and columns, respectively. The program prints the matrix stored in the memory and the number of 1s in the largest island.

Memory at the beginning of the execution

```
.data

matrix: .byte 5, 6, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0,
1, 1, 0, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0
```

Example Run:
Output
```
 0  0  0  1  1  1
 1  1  0  0  1  1
 0  1  0  0  1  1
 0  0  1  0  1  1
 1  0  1  0  1  0
```
The number of the 1s on the largest island is 10.

Explanation for the example:

0	0	0	1	1	1
1	1	0	0	1	1
0	1	0	0	1	1
0	0	1	0	1	1
1	0	1	0	1	0

Assumptions and Requirements

- The arguments to the procedures are stored in $a registers; i.e., the first one is in $a0, the second one is in $a1, and so on.
- Only valid arguments are passed into the procedures. Therefore, you do not need to check the arguments for their validity.
- When you invoke a procedure, the values of all **$a0-$a3** (argument registers) should be preserved. Their values should be same at the end of the procedure call as they were at the time of call.
- You have to use QtSpim or MARS simulator in your implementation. Any other simulator is not allowed.
- You are required to submit a minimum 2-page report (**5 points**) explaining implementation details of your project. Your report will have four parts (one for each question) and it will also include screenshot of your sample runs, as well.
- You should submit a fully commented source code that includes details of your implementation. Note that the name of the file should include surnames of the group members such as *surname1_surname2_surname3_surname4.s*
- Zip your fully commented source code file and the project report into a single file and submit the zip file via Canvas.

General Policies for the Project

- *You must work in groups of 3 or 4*. You will select your partners and partners will not be changed throughout the semester. *It is not acceptable of a team (or a team member) to work with other teams. You should email the names of the group members to Zuhal Öztürk (zuhal.ozturk@marmara.edu.tr) until March 20th.*
- **_A portion of your project grade will be set with a Project Quiz_**. Note that if you do not submit the project, you will not attend the Project Quiz.
  Project Quiz will be on April 4 (Thursday). The time of the quiz will be announced later. There will be no makeup for the quiz.
- Copying (partially or full) solutions from other students/teams is a form of cheating. Copying (partially or full) solutions from Web including ChatGPT, Github (and similar sites/tools) is another form of cheating. It is NOT acceptable to copy (or start your) solutions from Web using the tools specified. **In case of any forms of cheating or copying among the groups, the penalties will be severe. Both Giver and Receiver are equally culpable and suffer equal penalties!!!**
- No late submission will be accepted!