

**Computer Programming**  
**Bachelor in Biomedical Engineering**  
**Bachelor in Applied Mathematics and Computing**  
**Course 2020 / 2021**

**Exercise Sheet 12**  
**Recursion, Input/Output, ...**  
**- SOLUTIONS -**

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## Exercise 1

Ulam stated that starting from any integer number, if you follow these steps you'll reach number 1:

- If the number is even divide it by 2
- If the number is odd multiply it by 3 and add 1

Write a recursive function to prove Ulam's conjecture. The program asks the user to introduce a number and prints on screen all the numbers obtained until it reaches 1.

### SOLUTION

```
function recUlam(num)
if num == 1
    fprintf('%d\n', num);
else
    if rem(num,2) == 0
        newnum = num/2;
    else
        newnum = num*3+1;
    end
    if newnum ~= 1
        fprintf('%d\n', newnum);
    end
    recUlam(newnum);
end
end
```

## Exercise 2

Normally, numbers are represented using the decimal system (base 10). It is said that the decimal system is a positional system, since the value of each digit depends on its relative position. For example:

$$792 = 7 * 10^2 + 9 * 10^1 + 2 * 10^0$$

Write a recursive function that transforms a number from the decimal system base representation to another base. Additionally, write a main program that asks the user to introduce a number and its new base, and that prints the correspondent value in that new base on screen.

To transform the number follow the following steps:

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**Example:**

Introduce the number to transform: 8

Introduce the new base: 2

The new value is 1000

Note:  $1000 = 1 \cdot 10^3 + 0 \cdot 10^2 + 0 \cdot 10^1 + 0 \cdot 10^0$ **Example:**

Introduce the number to transform: 6

Introduce the new base: 2

The new value is 110

Note:  $110 = 1 \cdot 10^2 + 1 \cdot 10^1 + 0 \cdot 10^0$ **MAIN PROGRAM**

```
value = input('Introduce the number to transform: ');
base = input('Introduce the new base: ');
rdo = changebase(value,base);
fprintf('The new value is %d\n', rdo);
```

**FUNCTION**

```
function [value] = changebase(num,base)
if num ~= 0
    vcoef = floor(num/base);
    vrem = rem(num,base);
    value = vrem+ 10*changebase(vcoef,base);
else
    value = 0;
end
end
```

**Exercise 3**

Write a function 'reverseVector' that receives a vector and, using recursion,

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```

if maxLength == 1
    revVect = vect;
else
    revVect = [vect(maxLength) reverseVector(vect(1:maxLength-1))];
end
end

```

### Exercise 4

Write a program for maintaining a phone list. The program uses a text file named 'phones.txt' to store the information about the phone numbers and the person they belong to. The format of the file is:

*name phonenumber*

where both *name* and *phonenumber* are strings (let's consider you might need to store international numbers including the character '+')

The program should allow the user to perform the following operations:

- introduce a new phone number: this operation requires the user to introduce the name of the person and his/her phone number
- modify the number of a person: this operation requires the user to introduce the name of the person which exists in the file and his/her new phone number
- list all the phone numbers
- display the phone number of a given person
- exit the program

Note: the program should create the file if it doesn't exist already. When the user finishes the program (exit) it should store all the phone numbers in the file, so the next time he/she runs the program this information can be retrieved.

Example:

1. Insert a new phone number
2. Modify existing person's phone number
3. List all
4. List a person's phone number
5. Exit (save to file)

Enter option: 1



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5. Exit (save to file)

Enter option: 1

Enter the name of the person: **Bolson**  
 Enter the new phone number: **+34565673422**  
 Press any key to show menu

1. Insert a new phone number
2. Modify existing person's phone number
3. List all
4. List a person's phone number
5. Exit (save to file)

Enter option: 3

Name	Phone
Baggins	+34647564234
Bolson	+34565673422

Press any key to show menu

1. Insert a new phone number
2. Modify existing person's phone number
3. List all
4. List a person's phone number
5. Exit (save to file)

Enter option: 2

Enter the name of the person whose number you want to change: **Baggins**  
 Baggins's number is +34647564234  
 What should the new number be? (empty to erase) **+34647564666**  
 Baggins' number has been overwritten with value **+34647564666**  
 Press enter to show menu

1. Insert a new phone number
2. Modify existing person's phone number
3. List all
4. List a person's phone number
5. Exit (save to file)

Enter option: 4



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2. Modify existing person's phone number
3. List all
4. List a person's phone number
5. Exit (save to file)

Enter option: 5

File saved. Bye!

Content of the file *phones.txt* after execution:

```
Baggins +34647564666
Bolson +34565673422
```

## SOLUTION

See exercise 5.

### Exercise 5

Modify the previous program to allow to store up to three phone numbers per person. The format of the file will now be:

*name phonenumber1-phonenumber2-phonenumber3*

Note that some of the contacts in your phone list might have only one number, while other might have two or three.

Example content of the file:

```
Baggins 647564234-456876780-345634567
Bolson 345656734 --
```

## FUNCTION

```
function [index] = indexByName(phoneList,nameToLookFor)
% looks for nameToLookFor in phoneList struct array and returns the index
% of the first occurrence or -1 if not found
% phoneList struct has field .name
bFound = 0;
i = 1;
while (bFound == 0) && i <= length(phoneList)
    if strcmpi(phoneList(i).name, nameToLookFor) ==1
        bFound = 1;
    end
end
```

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```

else
    index = -1;
end
end

```

### MAIN PROGRAM

```

clear;
clc;
filename = 'phones.txt';
% First, open the file to be able to read the list from the file into a
struct array
fid = fopen(filename, 'rt');
if (fid ~= -1) % No error opening file (file already exists)
    % Store all file content into a struct
    % Then, modify this struct
    % When finished, overwrite the file with the new struct
    %
    % The struct has two fields:
    %   phoneBook(i).name   stores the name of the person
    %   phoneBook(i).numbersCA stores a cellArray of phonenumbers
    %   (length can vary from 1 to 3 phonenumbers)
    % e.g.
    %   phoneBook(1).name   Baggins'
    %   phoneBook(1).numbersCA  {'666110000'}, {'666001122'}

    i = 0;
    while (feof(fid) == 0)
        i = i + 1;
        clear phoneCA;
        phoneCA = textscan(fid, '%s %s', 1);
        phoneBook(i).name = phoneCA{1}{1};
        numbersToSplit = phoneCA{2}{1};

        clear auxCA
        auxCA = {};
        [auxCA{1}, rest] = strtok(numbersToSplit, '-');
        [secondNumber, rest] = strtok(rest, '-');
        if isempty(secondNumber) == 0
            auxCA{2} = secondNumber;
            [thirdNumber, rest] = strtok(rest, '-');
            if isempty(thirdNumber) == 0
                auxCA{3} = secondNumber;
            end
        end
        phoneBook(i).numbersCA = auxCA;
    end
    fclose(fid);
else % If file did not exist
    phoneBook(i).name = ' ';
end

```

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```

fprintf('\n');
while (isempty(option) == 1) || option < 1 || option > 5
    option = input('Enter a valid option: ');
end
while (option ~= 5)
    switch(option)
        case 1 % Insert a new phonenumber (and possibly a person)
            name = input('Enter the name of the person: ', 's');
            % Check if the person is currently in the list or not
            i = indexByName(phoneBook,name);
            if i ~= -1
                alreadyPresent = 1;
            else
                alreadyPresent = 0;
            end
            if alreadyPresent == 1
                % Check if we can add a new phone number to the existing
                % person
                clear auxCA;
                auxCA = phoneBook(i).numbersCA;
                if length(auxCA) < 3 % At least one space to add a phone
number
                    newPhonenumber = input('Enter the new phonenumber:
', 's');
                    while (isempty(newPhonenumber) == 1)
                        newPhonenumber = input('Enter a valid new
phonenumber: ', 's');
                    end
                    % Add number at the end of this person's phone number
list
                    auxCA{length(auxCA)+1} = newPhonenumber;
                    phoneBook(i).numbersCA = auxCA;
                    fprintf('Number %s added to %s's phone number
list\n', newPhonenumber, name);
                else
                    fprintf('Sorry, %s's phone list is full\n', name);
                end
            else % Not already present (new name)
                newPhonenumber = input('Enter the new phonenumber:
', 's');
                while (isempty(newPhonenumber) == 1)
                    newPhonenumber = input('Enter a valid new
phonenumber: ', 's');
                end
                clear auxCA;
                auxCA{1} = newPhonenumber;
                newIndex = length(phoneBook) + 1;
                phoneBook(newIndex).name = name;
                phoneBook(newIndex).numbersCA = auxCA;
            end
        case 2 % Modify an existing person's phone number list
            nameToLookFor = input('Enter the name of the person whose

```

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```

        else % At least one number to modify available
            % Print available numbers
            for j=1:length(auxCA)
                fprintf('%s''s number %d is %s\n' ,
nameToLookFor, j, auxCA{j} );
            end
            numToChange = input('Which number do you want to
replace? ');
            while (numToChange < 1) || (numToChange >
length(auxCA)) % Invalid number
                numToChange = input('Invalid number. Which number
do you want to replace? ');
            end
            newNum = input('What should the new number be? (empty
to erase) ','s');
            if (isempty(newNum) == 1) % Erase number
                auxCA(numToChange) = []; % Note () for accessing
cell, not cell content
                phoneBook(i).numbersCA = auxCA;
                fprintf('%s''s number %d has been deleted\n',
nameToLookFor, numToChange);
            else % Overwrite number
                auxCA{numToChange}=newNum;
                phoneBook(i).numbersCA = auxCA;
                fprintf('%s''s number %d has been overwritten
with value %s\n', nameToLookFor, numToChange, newNum);
            end
        end
    else % If name not found
        fprintf('Sorry, %s was not found in this list\n',
nameToLookFor);
    end
    case 3 % List all
        fprintf('Name\tPhone1\tPhone2\tPhone3\n');
        for i=1:length(phoneBook)
            fprintf('%s', phoneBook(i).name);
            auxNumbersCA = phoneBook(i).numbersCA;
            for j=1:length(auxNumbersCA)
                fprintf('\t%s',auxNumbersCA{j});
            end
            fprintf('\n');
        end
    case 4 % List phone numbrers of a person
        % Ask for person's name and look for it
        % (list considered not ordered)
        nameToLookFor = input('Whose phones do you want to know?
','s');
        while (isempty(nameToLookFor) == 1)
            nameToLookFor = input('Invalid name. Whose phones do you
want to know? ','s');
        end
        i = indexByName(phoneBook,nameToLookFor);

```

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```

        fprintf('Sorry, %s was not found in this list\n',
nameToLookFor);
    end
    % Case 5 (exit) implemented after while loop
end

fprintf('\n');
input('Press any key to show menu ');
fprintf('\n');
disp('1. Insert a new phonenumber');
disp('2. Modify existing person's phonenumber');
disp('3. List all');
disp('4. List a person's phonenumber');
disp('5. Exit (save to file)');
fprintf('\n');
option = input('Enter option: ');
fprintf('\n');
while (isempty(option) == 1) || option < 1 || option > 5
option = input('Enter a valid option: ');
end
end
% Case exit: dump list to file, overwriting it
outputfid = fopen(filename, 'wt'); % Empties file if it exists
if outputfid == -1
disp('Error opening file for dumping info');
else
for i=1:length(phoneBook)
auxNumbersCA = phoneBook(i).numbersCA;
fprintf(outputfid, '%s %s', phoneBook(i).name, auxNumbersCA{1});
j = 2;
while j <= length(auxNumbersCA)
fprintf(outputfid, '-%s', auxNumbersCA{j});
j = j + 1;
end
while j <= 3
fprintf(outputfid, '-');
j = j + 1;
end
fprintf(outputfid, '\n');
end
fclose(outputfid);
disp('File saved. Bye!');
end

```

## Exercise 6

Write a version of the game “Simon Says” for MATLAB. The program presents a sequence of numbers between 0 and 9, one by one. More specifically, MATLAB shows a number, pauses for 1 second, cleans the screen, shows another

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**Note:**

- to clear the window you can use the command: `clc`
- to pause the execution one second use: `pause(1)`
- to obtain a random number between 0 and 9: `floor(rand()*10)`

**Example:**

\*\*\*\* New sequence \*\*\*\*

Press s when you are ready to start: s

Here, MALTAB will show the sequence of numbers 7 7 1 4 4 one by one, pausing one second between numbers and cleaning the screen each time

Now introduce the values in the same order

Introduce a value: 7

Introduce a value: 7

Introduce a value: 1

Introduce a value: 4

Introduce a value: 4

Well done!

\*\*\*\* New sequence \*\*\*\*

Press s when you are ready to start: s

Here, MALTAB will show the sequence of numbers 6 7 7 2 6 6 one by one, pausing one second between numbers and cleaning the screen each time

Now introduce the values in the same order

Introduce a value: 6

Introduce a value: 7

Introduce a value: 7

Introduce a value: 2

Introduce a value: 6

Introduce a value: 6

Well done!

\*\*\*\* New sequence \*\*\*\*

Press s when you are ready to start: s

Here, MALTAB will show the sequence of numbers 1 1 4 9 2 6 6 one by one, pausing one second between numbers and cleaning the screen each time

Now introduce the values in the same order

Introduce a value: 1

Introduce a value: 1

Introduce a value: 4

Introduce a value: 9

Introduce a value: 2

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## SOLUTION

```

clear;
clc;
clear numbers;
clear usnumbers;
vnums = 4;
misses = 0;
while (misses <3)
    disp('**** New sequence ****');
    sready = input('Press s when you are ready to start ', 's');
    while (sready ~= 's')
        sready = input('Press s when you are ready to start ', 's');
    end
    for i=1:vnums
        clc;
        value = floor(rand()*10);
        fprintf('%d\n', value);
        numbers(i) = value;
        pause(1);
    end
    clc;
    disp('Now introduce the values in the same order');
    for j=1:vnums
        auxval = input('Introduce a value: ');
        while (isempty(auxval) == 1)
            auxval = input('Introduce the last value again: ');
        end
        usnumbers(j) = auxval;
    end
    if usnumbers == numbers
        disp('Well done!');
        vnums = vnums + 1;
    else
        disp('You failed!');
        disp('The right sequence was: ');
        for i=1:vnums
            fprintf('%d ', numbers(i));
        end
        misses = misses + 1;
        fprintf('You have %d more attempts\n', 3-misses);
    end
end
fprintf('End of the game. You were able to reproduce %d sequences\n',
vnums-4);

```



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