Exercises and assignments, C-programming

Exercises and assignments for the course DIT165 Development of Embedded systems _ Part 1

The aim for this course is to give you an overall introduction in developing of software for embedded and real-time systems. One way of getting this knowledge is to develop different programs intended for such systems. Today the most common language for embedded systems is still C or C++. One reason for this is because C is “closer” to the assembly language than other language, i.e. a C-program generates less assembly instruction then other high level program languages and by that needs less of memory. Another advantage is that it’s easier to write program segments including interaction with hardware and I/O modules.

During the course you will solve a lot of exercises. The exercises are divided into Work package (WP #nr), one for each course week. Each WP consists of different exercises to be solved during corresponding week.

Groups work and group members: In this course you will work in a group of up to three students and you can choose group members as you want. All members in a group register by themselves into the specific project groups at the homepage for this course (DIT632). The name of the Groups are: Working groups <1-40>. Find on course homepage, left menu, People, Working groups.

Mandatory Exercise sub module (3 hec) and bonuspoints:

The exercises are a part of the mandatory course sub module **Assignments (3 hec).** To pass this module you must hand in solutions for the exercises. For each WP nr you get a number of exercise points. For the moment the total sum of exercise points in the course is 52. To pass the sub module Assignment you must get 65 % or more of maximum exercise points. If you get more than 70 % of the maximum points you get 2 or 4 bonus points. This will be included in the final written exams during the calendar year. After that the points expire.

Terms of assignments and bonus
All exercises that are submitted (possible for all in WP2 - WP6) must meet the following requirements for contribute to bonus points at final exam.
Includes a program header as below:

```
/ * ====================================
File name: exerc_x_y.c (or cpp)
Date: 2019-mm-dd
Group nr xxx
Members that contribute to the solutions
xxxxxxx xxx
yyyyyyy yyy
zzzzz  zzzzzz
Member not present at demonstration time:
Yyyyyy  yyyy
Demonstration code: [<Ass code 1-4> <abc>]       Important , No code no exercise points !
==================================== * /
```

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All submissions must be handed in by one of the group members via course home page and before handed in be demonstrated for one teaching assistant (TA) and if approved the you will get a specific unique examination code <xxxx> to write in to the program header for this exercise.
After that you can hand in the program source code (filename.c) and its header files (filename.h).
You should only hand in one file per WP <#>. All programs for a WP should be included in one xxx.zip file. If there are any solutions containing more than two files you had to put them in a separate directory.

Work package nr 1 / Intro week

Exerc_1_ 0

Install (or test an existing) an IDE to be used when working with the exercises below and for the project in the project course running parallel with this course.

For the project course (DIT168) there is a proposal for using Eclips , gcc, gdb . You should install and test such an environment on some of the group's computers.

In this course we are going to develop rather small programs, so it doesn't matter what IDE you will use. Good examples are Eclips or CodeLite. You should also learn to work directly with the compiler (gcc) together with a simple editor (Notepad++, …) from the console window.

Exerc_1_ 1 : (Filename exerc_1_1.c)

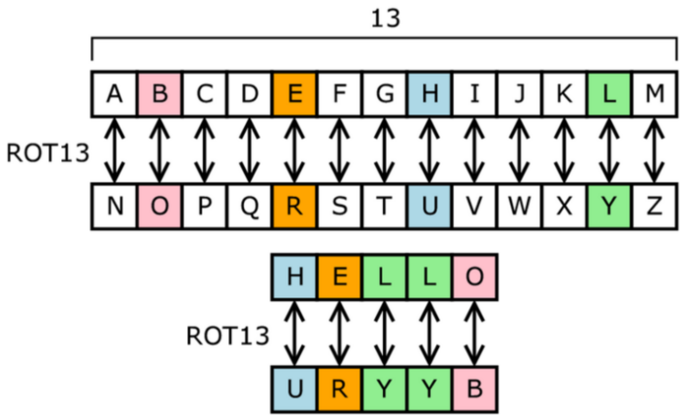
Write a program that reads in an integer number between 1 and 5 from the keyboard and prints out one of existing five sentences on the console depending on what number was entered.
The program continues to ask for a new number and exits if number isn´t in the interval 1 to 5.

Exerc_1_ 2 : (Filename exerc_1_2.c)

Write a program that reads in a sentence of MAX characters and counts the number of words in it.
The number of words should then be printed out on the console window.

Exerc_1_ 3: Encryption , (Filename exerc_1_3.c)

Create a very simple encryption program. The program is based on the principal of “shifts of characters” in the ASCII-code table. In the example below, A has shifted to N, B to O, etc., that will mean 13 steps in the table. Only capital letters are viewed in the figure but the same ideas applies to lower case letters. The word HELLO becomes URYYB after encryption.



The user enters a text and the program prints out the encrypted text. Let the program read character by character, and encrypt it as above. The program is repeated until EOF indicated the program ends. (EOF, the user enters Ctrl +z for Windows and Ctrl + d for Linux system).

Example of a test run :

HELLO (+enter)
URYYB
Banana (+enter)
Onanan
(+Ctrl-z)
(Program ends)

Exerc_1_ 4 : Guess the number , (Filname exerc_1_4.c)

You should develop a very simple game in which the computer creates a random integer number between 1..100. The user then tries to guess the number. The program should work as specified below:

- The computer creates a random number
- The user guess the number
- The computer respond by printing one of :
  You have guessed xx times and your guess is correct. Or
  Your guess is to low or to high.
- If wrong the user is asked for a new guess, this will continue until the guess is right or the number of guesses exceeds the value MAX_NUMBER.
- After end of one round the user is asked for a new round or to finish.

The program should only except guessed numbers in the range of 1 …100.

An option, but not a demand, is to secure that the program not fail (crashes) if a user by accident put in any character instead of a number.

Work package nr 2 / General C-programming (Max 12 p)

Exerc_2_ 1 : (Filename exerc_2_1.c) (1p)

Write a program that reads in a string with a maximum of 20 characters from the keyboard and stores the string in a local string variable.
Copy the string to another string by using:
a) The library function strcpy(..)
b) Your own function ***void copyString(…)*** not using any library function.
Main program ends by printing out the copied string in the console.

The program should be able to both read in from keyboard or from a text file 'myfile.txt' containing one string of characters. You create this file with notepad or any other text editor. The reading from the text file should be done by redirect the readings from command line when program execution starts as follows: *Exerc_2_1 < myfile.txt*

Where Exerc_2_1 is the filename of the compiled program. You **shall not** use standard file managing by opening the file and the read from it.

Exerc_2_ 2: (Filename exerc_2_2.c) (1p)

Write a program that creates an array of integers, array[MAX], and then fill it with MAX no of random integers from 1 to 99. Let then the program prints out the following:

The value of the label *array* (address) is: xxxxxxxxxx
First integer in the array is (array[0]) : xxxxxxxxxx
The size of an integer (number of bytes) is : xxxxxxxxx
The size of the whole array is : xxxxxxxxx

The program shall then, by use of a pointer, print out each integer value and it´s double value.

Exerc_2_3 : (Filename exerc_2_3.c) (1p)

Create a program that reads in a number of strings **from the command line** when it starts and then checks if it is two strings and if exactly two check if they are identical or not. Do this with and without use of library function strcmp(..). Let the program print out the result in some way.

Start from command line: *exerc_2_3 string1 string2*

Exerc_2_4 : (Filename exerc_2_4.c) (1p)

Create a program that reads in a string and determines if the string is a palindrome. A word is a palindrome if it is the same word reading from left to right or right to left. We can assume that it is a simple strings without any space character in it.

Example of palindrome : level, rotor and racecar.

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Exerc_2_5: Pointer exercise (2p)

You should develop a program that calculates some statistical values for an array of integers. Among other things, the program will plot a histogram for the frequency of different numbers in the array. To test it you need to create an array of integers (*table* [MAX]) with MAX number of random numbers between 0 and MAXNUMBER. Then you should write a function that for each possible number between 0 – MAXNUMBER calculates how many times the number exists in the array. The result is then stored in a new array (*frequency* []).
Finally, you write a function that given the array *frequency []* draw a histogram as below figure:
You should use the function declaration as below.

Given an array table[]={ 1,2,12, 5,1,0,0,5,9,12, 0,2,3,0} the program will printout:

```
0   xxxx
1   xx
2   xx
3   x
5   xx
9   x
12 xx
```

Note: Numbers with frequency 0 in the array *frequency[]* is not printed out.

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

#define MAX 100
#define MAXNUMBER 20

// ------ Function declaration   ----------
void create_random( int *tab );                    // Use pointer to fill the table
void count_frequency(int *tab, int *freq );    // Use pointer
void draw_histogram(int *freq );                 //  Use pointer
int main ( void){
   int table[MAX], n ;
   int frequency[MAXNUMBER];
   ….

}
```

Exerc_2_ 6 (2p)

We want to use an array for a queue of positive integers. The numbers must be entered in to the queue which is done by putting them into the first vacant location in the field. (In the figure below from left) . An integer is taken out from the queue by taking the first number in the array. When an integer is taken out the other integers should be shifted one step up to left in the queue.
A vacancy in the queue is represented by the integer -1. In a full queue there is no integer -1.
When taking out an integer from a full queue , the integer -1 must be written in the last position.
Examples below show a queue with five positions.

int que [MAX] ; // MAX equal to 5 in this example

Queue from the start:	-1 -1 -1 -1 -1
Queue after you first put in the numbers 3 and then 4 and 5.	3 4 5 -1 -1
Queue after additional put in of 8 :	3 4 5 8 -1
And after taken out an integer	4 5 8 -1 -1

a) Write a function void ***initQue (int list [], int max)*** that initializes a list to initially containing max nr of vacant positions (-1).

b) Write a function ***int input (int list [] , int number, int max)*** that adds a number in the queue according to the rules , and return 1 if the number could be entered and 0 if the queue is full.

c) Write a function ***int output(int list[], int max)*** that returns the value if any to fetch or 0 if que is empty.

d) Finally write a main-program that sets up an empty queue with 5 positions and then call all functions for test of its function.

Exerc_2_ 7 (2p)

Create a program that checks an entered Swedish person number. The number is entered in the form of : 7107254786 (yymmddxxxc). The number should be read in as a string and converted to integers for year, month , day and number.
The last digit (here 6) is a control digit and is calculated from the other digits by an algorithm that you can find on the internet.

The user inputs the number, the program first checks that the number of month and day is in the right range and after that calculate and checks the control digit. The program then prints out the result and asks for a new person number. This is repeated until the user inputs a ‘q’.

The program should at least consist of the functions:

main() , readPersnr(char *person), int controlDigit(const char * persnr) .

Exerc_2_ 8 (2p)

a) The game Nim works as follows: On the table is a stack of 13 coins. Two players take in turn between one and three coins from the stack. Whoever are forced to take the last coin have lost.

Your task is to develop the game Nim by using the code skeleton which is available on the course webpage in Documents / Work package nr 2 .

The program is also available in the form of an executable demo program at the same place.

• Download the code skeleton. Read the code and the comments, and try to understand how the program is structured.

• Compile and run it.

• In the function declarations you can read a description of what the function should do. All function definitions are empty (called stubs). Read through the comments and develop the functions so that the program works. NOT all at once, do ONE by ONE. Try to test each function in any way. For example use the debugger function or print out a value.

TIPS: Create a test area at the beginning of main. Test there to call and print the result of a function at a time. You can write return (0) immediately after printing, so you do not run the entire program. Remove the test parts when the test is complete.

b) When the game works well, you can only play one round. Change the program so you can play several rounds. After each round the program asks if you want to play again. Use function play again()

Work package nr 3/ Extended C-programming (Max 10 p)

For this week tasks we will develop some, a little bit more advanced general C-programs.

Exerc_3_ 1 (Filename exerc_3_1.c) (2p)

Implement a test program for a robot. The program asks for the robot's starting position (x, y coordinates, range 0-99) and then **for a string of characters 'm' and 't'**, where **m** stands for move one step in current direction and **t** for turn of direction as below.

move:	means that the robot takes one step in the current direction.
turn:	means that the robot turns 90 degrees clockwise. Start direction is always north.

The program performs the instructions of the string one by one. When all instructions are executed robot stops and the program prints out the new robot position for the robot. The program then asks for new starting position, etc.

Implement the functions move() and turn() as two void functions and use a pointer parameters as arguments so that the function can update the robot position which is a variable in the main function (calling function).
Use enum and a record of type ROBOT as below for the robots position and direction.

```
 enum DIRECTION {N,O,S,W};

typedef struct {
      int xpos;
      int ypos;
      enum DIRECTION dir;
} ROBOT;
```

Exerc_3_ 2 (Filename exerc_3_2.c) (2p)

All sub tasks in this exercise (Searching and sorting) should be implemented and tested in the same program.

a) Write a function that given an integer **n**, an array of integers and the size of the array determines if **n** is in the array. If so the function should return the index for the first position of the number (in case of several) otherwise returns -1.
For testing the function, write a main program that tests the function with help of an array initiated in the main program as below and with a function declaration:

```
int search_number( int number, int tab[], int size);
int test [] = { 1,2,34,5,67,3,23,12,13,10};
```

b) There are a lot of ways to sort an array. For example, bubble sort which not is the fastest, but it is easy to understand and implement. Write a sorting routine that use the following algorithm to sort an array of integers.

• Find the minimum value in the list.
• Swap the minimum with the first in list.
• Repeat this but exclude the previous minimum on top of the list and search only in the rest of the list.

Implement the sorting function using the function declaration:

void sort (int number, int tab []);

Test the function by use of a main program and an initiated array as above. For checking purpose print out the sorted array.

Exerc_3_ 3 (Filename exerc_3_3.c) (2p+1p)

a) Write a function that creates a linked list with a NUMBER of records of type REGTYPE (see below). The value of the variable data is given a random number between 0 and 100.

Function declaration : **REGTYPE * random_list (void);**
Complete the program with a main program that tests the function (a first draft below).

b) Extend the program with a function with the function declaration:
REGTYP * add_first (REGTYPE * temp, int data);
That adds a new record first in the list and assign the field *numbers* the value of *data*.
The function must return a pointer to the new first entry in the list. Extend main so that this function is tested.

```
/*********************************************
    DIT1165 Program     file exerc_3_3.c                **
    2018-01-04                                          **
*********************************************/
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

//#### Konstanter #####
#define MAX 5

// ##### Typedefs        ####
typedef struct q{
      int number;
      struct q *next;
      struct q *prev;
} REGTYPE;

// ##### Funcion declarations   #####

REGTYPE* random_list(void);
REGTYPE* add_first(REGTYP* temp, int data);
```

```
//###### Main program #######
int main(int argc, char *argv[])
{
   int nr=0;
   REGTYPE *akt_post , *head=NULL;

   srand( time(0));  //   Random seed
   head=random_list();
   akt_post=head;
   while( akt_post!=NULL){
         printf("\n Post nr %d : %d" , nr++, akt_post->number);
         akt_post=akt_post->next;
   }

     ………
     ………

 // --- Free of allocated memory  ---

  while((akt_post=head)!=NULL){
    head=akt_post->next;
    free(akt_post);
  }

  //------------------
  return 0;
}
// ====     End of main   ======================================
REGTYPE* random_list(void ){
   int nr,i=0;
   REGTYP *top, *old, *item;
   ……….


   return(top);
}

 //==========================================================
REGTYPE* add_first(REGTYPE* temp, int data){
// Adds a record first i list and set the field tal to data


}
```

Exerc_3_ 4 (Filename exerc_3_4.c) (3p)

File managements of a person register

You should write a program for manage a database of people. The database should be stored to the hard disc as a binary file. The function of the program is easiest to understand by reading the description and program skeleton below.

From the **main program** you should be able to choose between these options:

1 Create a new and delete the old file.
2 Add a new person to the file.
3 Search for a person in the file .
4 Print out all in the file.
5 Exit the program.

After entered the choice the program executes the task and returns to the menu for new choices.

1. Create a new and delete the old file.
   Program creates a new file with the specified filename (fixed) and writes a first dummy record to the file and then close it.

2. Add a new person to the file.
   First gives an opportunity to put in one new person to a temp record and then add this record in the end of the file.

3. Search for a person in the file.
   Gives you an opportunity to search for all persons with either a specified first name or family name (by choice).The program prints out all person with that name.

4. Print out all in file.
   Prints out the whole list

5. Exit the program.
   Just exits the program.

```
/ * ====================================
File name: exerc_3_4.c (or cpp)
Date: 2019-mm-dd
Group Number:xxxx
Members that contributed:
…..
Demonstration code: [<Ass code 1-3> <abc>]       Important !
====================================== * /
```

```
#include <stdlib.h>
#include <stdio.h>

// -----Typedefs -------
typedef struct {
	char firstname[20];
	char famnamne[20];
	char pers_number[13]; // yyyymmddnnnc
}PERSON;

// Function declaration (to be extend)
PERSON input_record( void);          // Reads in a person record.
void write_new_file( PERSON *inrecord); //Creats a file and write a first record
void printfile(void); // print out all persons in the file
void search_by_firstname( char *name);// print out person if in list
void append_file(PERSON *inrecord);// appends a new person to the file

int main( void){
   PERSON ppost;


   return(0);

}
```

Exercises and assignments for the course DIT165 Development of Embedded systems _ Part 2

This is included in a separate document: DIT632 Exercises_P2_v19xxxx.pdf that will be uploaded to Course homepage during Course Week nr 3.