Instructions for the exam

DIT632, Development of Embedded and Real-time systems

This exam should be an individual work for you. You are not allowed to use any outside help.

If you are allowed to use a compiler, there is a link to an online one, which will open in a separate window. You can test the code in the online compiler, but **you must remember to copy-paste it back to the exam**, otherwise your code will disappear once you close the window.

The same is true for TinkerCad, please remember to copy-paste the code from TinkerCad to the exam.

If you access the code from your saved documents in TinkerCad, and use it in the exam, you MUST reference that code and describe clearly what you copied to the exam.

You are not allowed to copy code from your colleagues or any other external source.

Remember: In programming questions, if the code does not compile, you get 0 points for the question!

In order to pass the exam (grade G), you must get 50% of the total points.

To get VG, you must have at least 85% of the total points in the exam.

Good luck!

/Miroslaw
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1 Stack and heap

1. Please explain the concepts of **stack** and **heap** in a program.

2. What does it mean that a variable is placed in a memory on the stack?

3. What does it mean that a variable is planed in a memory on the heap?

4. How do we define and allocate memory for a variable of type int on the stack?

5. How do we define and allocate memory for a variable of type in on the heap?

6. What can we do with the allocated memory on the heap, that we cannot do with the memory on the stack?

Your answer:

Teckenf…

Ord: 0

Totalpoäng: 6

2 Reading pointers

Please choose the right interpretation of "X" in each of the statements:

int *x();

- x is a pointer to a function that returns an int
- x is a function that returns a pointer to an int
- x is a variable of type int
- x is a pointer to a pointer to a function that returns a variable of type int

int (* x []) ();

- x is an array of pointers to functions that return int
- x is a function which takes as an argument an array of pointers to variables of type int
- x is a function that takes an array as an argument and returns a pointer to int
- x is a pointer to a function that takes as an argument an array of integers

char * (* (* x [ ] [8]) ( )) [ ];

- x is array of array of 8 pointers to a pointer to functions returning pointer to array of pointer to char
- x is an array of 8 pointers to pointer to function returning pointer to array of pointer to char
- x is array of array of 8 pointers to a function returning pointer to array of pointer to char
- x is a function that takes as input an array of 8 pointers to pointer to an array and returns a pointer to array of pointer to char

int (* (* x) [ ]) ( );

- x is an array of pointers to functions that take no arguments and return pointers to int
- x is a function that takes as argument an array of pointers to functions and return a pointer to int
- x is a function that takes as an argument a pointer to an array of pointers and returns a pointer to int
- x is a pointer to an array of pointers to functions returning an int

char (* * x ( )) [20];

- x is an array of pointers to functions returning pointers to functions returning pointers to char
- x is a pointer to a function returning a pointer to an array of 20 elements of type char
- x is a function returning a pointer to a pointer to an array of 20 elements of type char
- x is an array of 20 pointers to functions returning char

Totalpoäng: 5

3 Substrings

Please write a program that contains a function for checking if a string contains a substring. The signature of the function should be like this:

int contains_substring(const char *stringone, const char*substring);

The function should return:
* position of the substring, or
* -1 if the substring is not found

You are NOT allowed to use any build-in or library functions for handling strings

You can use the online C compiler for this task: Online C compiler

Your program should include:

- write the function (2 points)
- main() procedure to test this function (2 points)
- comments (2 points)

Please write your program here

```
1
```

Totalpoäng: 6

4 The fraction calculation program

Write a program that does calculations on fractions.

Just as a reminder, to add fractions:

$$\frac{a}{b} + \frac{c}{d} = \frac{ad+bc}{bd}$$

and to multiply them:

$$\frac{a}{b} * \frac{c}{d} = \frac{ac}{bd}$$

Your solution should include the following functions, which take fractions as input, returns the approximated value (as double) and print the nominator and denominator. It shuold

- double addFraction(int a, int b, int c, int d)
- double subFraction(int a, int b, int c, int d)
- double multFraction(int a, int b, int c, int d)

An example input for addFraction(1, 2, 1, 4) should be:

aproximated double: 0.75
exact value: 1/2 + 1/4 = 3 / 4

Grading:

- code for each function: 2 points * 3 = 6 points
- comments: 2 points
- main function which tests each of these functions: 3 points

You can use the onlinedebugger to solve this assignment, remember to copy the code below.

Write your solution here

```
1
```

Totalpoäng: 11

5 Multithreading

Write a program that implements multithreading and synchronizes threads using semaphores.

The program should have three separate threads. Each thread should print out a number modulo 3. The program should finish when the program reaches the MAXNUMBER, which is defined by the user.

For example, thread #1 should write numbers 1, 4, 7, 10, etc. Thread #2, should print numbers 2, 5, 8, etc.

To make the output more coherent, each thread should print it's number before the number, e.g. "thread #1: number 1". There should be one number per line.

The program should use threat synchronization to print the numbers if the right sequence, e.g.:
"thread #1: number 1"
"thread #2: number 2"
...

Since onlinegdb is Linux-based, please use the pthread library.

The program will be greaded in the following way (total 8 points):
* Correct use of multithreading: 3 points
* Correct synchronization: 2 points
* Correct usage of parameters: 1 point
* Correct commenting: 2 points

You are allowed to use the online C Compiler: Online C Compiler

Signature for the function pthread_create:

```
int pthread_create(pthread_t *restrict thread,
                   const pthread_attr_t *restrict attr,
                   void *(*start_routine)(void *),
                   void *restrict arg);
```

and pthread_join

```
int pthread_join(pthread_t thread, void **retval);
```

and for the semaphores:

```
int sem_init(sem_t *sem, int pshared, unsigned int value);
```

```
int sem_wait(sem_t *sem);
```

Write your solution here

```
1
```

Totalpoäng: 8

6 Guessing game with file logging

Guessing game with file log.

Your task is to write the program for the guessing game and save the history to the file.
The program should randomly find a number between 0 and MAXNUMBER. It should print the MAXNUMBER for the user so that he/she knows the limits of the game. Then the user should be asked for a name, so that the computer knows who plays the game.

Then the user should be asked to provide a number and the program checks whether it is the right one. If the number is not the correct one, the program should write whether the guess was too high/too low and give the possibility to forfeit the game. The game continues until: a) the user guesses the number correctly, 2) the user forfeits the game, or 3) a MAXSTEPs number of steps is reached.

The program should log every step of the game in a text file (textfile.log), along with the name of the player, MAXSTEPS and MAXNUMBER.

The points will be assigned in the following way (total 9 points):
* Correct implementation of the guessing game: 3 points
* Correct handling of the file: 2 points
* Correct usage of parameters/declarations: 2 points
* Correct usage of comments: 2 points

You can use the online C compiler to test your answers: Online C compiler

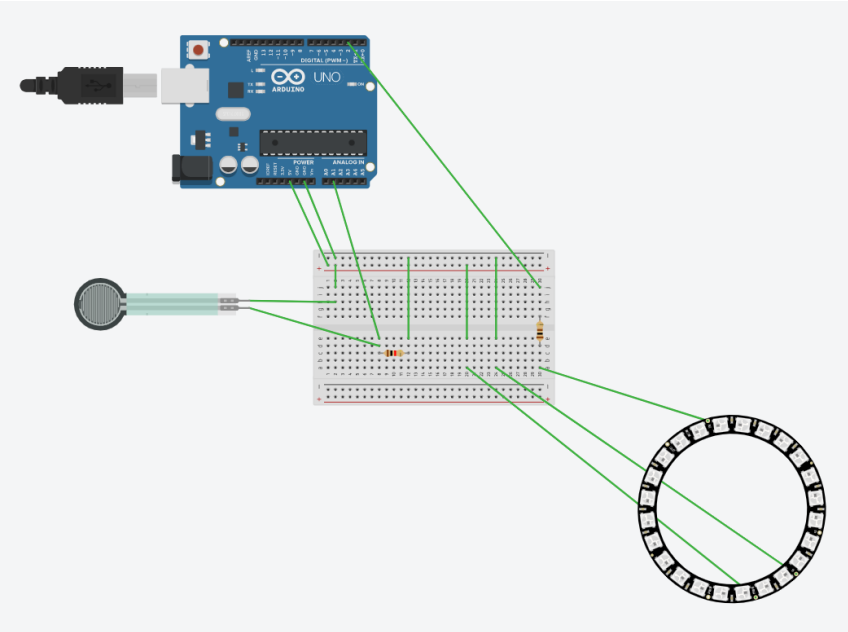
Please write your code here

```
1
```

Totalpoäng: 9

7 Arduino board programming

Create a system with the force sensor and a neopixel ring as shown in the picture below.



The system should use the neopixel ring to show how much force is applied to the force sensor. The number of pixels in the ring should increase linearly with the force applied.

You can use interrupts or a loop for this exercise.

You should use TinkerCad: https://www.tinkercad.com

You should deliver the following:

- Code, pasted in the box below. The code should include:
  - Code to solve the problem (3 points)
  - Where you use #define or constants to predefine how the number of pixels correspond to the force; or you can use a mapping function for that (2 points)
  - Where you have a separate function that reads the force and turns on/off the pixels (3 points)
  - Comments (2 points)

Please write your code here

```
1
```

Totalpoäng: 10